

LEARNING IN INDUSTRY, INNOVATION AND GROWTH

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ABSTRACT

This thesis investigates issues of learning, innovation and growth by considering arguments from disparate schools of theory, and by an empirical investigation. The development of new growth theory models that demonstrate sustained growth driven by endogenous learning and innovation is reviewed. The importance of learning to the growth mechanisms of many of these models suggests that the new growth theories may have a contribution to make on the understanding of learning in industry. However, it is found that, in focusing on advancing neoclassical growth theory, the new growth theories have introduced learning in scenarios that are schematic and designed to suit the modelling enterprise rather than to capture the nature and process of learning in industry.

The importance of learning is argued to require empirical and theoretical insights that are beyond the scope of the new growth theories. Nevertheless, the new growth theories identify the importance of practical issues of how learning is done, what is learned and why it is learned, for industry. These issues form the basis of an investigation of select learning theories from psychology and sociology. That investigation concludes that the practical aspects of learning in industry are conditioned by relationships and institutions that give value to knowledge and allow the parties to assess and access that knowledge within bounds determined by various forces within society and industry. Moreover, the national system of innovation approach argues that learning and innovation, and the relationships and institutions that modify them, can only be understood within a broader system.

The lack of relevant empirical information about learning at the company level within the industrial and broader context indicated the need for an empirical investigation into the practical issues of learning within the industrial context of the modifying relationships and institutions. Such an investigation forms the empirical component of this thesis. A case study of learning in the telecommunications company, Ericsson, in Sweden and Australia is presented. The major finding is that learning is endogenous, as indicated by the new growth theories, and is heavily influenced by relationships and institutions that are alien to the new growth theories. More generally, the findings of the case study support the creative and translational learning theories as noted above. The finding that changes to the regulatory environment, especially the introduction of competition in telecommunications service provision, and the consequent changes to the relationships between Ericsson and its major customers, have radically changed Ericsson's innovation and learning practices, provides strong support for the systematic and institutional arguments of the national system of innovation approach. The strength of the finding that both the rate and direction of learning and innovation are determined by systemic factors, suggests that policies may be designed to achieve performance objectives through the manipulation of relationships and institutions.

INTRODUCTION

Two issues that have attracted considerable attention from economists in recent years are growth and innovation. One arm of neoclassical economics, the new growth theories, has succeeded in modelling sustained endogenous growth driven by learning in industry and innovation. This approach has aroused theoretical interest and is increasingly important in policy. However, the focus on modelling growth within the rigours of the neoclassical paradigm limits the ability of new growth theories to introduce learning scenarios that involve conditions that violate that neoclassical competitive framework. Their treatment of learning is thus schematic and restricted. So, on the one hand, the new growth theories highlight the importance of learning in industry for innovation and growth, while on the other hand, they restrict the treatment of that learning to comply with the neoclassical paradigm. They thus raise the profile of learning in industry without explaining its nature and process.

This thesis presents a theoretical and empirical investigation into the nature and process of learning in industry, in order to improve the understanding of innovation and growth. The theoretical component begins with a review of the development of neoclassical growth theory from the Solow-Swan model to models of sustained endogenous growth in conditions of monopolistic conditions. This review highlights the limitation on the models imposed by the rigours of the neoclassical framework. These limitations are shown in Chapter 2 to restrict the scenarios that the new growth theorists use to introduce learning to their models. However, those scenarios do indicate the importance of understanding the practical issues of what is learned in industry, how it is learned and why it is learned. Chapter 2 continues with an investigation of theoretical literature from psychology and sociology on the nature and process of learning. That investigation concludes that learning is social in nature and process, and that to understand learning and innovation it is necessary to understand the social context in which it is undertaken.

Chapter 3 draws from psychology and sociology literature to discuss material on relationships and institutions that constitute the social context of learning in industry. Those relationships and institutions are argued to influence separately and together learning and innovation in industry. The concept of the national system of innovation is introduced in order to understand the systemic way that relationships and institutions interact with each other and with the broader context to determine the rate and direction of learning and innovation. The national system of innovation's evolutionary approach to understanding the link between learning, innovation and growth is contrasted to that of the new growth theorists.

The theoretical component concludes by identifying a need to investigate empirically the nature and process of learning in the industrial context. In particular, the need is identified for an investigation that focuses on the practical issues of what is learned, how it is learned and why it is learned, and the relationships and institutions that influence that learning. The empirical component of this thesis presents such an investigation, which addresses the following questions:

- What is the nature of the relationships that influence learning in industry?
- What is the nature of the institutions that influence learning in industry?
- How is learning done in industry?
- Why is learning undertaken in industry?
- What is learned in industry?

The selection of a descriptive case study method is shown in Chapter 4 to be based on the importance of contextual material, and the purpose of producing a rich description of learning in industry. Chapter 4 continues with background material on the case study of the telecommunications equipment company, Ericsson. This material relates to the telecommunications industry and to the Swedish and Australian national systems of innovation as well as to Ericsson's operations.

The research method is further detailed in Chapter 5, in which the nature of qualitative method is discussed and the data collection and analysis techniques are

detailed. The chapter describes the choice of qualitative techniques for data collection and analysis to suit the qualitative nature of the concepts of learning, relationships and institutions.

The data that address the first two research question are summarised in Chapters 6 and 7, respectively. The data that address the last three research questions are summarised in Chapter 8. These findings are discussed and interpreted in the light of the theoretical material in Chapter 9, which also provides a conclusion to the thesis.

Overall, the thesis demonstrates that arguments from various theoretical perspectives make contributions to the understanding of learning, innovation and growth. The worth of those contributions is discussed in the conclusion to this thesis.

CHAPTER 1

The Development of Neoclassical Models of Endogenous Growth Driven by Learning

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1.1 Introduction

The theory of economic growth has been dominated by the development and refinement of Solow's neoclassical general equilibrium steady state growth model for more than three decades (Grossman and Helpman, 1994). One important recent stream of that development has been a body of theory that identifies the learning associated with endogenous technological change as the engine of sustained growth. The theoretical implications of that body of work can be understood within the context of the development of that stream of neoclassical growth theory.

This chapter describes key elements of the development of the neoclassical growth models from the work of Solow (1956) and Swan (1956) to the sustained endogenous growth models of the new growth theorists. This is achieved by drawing together critical points from selected contributions in order to highlight the path from growth theory with no technology, through early neoclassical growth

theory with exogenous technology and no learning, to sustained growth models with endogenous technological change and learning. Section 1.2. presents early growth models beginning with the Harrod-Domar model, which is followed by the neoclassical models of Solow-Swan, and Cass-Koopmans. Section 1.3 focuses on models in which learning drives growth under conditions of perfect competition with external increasing returns. Works reviewed in section 1.3 are Arrow (1962a), Romer (1986), Stokey (1988) and Lucas (1988). Section 1.4 presents models of learning-driven sustained growth in conditions of limited monopoly. Works reviewed in section 1.4 are Romer (1990), Grossman and Helpman (1991a, two models) and Young (1994). Conclusions are drawn in section 1.5.

1.2 Early neoclassical growth models

The development of neoclassical growth models has had four general features. The first is that it has been generally consistent with the precise formulation of the competitive paradigm with perfect foresight. The second is that the modelled growth has been long run, steady state¹ growth in general equilibrium. The third is that there has been an ongoing tendency to endogenise key factors. The fourth is that there has been an ongoing move towards increased realism in response to observed phenomena. These features of that development are apparent when early neoclassical models are compared with the earlier Harrod-Domar model.

1.2.1 Harrod-Domar model

The Harrod-Domar growth model shows that, in a competitive model with perfect foresight and all key variables exogenous, steady state growth with full employment cannot be guaranteed. The single-good, two-inputs model assumes constant returns to scale, fixed coefficients, a constant ratio of savings to national income (s) and a constant given rate of population growth (n). Fixed coefficients means that if only one input is increased, output remains unchanged, if both inputs increase but at different rates, the increase in output is restricted to the lower rate. Therefore, in a

¹ Steady state is typically defined as a situation in which consumption, output and capital grow at the same constant rate.

model in which labour is exogenously determined, regardless of the increase in capital, the maximum growth rate of national income is limited to the population growth rate (n). A growth rate equal to the rate of growth of the population, the *natural growth rate* (n), is required for continuous, full employment, labour market equilibrium. In the capital market, full employment equilibrium occurs when savings equal investment. The *warranted growth rate* for equilibrium in the capital market requires that the growth in national income will be equal to the growth of the capital stock (s/v , where v is the fixed capital-output ratio).

Steady state growth with equilibrium in both the capital and labour markets implies that the natural rate (n) equals the warranted rate (s/v):

$$(1) \quad n=s/v$$

Because the population growth rate, the savings ratio and the capital-output ratio are all exogenous, this equality will only be met by coincidence. If savings are too great or the capital-output ratio is too small then there will be unemployed capital. If there are inadequate savings then there will be unemployed labour. The Harrod-Domar model therefore concludes that full employment, steady state growth is not generally predicted within a competitive framework.

The Harrod-Domar finding that full employment, equilibrium growth cannot be guaranteed was consistent with economic history at the time that the Harrod-Domar model was developed. The post war period of sustained full employment growth called for new theoretical arguments. The early neoclassical growth models modified the Harrod-Domar production assumptions to develop models of steady state, full employment, equilibrium growth in a rigorously competitive structure. There have been at least three approaches within that vast literature. The first was to introduce technological change and so abandon the assumption of a fixed capital-output ratio (v). This approach was adopted by Solow (1956) and Swan (1956). The second was to make the savings ratio (' s ' in Harrod-Domar) an endogenous function, as done by Cass (1965) and Koopmans (1965). Thirdly, Becker, Murphy

and Tamura (1990) endogenised the labour supply. The two most influential of these approaches have been the contributions of Solow and Swan and of Cass and Koopmans, both of which concentrate on determining the economic growth rate with a constant and exogenous rate of growth of the population and of the labour supply.

1.2.2 The Solow-Swan model

The Solow-Swan model abandons the Harrod-Domar assumption of fixed factor proportions in order to model full employment, steady state growth in competitive conditions. The two related effects of this are that it allows output to grow when only one input is increased, and it allows the capital-output ratio to vary over time due to technological change. The Solow-Swan model is couched in a full employment, competitive, equilibrium framework with constant or decreasing returns, capital and labour markets continually clear, wage rate equal to the marginal product of labour, interest rate equal to the marginal product of capital and savings equal to investment. Both population growth and technological progress are constant, exogenous rates.

The Solow-Swan production function can be expressed in the Cobb-Douglas form:²

$$(2) \quad Y = AK^{\beta}L^{\alpha}$$

Where: Y is output

A is technology

K is physical capital

L is labour

The usual neoclassical production function conditions for each input apply³. With constant returns to scale, there are decreasing returns to capital. As labour is

² For simplicity, subscripts denoting time are omitted but they are implied.

³ The function is increasing, strictly concave and twice differentiable, that is: $f(0)=0$, $f'(x)>0$, $f''(x)<0$, $\lim_{x \rightarrow \infty} f'(x)=0$, $\lim_{x \rightarrow 0} f'(x)=\infty$ where x is an input

assumed not to be accumulated, there is decreasing returns to the only accumulated input (capital). Capital accumulates through net investment (\dot{K}) which is equal to savings less depreciation. The accumulation equation for capital is:

$$(3) \quad \dot{K} = sY - \delta K$$

Where: s is the savings ratio

δ is the rate of depreciation.

As the return to capital decreases with the accumulation of capital, there is a reduction in the incentive to invest. Substituting the equation (2) into equation (3) gives capital accumulation as a function of inputs:

$$(4) \quad \dot{K} = sAK^\beta L^\alpha - \delta K$$

The steady state rate of growth of the capital stock can be determined by rearranging equation (4), taking logarithms, differentiating with respect to time, and imposing the steady state condition $\frac{d}{dt}(\ln \frac{\dot{K}}{K}) = 0$. This gives the growth rate of capital as:

$$(5) \quad \frac{\dot{K}}{K} = \frac{1}{1-\beta} \left(\frac{\dot{A}}{A} \right) + \frac{\alpha}{1-\beta} \left(\frac{\dot{L}}{L} \right)$$

Therefore, the rate of growth of capital is a function of the rate of growth of labour and of technology. If both labour and technology grow, the rate of growth of capital is a weighted average of the two. The weights are the relevant elasticities of output. Steady state growth is defined as a common constant growth rate:

$$(6) \quad \frac{\dot{K}}{K} = \frac{\dot{C}}{C} = \frac{\dot{Y}}{Y}$$

Obviously, when the rates of growth of labour and technology are zero, the steady state rate of growth of capital is zero. As this is the only accumulated factor in equation (2), the steady state rate of growth of output is also zero in the absence of exogenous growth in either labour or technology or both. However, if either labour or technology grows, there is growth in capital, consumption and income. The outcome is predictable steady state full employment growth in a competitive model. The main result of the Solow-Swan model is that technological change can be shown to bring about an increase in per capita growth.

The model's ability to show sustained per capita growth driven by exogenous technological change, but not driven by the endogenous accumulation of inputs is, according to (Arrow, 1962b), an inadequacy that is a confession of ignorance. The inability to model sustained endogenous growth driven by the accumulated input is due to decreasing returns to capital. Moreover, the exogeneity of technological change is incompatible with the neoclassical paradigm in which decisions are made in response to market signals.

1.2.3 The Cass-Koopmans model

Cass (1965) and Koopmans (1965) enhanced the theoretical rigour and intuitive appeal of neoclassical growth theory by introducing an endogenous savings function to the perfect foresight, competitive, full employment, equilibrium framework common to the Solow-Swan model. In so doing, they established growth theory as a formalised constrained dynamic optimisation problem. In the Cass-Koopmans model, savings decisions are made by infinitely-lived utility-optimising consumers subject to budget constraints. A dynamic growth model is created by linking periods through consumers' intertemporal consumption smoothing preferences. Analysis of the complex dynamics of intertemporal optimisation was made possible by the use of Hamiltonian functions and the Maximum Principle, which enable the consequences of choices to be modelled through time. The use of infinite horizon decision making has become a standard feature in subsequent neoclassical growth models.

In per capita terms the Solow-Swan production function (equation (2)) can be expressed as:

$$(7) \quad y = Ak^\beta$$

Where: lower case indicates per capita values.

The rate of growth of per capita output is therefore a function of the per capita rate of growth of capital. The standard neoclassical production function conditions apply if $0 < \beta < 1$. The rate of growth of capital is the outcome of the saving-investment decision of the utility-optimising, infinitely-lived consumers. The utility function is infinite horizon Ramsey-style with constant elasticity of substitution:

$$(8) \quad U(0) = \int_0^{\infty} e^{-(\rho-n)t} \left[\frac{c^{1-\sigma} - 1}{1-\sigma} \right] dt$$

Where: ρ is the discount rate

c is the consumption per capita

n is the growth of population, assumed zero in the following

σ is a measure of the preference for consumption smoothing overtime.

The equation for the accumulation of capital is:

$$(9) \quad \dot{k} = y(k) - c - \delta k$$

The utility maximising problem facing the social planner can be solved by constructing the Hamiltonian function shown in equation 10, and using the Maximum Principle to obtain the first order conditions for this function to attain a maximum.

$$(10) \quad H = e^{-\rho} \left[\frac{c^{1-\sigma} - 1}{1-\sigma} \right] + \lambda(y(k) - c - \delta k)$$

Where: λ is the shadow price of investment.

Applying the first order conditions, the transversality condition for the behaviour of the system in the very long run, and differentiating with respect to time yields an expression for equilibrium that implies equality between the rate of return to consumption (allowing for the discount rate and consumption smoothing), and the return on investment (that is, the marginal product of capital less the depreciation rate):

$$(11) \quad \rho + \sigma \frac{\dot{c}}{c} = y'(k) - \delta$$

If a steady state prevails, then by definition $\frac{\dot{c}}{c}$ is a constant, with constant prices and smoothing preference, so is the marginal product of per capita capital ($y'(k)$). This in turn, implies that the instantaneous rate of growth rate of capital is equal to zero:

$$(12) \quad \frac{\dot{k}}{k} = 0$$

Given constant labour supply, the instantaneous rate of growth of total capital ($\frac{\dot{K}}{K}$) is also zero. From the definition of steady state growth with constant labour supply:

$$(13) \quad \frac{\dot{k}}{k} = \frac{\dot{c}}{c} = \frac{\dot{y}}{y}$$

This no-growth steady state reconfirms the Solow-Swan finding that when the labour supply and technology are fixed, the steady state growth rate is zero. Thus, although the inclusion of an endogenous savings function based on optimising consumer behaviour succeeded in establishing growth as an optimisation problem, it did not result in a model of sustained growth because it did not overcome the

problem of decreasing returns to capital that reduces the incentive to invest. This is not to say that the savings rate has no effect on growth at all. It has level effects, but does not affect the steady state rate of growth.

Thus, the early neoclassical growth theory had two inter-related features that were later seen to be anomalous to modelling sustained per capita endogenous competitive steady state growth:

- Per capita growth was driven by unexplained exogenous technological change.
- Decreasing returns to the accumulated input prevented sustained investment in that accumulation without exogenous increases in the non-accumulated input.

Together these mean that investment decisions have no role in steady state growth, which is not only anomalous to the neoclassical emphasis on market driven decision making, but also intuitively and empirically insupportable (Wolff, 1987; De Long and Summers, 1991). According to Solow (1994) the question is: How to stop the returns to investment falling below the discount rate and so overcome investment pessimism in the neoclassical growth theory?

Sustained endogenous economic growth in the neoclassical competitive, marginalist framework requires that the marginal product of the accumulated input is maintained at an adequate level. That is, the marginal returns to capital must be bounded from below, at which point they become constant returns. The implication of constant returns to accumulated inputs is that either there are increasing returns to scale when non-accumulated inputs are also considered, or that there are no non-accumulated inputs. These alternatives have been adopted by two streams of neoclassical growth models. In one stream, Rebelo (1991) achieved sustained endogenous growth in a competitive model with only one input. That one input is accumulated with constant returns, so there is no problem of either decreasing returns to that input or monopolisation due to increasing returns to scale. In the other stream, referred to here as the new growth theories, theorists (eg Romer, 1986 and 1990; Grossman and Helpman, 1991a) have developed neoclassical growth models with constant returns to the accumulated input and increasing returns to

scale. The problems that this presents to the competitive framework have been dealt with in two ways. The first way is to introduce externalities in a rigorously competitive framework, so that the increasing returns are external to the firm but internal to the economy. The second way is to introduce limited non-competitive conditions in an otherwise competitive framework. In many examples of both these approaches adopted by the new growth theorists, growth is driven by the learning associated with technological change. These general equilibrium models that show sustained steady-state growth in the absence of increased labour and in the presence of non-accumulated inputs are the subject of the rest of this chapter.

1.3 Competitive models of learning-driven growth

Early new growth theory extensions to neoclassical growth theory sought to capture the link between technological change and growth by focussing on the externalities generated by learning within a competitive framework. The key contributions to the development of this approach are reviewed here.

1.3.1 Arrow 1962

The work of Arrow (1962a) was seminal in making the link between learning and technological change and growth, which inspired the subsequent new growth models. Arrow reasoned that the failure of the Solow-Swan model to endogenise technological change was because it missed the empirically-obvious point that the knowledge associated with technological change is continually growing as the result of production experience. Earlier work by Lundberg (1961) had presented empirical evidence that productivity grows as a result of experience-induced learning by doing. In Arrow's scenario the design of labour saving machines provides the experience that stimulates the learning by doing that leads to the design of still better machines. The lack of absolute secrecy means that knowledge spills over to create increasing returns that are external to the firm. Modelling the link between these external increasing returns and growth is Arrow's chief theoretical contribution.

In Arrow's model, a machine with serial number G uses $\lambda(G)$ labour in production. This labour intensity of production ($\lambda(G)$) is a non-increasing function of the serial number. The output capacity of the machine with serial number G is $\gamma(G)$, which is a non-decreasing function that is assumed to be a constant (a), for simplicity. The impact of learning on the labour intensity function is:

$$(14) \quad \lambda(G) = b(G)^{-n}$$

By assuming that $n=1$, Arrow imposes constant returns to the serial number and to the knowledge embodied in it. This implies exogenously determined strict proportionality between knowledge and the physical capital in which it is embodied. Embodied technology implies that $\lambda(G)$ and $\gamma(G)$ cannot change after the machine is installed. However, the new machine enhances learning by doing that spills over completely so that all firms have the knowledge to develop machines with higher serial numbers (more labour saving). Aggregate output is a function of the labour supply (L) and the serial number (G), as a proxy for knowledge:

$$(15) \quad x = aG(1 - e^{-L/b}), \text{ (if } n=1\text{)}$$

Output increases proportionally if either labour or the serial number is increased. It increases more than proportionally if both are increased. These increasing returns to scale, which result from the spillover of the knowledge, are external to the firm and so do not pose a problem for a competitive solution. The steady state common rate of increase in the serial number and output is $\frac{\sigma}{(1-n)} = \frac{\theta}{n}$ where σ is the constant rate of increase in the labour force, and θ is the constant rate of increase in the wage rate, which is the incentive to introduce labour saving machines.

Tension in the model is due to the fact that while investment in machinery is driven by the incentive to avoid increasing wages, that investment increases the wage rate

and so decreases the expected stream of returns. On-going investment decreases the rate of return until the incentive to save labour costs is inadequate to drive further investment. Thus, the growth peters out. Therefore, the introduction of external increasing returns was not enough to maintain the incentive necessary to sustain growth.

While Arrow's model is consistent with the neoclassical competitive general equilibrium framework, it challenges the early neoclassical tenet that competitive growth is optimal. The introduction of externalities from the spillover of knowledge implies that the competitive outcome is below the social optimum.

In Arrow's model the accumulation of knowledge was linked to the accumulation of the physical capital in which it was embodied. This integration of the growth in knowledge with the growth in physical capital reflects the popularity at that time of attributing growth to capital. However, the accumulation of knowledge by learning by doing is quite different to the accumulation of physical capital for two reasons. Firstly, physical capital accumulates as the result of net investment (planned) or through increases in stocks (unplanned). Learning by doing as the by-product of economic activity is neither planned nor unplanned. Romer (1986) addressed this issue by making knowledge accumulation the outcome of deliberate investment in that accumulation. Secondly, the external nature of the spillover is different to that arising from physical capital. The recipient of a knowledge spillover has the use of the actual knowledge, while the recipient of externalities associated with physical capital gets a pecuniary benefit but not the use of the physical capital. This difference was not explicitly addressed until Romer (1990).

1.3.2 Romer 1986

Romer (1986) explicitly extends both the Arrow and the Cass-Koopmans models in a dynamic growth model in which the production of consumption goods is globally convex, as a function of the accumulated input (knowledge). This global convexity is due to the assumed increasing marginal product of knowledge in production

although there are decreasing returns to R&D in the production of knowledge. Knowledge spills over to form the social stock of knowledge. The output of the representative firm is a function of the technology of the social stock of knowledge. A competitive solution is said to exist because returns to the inputs specific to the firm are equal to their marginal product. While there are constant returns to scale when only the firm-specific inputs are considered, there are increasing returns when the stock of knowledge is included. This is demonstrated by considering production by a representative firm to be a function of the knowledge held by that firm (k_i), other firm specific inputs (x_i) and the social stock of knowledge in the economy

$$(K = \sum_{i=1}^N k_i):$$

$$(16) \quad F(\phi k_i, \phi K, \phi x_i) > F(\phi k_i, K, \phi x_i) = \phi F(k_i, K, x_i) \text{ if } \phi > 1$$

Although Romer does not provide a production function, it may be assumed to be of the general form:

$$(17) \quad Y = k_i^\beta x_i^{1-\beta} K^\eta, \eta > 0$$

Where: η is the elasticity of output with respect to the social stock of knowledge

There are decreasing returns to both x_i and k_i . There are constant returns to scale if only firm specific inputs are considered, but increasing returns when the effect of the social stock of knowledge is considered (provided that $\eta > 0$). The assumption of globally increasing marginal product of knowledge from a social perspective is a much stronger assumption than that made by Arrow and results in the convex production function with respect to knowledge.

The rate of growth of knowledge is assumed to be a concave function of investment in research and the existing firm specific knowledge:

$$(18) \quad \dot{k}/k = g(I/k)$$

The evolution of the stock of knowledge function (g) exhibits decreasing returns to the accumulation of knowledge. In fact, the marginal product of additional research falls to zero implying that the knowledge function is bounded from above. The convexity of the production function in spite of the usual non-convex learning function is due to the extremely strong assumption of globally increasing marginal product of learning in production. This maintains the incentive to invest in research. 'Assuming that the increasing returns arise because of increasing marginal productivity of knowledge accords with the plausible conjecture that, even with fixed physical capital, knowledge will never reach a level where its marginal product is so low that is no longer worth the trouble it takes to do research.' (Romer 1986: 1020). The assumption of the globally increasing marginal product of learning thus prevents the erosion of the incentive to invest, so growth is sustained.

Romer (1986) is widely acclaimed as the first neoclassical model to achieve sustained endogenous growth in a competitive model with non-accumulated inputs. However, the introduction of costly research raises two related problems of replication. The first is that the fixed cost of research cannot be funded within a perfectly competitive pricing regime. The neoclassical competitive framework only considers variable costs (Layard and Walters, 1987). Marginal cost pricing provides a return to each variable input equal to its contribution to the value of production. The return to each input equals its marginal product multiplied by the quantity used in production. If there are two inputs (x_i, y_i) , each of which is variable, the output is equal to the return to the sum of the returns to the inputs.

$$(19) \quad F(x_i, y_i) = x_i \frac{\partial F}{\partial x_i}(x_i, y_i) + y_i \frac{\partial F}{\partial y_i}(x_i, y_i)$$

The neoclassical competitive framework is not suited to modelling circumstances in which fixed costs arise because marginal cost pricing does not generate rent with

which to fund them. Therefore, the fixed costs of R&D in Romer's model are unfunded.

Moreover, in an ex-post situation, if R&D has been undertaken and the knowledge is excludable, it will lead to monopolisation because knowledge provides 'intertemporal externalities' (Dasgupta and Stiglitz, 1988a), which provide the investing firm with a competitive advantage. This is not a problem with Arrow's work because the knowledge in that model is totally unappropriated and spills completely and costlessly. In Romer (1986) the presence of knowledge controlled by the firm (k_i) is indicative of the exclusion that is incompatible with sustained competition. If Romer had the output of R&D (K plus k_i) as non-rival and controlled by the firm (excludable), marginal cost pricing would no longer apply because of the monopoly power achieved through that exclusion. That is, the R&D would be funded, but competition would be abandoned. If, on the other hand, that knowledge was completely non-excludable, there would have been no violation of competitive conditions, but the R&D would be unfunded. Romer (1994) admits that his (1986) attempt to have both competition and excludability was a sleight of hand. The conclusion is that growth models with either costly learning or excludable knowledge cannot be competitive models.

Other contributions have followed Romer (1986) and Arrow in presenting growth models under conditions of competition with external increasing returns. Two that are reviewed here are Stokey (1988) and Lucas (1988).

1.3.3 Stokey 1988

Stokey (1988) presents a competitive, perfect foresight general equilibrium model in which economy-wide learning by doing, resulting from production experience, drives sustained growth. Learning does not lead to technological change as it does in Romer's (1986) model, rather technological change leads to learning as in Arrow's model. In fact, the technological change associated with the development of newly

introduced products is external to the model and apparently God given⁴. The dynamics of the model rely on the link between production in one period and the knowledge level in the subsequent period. Therefore, on the one hand, Stokey strengthens the link between technological change and growth by resting the dynamics of the model on the associated learning, while on the other hand, she abstracts from the link between that learning and subsequent technological change.

Stokey argues that as models with physical capital have not generated growth there is little lost by having no physical capital. This simplification implies that there is no saving or investment either. Again, these have been shown to only effect the level and not the rate of growth. Moreover, the absence of saving makes it unnecessary to have an infinite-horizon Ramsey-style consumption function. Stokey's consumption function has preference for quality rather than consumption smoothing. The loss of this dynamic link between the periods is compensated by the learning function that links production between periods:

$$(20) \quad k_{t+1} = h(k_t, x_t)$$

Where: k is knowledge

x is index of goods produced

The accumulation of knowledge is not a function of the sophistication of the good produced. The only restriction on the learning function is that $h(k,x) \geq k$, which implies that production can't have a negative impact on knowledge.

⁴ The simplifying abstraction that a continuum of better quality goods awaits production, initially appears to be a move away from reality. However, in practice, many designs are available long before it becomes viable to produce the goods. Contrary to the argument that monopoly rents are captured by the inventor, there is casual empirical evidence that the first mover goes broke. It is subsequent appliers of their ideas who profit Rosenberg (1982). This observation was made by Marx 'the far greater cost of operating an establishment based on a new invention as compared to a later establishments arising *ex suis ossibus*. This is so very true that the trail-blazers generally go bankrupt, and only those who later buy the buildings, the machinery, etc, at a cheaper price, make money out of it.' Marx, K., *Capital*, Foreign Languages Publishing House Moscow, cited in Rosenberg (1982).

That growth implies better quality rather than greater quantity, can be interpreted two ways. Either, the cost of producing the parcel of goods in period (t+1) with the knowledge accumulated in (t+1) is the same as the cost of producing the previous period's parcel in the previous period. Or, the cost of producing the period (t) parcel with period (t+1) knowledge is less than producing that parcel with period (t) knowledge. These are expressed as:

$$(21) \quad \int_0^{\infty} p(s, k_t) x_{t+1}(s) ds > \int_0^{\infty} p(s, k_{t+1}) x_{t+1}(s) ds = \int_0^{\infty} p(s, k_t) x_t(s) ds$$

Where: s is the particular good

p(s,k) is the total labour to produce good s with knowledge k

x(s) is the allocation of particular goods

The productivity of the fixed supply of labour is augmented by learning by doing that spills over completely. The side-effect nature of this learning means that there is no need for an incentive to invest in learning. Each good is produced with constant returns to scale. This specification overcomes two of the key problems with earlier neoclassical models. Firstly, it frees the model from the problem of lack of incentive due to decreasing returns to the accumulated factor in models with constant return to scale. Secondly, both aspects of the replication problem discussed above are avoided because there is no need to fund learning and there is no tendency for monopolisation due to the lack of appropriated knowledge.

There is assumed to be a continuum of goods of increasing technological sophistication available for production. An income constraint ensures that only some goods are produced at any time. The labour cost of producing a good is an increasing function of its quality. Therefore, the labour intensity function is effectively the production function:

$$(22) \quad \int_0^{\infty} p(s, k) x(s) ds$$

The implication is that costs are increasing with quality in any period, but decreasing with the knowledge that increases as a result of production experience over time. Costs are a decreasing function of the production experience of any firm in any period and any good.

The endogenous growth mechanism is fundamentally that learning by doing reduces the cost of production and that this enables more expensive higher quality goods to be introduced to the production basket. The technology embodied in these goods stimulates further learning by doing, and so the process continues. The rate of growth depends upon the labour intensity, prices and the dynamics of knowledge accumulation, all of which are endogenously determined. Stokey has thus developed a model of sustained growth with only endogenous variables. This has been at the loss of some realism due to exogenous technological change and the abstraction from capital.

1.3.4 Lucas 1988

Lucas (1988) extends neoclassical growth theory by introducing human capital as the driving force for growth in a competitive model that is otherwise the same as the Solow-Swan model. In particular, there is no technological change, and savings are constant. The dynamic, perfect foresight, infinite horizon model aims to address two questions. Assuming that production does not lead to human capital accumulation, but that formal education does:

- How does the level of human capital affect current production?
- How does current time allocation between production and formal education⁵ affect the accumulation of human capital?

In Lucas' model, individual productivity is a function of both the personal level of skill and the average level of skill in the economy. Total production, which is consumption plus net investment, is a function of the individual skill level of the work force (h), the proportion of time devoted to production (u), the average skill

⁵ Formal education is suggested by Lucas as one way that human capital can be increased through withdrawal from production

level of the population (h_a), the level of technology (A), and the level of physical capital (K). The simplifying assumption of identical workers means that $h_a=h$. However, the subscript is maintained to emphasise the external effect:

$$(23) \quad Nc + \dot{K} = AK^\beta (uhN)^{1-\beta} h_a^\gamma$$

Where: h_a^γ is the external effect of human capital

N is the number of workers

The rate of accumulation of human capital is a function of the proportion of time devoted to its accumulation (1-u). It is assumed for simplicity that the externality (h_a^γ) has the same accumulation function:

$$(24) \quad \dot{h} = h^\xi \delta [1 - u]$$

Where: δ is the effectiveness of time allocated to the accumulation of human capital

Lucas follows Uzawa (1965) in assuming that there are constant returns to the accumulation of human capital (that is, $\xi=1$). Therefore, regardless of the current stock of human capital, a given percentage increase in that stock requires the same effort. ‘The striking feature of this solution, and the feature that recommends his formula to us, is that it exhibits sustained per-capita income growth from endogenous human capital accumulation alone: no external ‘engine of growth’ is required’ (Lucas, 1988: 19). Thus, the specification ensures the outcome of sustained growth.

The representative household is assumed to have preferences for intertemporal consumption smoothing consistent with a Ramsey-style consumption function. This smoothing is achieved through time allocation between production and education rather than through saving. The steady state equilibrium path requires that both physical capital and consumption grow at a constant rate and that the time allocation

to production is a constant proportion. The problem is to maximise utility subject to the production function, the accumulation function and that expectations are met.

The rate of evolution of human capital is $v = \frac{\dot{h}}{h} = \delta(1-u)$, from the accumulation equation (24). If the consumers' intertemporal consumption smoothing preference is too low, there will be too much time allocated to learning and a solution is not possible. The rate of accumulation is a function of allocation of time to the accumulation of knowledge and the exogenously-given effectiveness of that time. The allocation of time is a function of the exogenous discount rate and the exogenous risk aversion. The growth of human capital increases if the effectiveness of time devoted to its accumulation (δ) increases, or the discount rate (ρ) decreases. 'Here at last is a connection between 'thriftiness' and growth' (1988: 23). The link however is via the discount rate, which remains exogenous.

The common rate of growth of consumption and physical capital and therefore total output (χ) is a function of the rate of growth of human capital (v), the externality effect, and the power coefficient of capital in the production function (β):

$$(25) \quad \chi = \frac{\dot{c}}{c} = \left(\frac{1-\beta+\gamma}{1-\beta} \right) v = \frac{\dot{K}}{K}$$

Growth in Lucas's model is driven by the accumulation of human capital even if the external effect is zero ($\gamma=0$). A positive external effect ($\gamma>0$) implies that total output grows faster than human capital ($\chi>v$). Growth is therefore driven by non-decreasing returns to the accumulation of human capital and is magnified by external effects.

The external effect arising from the accumulation of human capital does not imply the spread of knowledge *per se*. Rather, it is equivalent to the pecuniary externality arising from physical capital accumulation, as is consistent with the focus on human capital accumulation, rather than on learning.

The pecuniary nature of the externality is one of the features that distinguishes Lucas's work from the other contributions to the new growth theory reviewed here, which focus on the spillover of knowledge, *per se*. The other distinguishing feature is that there is no technological change in Lucas' model. Learning does not result from technological change, nor does it lead to technological change. Moreover, learning does not lead to more learning. The accumulation of human capital can be seen as a series of discrete events, each linked to investment in that accumulation.

In summary, the progression to this point shows an increase in the competitive rigour of the neoclassical growth theory and success in modelling sustained endogenous growth under some circumstances. There are, in various models:

- endogenous savings,
- a role for the investment decision in those models that have capital,
- sustained growth in models with exogenous technological change
- sustained endogenous growth in models that either violate replication, have exogenously granted technological change or no technological change.

1.4 Models of learning-driven growth under conditions of limited monopoly

More recent contributions have drawn these threads together to achieve sustained endogenous, steady state, growth models that neither violate replication nor rely on exogenously determined relationships between variables. This has been achieved by the introduction of limited monopoly power and non-rival inputs, which protect the incentive to invest in learning, and provide the non-convexities associated with growth, respectively.

1.4.1 Romer 1990

Romer (1990) addresses two issues arising from the accumulation process described in earlier models. One of these issues is the incompatibility of costly investment in learning, and the appropriation of benefits of that learning with the competitive

framework. That is the replication issues discussed in section 1.3.2. The other, is the distinction between externalities arising from physical capital and those arising from the actual spread of knowledge, *per se*. These issues are closely related and their solutions rely on the distinction between rival and excludable inputs. In addressing these issues, Romer (1990) discusses three premises that are based on empirical observation. These are that:

- Technological change lies at the heart of economic growth. Technological change is defined as ‘improved instructions for mixing together raw materials’ (1990: S72).
- Technological change is largely due to intentional and costly actions in response to market incentives.
- Instructions for working with raw materials are inherently different to other economic goods, in that knowledge is a non-rival input that can be reproduced at zero marginal cost.

Romer (1990) addresses the replication issues by introducing limited monopoly power to accommodate costly research and the appropriation of its benefits in an otherwise competitive framework. According to Romer (1990), monopolistic competition is intimately related to the concepts of non-rivalness and partial excludability in the generation of unbounded growth.⁶ Knowledge is said to have two elements: rival human capital that is counted by the number of years of education and non-rival knowledge that is counted by the number of designs. Non-rival knowledge creates a non-convexity in the cost function and so overcomes the problem of decreasing returns.

The potential for non-rival inputs to lead to growth is demonstrated by Romer (1990) in a correction of the (1986) argument presented above (equation 16). Output is shown to increase proportionally if only the rival inputs are increased. An

⁶ Excludability is a function of both the legal system and the technological aspects of the good. It is excludability that creates monopoly power. Non-rivalness is a purely technical attribute that implies zero marginal costs of reproduction and enables accumulation without bound on a per capita basis. The use of a non-rival input does not reduce the ability of another to use that input. It is non-rivalness that introduces non-convexities in the cost function. While these non-convexities are essential for growth, it is monopoly power, due to excludability, that provides the incentives to invest.

increase in the number of non-rival designs in conjunction with an increase in the rival inputs results in a greater than proportional increase in output. The argument is presented as:

$$(26) \quad F(A, \lambda X) = \lambda F(A, X) < F(\lambda A, \lambda X)$$

Where: A are non-rival inputs

X are rival inputs

This explanation is not without problems that are linked to the second issue arising from the accumulation process of earlier neoclassical models, discussed in section 1.3.1. That is, the degree to which learning can be treated as similar to the accumulation of physical capital. If A were physical capital, equation (26) would imply increasing returns to scale. This production function would imply proportionally more of the same output from an increase in both inputs. However, A is not physical capital, it is designs, more of which implies product innovation and a change in the goods produced. Innovation thus introduces an ambiguity that hampers comparison. The production function no longer displays increasing returns to scale in the directly comparable sense of disproportionately more of the same good. This reinforces Romer's statement that instructions are different to other economic goods.

Romer's (1990) model has three sectors, two of which, the research and final goods sectors, are competitive. The third, the capital goods sector, is subject to symmetrical monopolistic competition⁷ due to the patenting of designs used in the production of capital goods. Symmetry implies that the capital goods are neither complements nor substitutes in the production of final goods. Therefore the impact

⁷ The key features of Dixit and Stiglitz's (1977) symmetrical monopolistic competition are that

- goods are differentiated
- each good is produced by a separate firm
- the goods are neither complements nor substitutes
- goods compete for market share, but not directly
- the number of goods is large and so entry and exit do not affect prices
- adjustment to competition is via quality and so there is typically excess capacity.

of innovations on existing goods is non-trivial but non-strategic in that while they increase competition for market share, they do not create direct competition.

It is assumed that rival knowledge as human capital (H) and labour are both fixed. The rate of growth of the number of new designs (A) is a function of the learning parameter (δ) and the stock of those designs. Growth in the number of designs increases the productivity of the human capital in the research sector where there is free access by all researchers to the entire stock of knowledge. Therefore, there is an external effect from the introduction of new designs on the production of subsequent design:

$$(27) \quad \dot{A} = \delta H_A A$$

Where: H_A is the human capital devoted to research.

The production function for new designs is assumed to be a linear function of both H_A and A when the other is held constant. The assumption that the marginal product of human capital in the research sector grows proportionally with the number of designs is said to be for analytical simplicity, the stated intention of which is to focus attention on Romer's main question of how other variables in the model affect the rate of growth of A. However, this linear relationship is crucial to the model because it ensures that labour does not leave research as the number of designs grows. 'Linearity in A is what makes unbounded growth possible, and in this sense, unbounded growth is more like an assumption than a result of the model' (Romer, 1990: S84). Each design is patented and sold to a single capital goods producer. Free entry to research ensures marginal cost pricing of designs while the uniqueness of designs means that the marginal cost is the fixed cost of research.

The designs are then used to produce capital goods, the accumulation of which is equivalent to forgone consumption [$\dot{K} = Y(t) - C(t)$]. The rate at which output is converted into capital goods is a constant (η). At any time the number of capital goods is a function of this conversion rate, the number of designs and the common

quantity of each capital good that is produced (\bar{x}), that is, $K = \eta A \bar{x}$. The capital goods are then sold at a mark-up price in accordance with the elasticity of their demand curves:

$$(28) \quad \bar{p} = \frac{\eta}{1 - \alpha - \beta}$$

Where: r is the rate of interest

Quantities of capital goods are set so as to maximise profits given these prices. This mark-up provides the rent for the research costs. In equilibrium the price of designs is constant and so the excess of profit over the marginal cost must just cover the interest on the initial investment in the design. Therefore, it is the introduction of a non-rival, partially excludable input in a monopolistic structure that overcomes the problem of the incompatibility of costly R&D and the appropriation of benefits from that learning, with the competitive regime by partially abandoning the rigours of that regime. In so doing, Romer also gives a role to the rate of interest in the growth process.

Final goods are produced in perfect competition using labour, human capital and additively-separable capital goods that reflect symmetrical monopolistic competition.⁸ The production function for the final goods is:

$$(29) \quad H(Y_A, L, x) = (H_Y A)^\alpha (LA)^\beta (K)^{1-\alpha-\beta} \eta^{\alpha+\beta-1}$$

Where: H_Y is the human capital devoted to final output

η is the fixed rate at which consumer goods are converted to capital goods

⁸ If it were not symmetrical, then the capital goods would either be complements or substitutes. If they were substitutes, new capital goods would render old capital goods obsolete. There would thus be incentive to prevent the spillover of knowledge in the design sector. The assumption of additive separability simplifies and ensures that rent seeking in this model does not extend to preventing technological change.

A is the design of capital goods; it appears in the production function although it is not used directly in final goods production, because of its impact on the formation of capital

This production function exhibits diminishing returns to capital accumulation. However, the impact of increasing returns to knowledge in its dual role of producing new ideas and increasing the productivity of human capital in subsequent research means that there are increasing returns to scale even though there is no non-rival knowledge used directly in final good production.

A balanced growth path with A, K and Y growing at constant exponential rates is said to exist if \dot{A} grows at a constant exponential rate, as in the Solow-Swan model.

That happens if \dot{A} is linear in A (equation 27) and the human capital devoted to research stays constant. In balanced growth, the human capital to physical capital ratio is constant, as is the non-inflationary demand for designs. The wage in the final goods sector grows in proportion to A as does the productivity of labour in the research sector. Given that the price of new designs doesn't change, there will be no shift of labour between sectors. The steady state growth rate is:

$$(30) \quad g = \frac{\dot{c}}{c} = \frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{A}}{A} = \delta H_A$$

Romer (1990) therefore develops a model of sustained endogenous growth driven by the dual roles of learning that together imply increasing returns. The model relies on knowledge spillovers for the non-convexity in the cost function associated with growth, and monopolistic competition to provide the rent to invest in the accumulation of that knowledge. 'Both spillovers and price setting seem essential to capturing the features of knowledge in a model of growth' (1990: S89). While it is the spillover from learning that is the non-rival input that drives the growth, that learning is treated as though it were a non-rival benefit from the accumulation of physical capital. Romer regrets this. 'My greatest regret is the shift I made while

working on these external effects models, a shift that took me away from the emphasis on research and knowledge that characterized my 1986 paper and toward the emphasis on physical capital.....Looking back, I suspect that I made this shift toward capital and away from knowledge partly in an attempt to conform to the norms of what constituted convincing empirical work in macroeconomics' (Romer, 1994: 20).

Several authors have followed Romer's lead of introducing monopolistic competition and non-rival inputs to produce sustained growth. The contributions reviewed here are two models by Grossman and Helpman (1991a) and one by Young (1994). Grossman and Helpman's first model follows Romer (1990) by introducing symmetrical monopolistic competition, this time in the final goods sector. Their second, introduces oligopolistic competition in the consumer goods sector. Young (1994) presents a life-cycle model in which innovation in the intermediate goods sector are both substitutes and complements for older technology.

1.4.2 Grossman and Helpman 1991

Grossman and Helpman (1991a) present two models in which technological change in conditions of limited monopoly power lead to a sustained proportional increase in real per capita income. In both models industrial innovation is the outcome of the intentional commitment of costly resources in response to non-competitive profit opportunities. Both models have no physical capital in order to emphasize the move away from capital accumulation towards innovation.

In Chapter 3 of their (1991a) book, Grossman and Helpman present a model of increasing variety, in which sustained endogenous growth is driven by increasing returns to non-rival knowledge. In the two sector model, two types of knowledge are produced under perfect competition in the research sector. The first type, in the form of designs (n), has appropriable benefits that are protected by patents or by the costs of imitation. The second type, in the form of methods and ideas, is the general

knowledge stock (K_n) which has non-appropriable benefits. Therefore, the output of the research sector (knowledge) is both non-rival and partially excludable. The designs are used in the production of final output under conditions of monopolistic competition. The general knowledge stock is used in the production of further ideas. The production function for the designs is:

$$(31) \quad \dot{n} = \frac{L_n K_n}{a}$$

Where: n is the number of designs in existence

L_n is the labour devoted to R&D

K_n is the general knowledge stock

a is the exogenously given amount of labour required to produce a design

The impact of the external benefit from the general knowledge stock is to make subsequent learning cheaper by increasing the number of designs produced with a given supply of labour. If there was no spillover of knowledge, K_n would not appear the equation in (31) and the rate of innovation would decline.

Constant returns⁹ to the general stock of knowledge from each design ensure that the production of K_n is proportional to the number of designs (n). This proportionality means that the production function for innovation is also the production function for the general stock of knowledge if the appropriate measurement units for the proportionality set $K_n = n$. Constant returns in conjunction with the external benefit from research means that there are increasing social returns to research.

The decision to enter production in the monopolistically competitive goods market is a function of the expected rate of return. The returns from production are monopolistic profit and capital gains from the value of the firm. If the rate of return is inadequate then there will be no market for new designs and thus no increasing

⁹ Constant returns are not strictly necessary. It is sufficient that the returns are bounded from above $\frac{K_n}{n} > \bar{k} > \alpha p / (1 - \alpha)$ as n grows large.

returns to drive growth. These returns are a function of the number of varieties (n) and the consumers' utility function that reflects the households' taste for variety rather than for intertemporal smoothing:

$$(32) \quad U_t = \int_0^{\infty} e^{-\rho(\tau-t)} \log D(\tau) dt$$

Where: D is an index of consumption at time τ .

The goods enter the utility function symmetrically so that the same amount of any good offered will be consumed. As the number of goods offered increases and total expenditure remains unchanged, there is a decline in the quantity of each good consumed, but there is no obsolescence. While this reduces the expected return on subsequent designs, the cost of producing the design (wa/K_n) is a decreasing function of the number of designs and the general knowledge stock, where a is the labour in each design, w is the wage rate and K_n is the stock of general knowledge. The decision to enter the production of another variety depends on whether the costs of design are greater than its (discounted) impact on returns:

$$(33) \quad \dot{v} = \rho v - \frac{1-\alpha}{n}$$

Where: v is the value of the design to the firm

α is the preference for variety

ρ is the rate of discount

The evolution of the number of designs is a bifurcated function of the labour devoted to research, the preference for variety, the value of the designs, the number of designs existing and the effectiveness of labour in research. If there are too many designs, the value of the designs will be less than their cost and so there will be no innovation:

$$(34) \quad \dot{n} = \begin{cases} \frac{L}{a} - \frac{\alpha}{v} & \text{for } v > \bar{v}, \\ 0 & \text{for } v \leq \bar{v} \end{cases}$$

Assuming that there are not too many varieties to attract new investment in designs, the rate of growth in the GDP (G) is proportional to the rate of innovation. Here, GDP is defined as the sum of value added in manufacturing and R&D:

$$(35) \quad G = p_D D + v \dot{n}$$

So growth is dependent on innovation. The steady state rate of innovation is:

$$(36) \quad \frac{\dot{n}}{n} = (1 - \alpha) \frac{L}{a} - \alpha \rho$$

‘Sustained innovation is possible in this case because the cost of product development falls with the accumulation of knowledge capital, even as the return to the marginal innovation declines. The nonappropriable benefits from R&D keep the state of knowledge moving forward, and so the private incentives for further research are maintained’ (1991: 61-62).

In the absence of spillovers growth must grind to a halt because the rate of return will approach the discount rate. The essence is that without knowledge spillovers, the impact of the introduction of new varieties has one external effect: that of a decrease in the quantity sold of all goods. With spillovers there are two external effects: the decrease in quantity sold and a decrease in costs. With a balance between the appropriated benefits and the spillover benefits, Grossman and Helpman’s first model shows the incentive to invest in designs can be maintained. That non-appropriable benefits can sustain growth, which fully appropriable benefits cannot, is an interesting paradox

Furthermore, Grossman and Helpman show that if the diffusion of knowledge is not instantaneous, the rate of growth will be reduced. This is even though all the knowledge is eventually diffused. The introduction of a distributed lag function retards the accumulation of general knowledge, and so the rate of evolution of innovation is reduced. Equation (34) becomes:

$$(37) \quad \frac{\dot{n}}{n} = \begin{cases} k \frac{L}{a} - \frac{\alpha}{vn} & \text{for } v > \frac{\alpha a}{knL}, \\ 0 & \text{for } v \leq \frac{\alpha a}{knL} \end{cases}$$

Where: k is the ratio of the stock of knowledge to the cumulative R&D experience, which depends not only on the cumulative R&D experience, but also on the time lagged since that experience.

Grossman and Helpman's second model, as presented in Chapter 4 of their (1991a) book, demonstrates that sustained endogenous growth can be generated by the technological change associated with improved quality. There are many goods each of which is a quality level of a particular industry line. Goods in different industries enter the utility function symmetrically. Innovative activity is focussed on producing the next quality in a particular line. Each new good is a perfect substitute for a good already in the consumption basket, and as such is a direct competitor. Utility-maximising consumers spread consumption across industries by purchasing only the good that offers the lowest quality-adjusted price. Total consumer expenditure is constant and the share of each product line in that expenditure also remains unchanged.

The assumption of consumers' taste for quality ensures that only the best-value brand of each good will be consumed. The assumption of price competition ensures that the best quality good is also the best value. Therefore, oligopolistic competition exists between potential goods in each product line. Monopoly power is restricted because if the limit price is exceeded, lower quality goods will also be consumed.

This will reduce the profit earned by the holder of the state of the art patent. This imposes a significant negative externality on the usurped producers. Although this effect is anticipated, no rent seeking action is taken to prevent the spread of information. In fact, designs are freely accessed within the research sector.

All goods are produced with constant returns to scale and with constant marginal costs equal to the wage (w). Each good is priced at λw , where λ is the quality increment, and the quantity sold is $1/(\lambda w)$. The profit (π) on each good is a function of the quality increment, which is therefore an index of monopoly power:

$$(38) \quad \pi = 1 - \delta$$

Where: δ is the inverse of the quality increment λ .

The production function for innovations is couched in probability to reflect the risks associated with R&D. Committing (ai) units of labour for a period of time has a probability of (idt) of producing the next generation, and ($1-idt$) probability of failure. The assumption of constant returns to scale in the production of the probability of success implies constant marginal product of labour in research (a). This specification implies that current production does not influence the probability of developing the next generation. New comers to R&D in an industry do not have to retrace the steps taken earlier, they can leapfrog to the state of the art by inspection. Although innovators are aware that this implies their own eventual demise, they do not establish institutions to prevent the spillover of knowledge to those who will develop the subsequent generation.

Equity holders demand that research is undertaken at a level that will maximise their expected returns - that is, will maximise the difference between the expected gains from research ($vidt$) and its expected costs ($waidt$). If costs are too great there will be no research, but if costs are less than returns there will be unbounded returns.

Averaged over the economy, equity holders expect capital gains of $\dot{v} dt$ with a

probability of $(1-idt)$. On the other hand they expect capital losses of the entire value of the firm (v) with a probability of (idt) . In equilibrium, the expected yield on ownership shares must therefore equal the return on the same investment in risk-free bonds.

The rate of innovation is a function of the intensity of research:

$$(39) \quad \iota = \begin{cases} \frac{L - \delta}{a - v} & \text{for } v > \frac{a\delta}{L}, \\ 0 & \text{for } v \leq \frac{a\delta}{L} \end{cases}$$

The similarity between equation (39) and (34) suggests that the finding that growth is a function of the intensity of research is analogous to the earlier model's finding that growth is a function on the innovation rate. The intensity of research is maintained by the incentive to capture the quasi rents appropriated by the state of the art good, and to avoid the outcome of zero returns when innovations usurp the good in which shares are held.

1.4.3 Young 1994

Young (1994) presents a model of endogenous innovation, rather than growth. It is included here because of its direct relevance to the progression of neoclassical growth theory. Young posits that innovators' expectations about the net impact of innovation by others may be the most important determinant of the growth rate. Therefore, 'if models of endogenous growth are to be built around external effects, it is an issue that they must surely sooner or later, confront.' (1994: 805). The model is based on the historical observation that innovations have various impacts on older technologies. While some destroy the market for older technology by substituting for it in production, others provide opportunities for broader application in new markets and so are complements. These non-monotonic external effects are anticipated by innovators and built into their expectations of returns.

In Young's model, research into a new input also produces knowledge about a new final good that uses that input. The knowledge about the input is patented while the knowledge about the final good is non-appropriable and spills over to the perfectly competitive final goods industry. When an innovative input and its associated final good are developed they have three impacts on older technology. Firstly, the input is a substitute for older inputs in the production of final goods. Secondly, the new final good expands the market for the older inputs that it uses. Thirdly, the new final good could be either a substitute or a complement for older final goods. The expected weighting of these depends on the life cycle of the input innovation. In the initial stage of the life cycle, the input is used in new final goods, and so subsequent innovations create a market for that input although the associated new input innovation is a substitute for it. As the input's technology matures, it is used in fewer new final goods and so the substitution effect dominates. For simplicity, it is assumed that final goods enter symmetrically in the utility function due to an extreme preference for variety. While Romer (1990) and Grossman and Helpman (1991a, increasing variety model) use a similar assumption, they focus on external disbenefits arising from substitution in the expenditure function. In Young's specification with both substitution and market creating effects, if an equilibrium with only substitution effects exists, that equilibrium is unstable. The divergent paths from that equilibrium converge on a stable equilibrium dominated by complementary externalities that arise due to market creating effects.

The structure of the model has a fixed labour supply as the only factor of production. Labour is used for production and for invention of the intermediate goods. At any time, the economy knows how to produce a finite subset of inputs $[0, N]$ using N^{-1} units of labour. The accumulation of the number of inputs is a linear function of the labour devoted to research:

$$(40) \quad \dot{N} = N \frac{L_R}{a_R}$$

Where: N is number of inputs

L_R is the labour in research

a_R is the labour intensity of innovation

Final goods are produced in perfect competition with a CES production function that is similar to that employed by Romer, but with heterogeneous inputs. Input heterogeneity introduces the tension between complementarity and substitution:

$$(41) \quad Q(s) = \left[\int_{s_B}^{\min[s^\Theta, N]} x(v, s)^\alpha dv \right]^{\frac{1}{\alpha}} \quad \Theta \geq 1, 1 > B \geq 0$$

Where: s is a particular input or final good

Θ is the most advanced input used in the production of s , subsequent inventions after Θ are too advanced to be included in production of s

v is an index of final goods

B is the oldest input used in production of s , if $B=0$ then all inputs existing at the time of innovation of s are used in the production of s .

The extreme preference for variety in the additively-separable utility function ensures symmetry in the final goods market. Consumer expenditure is thus spread evenly over all final goods. This implies a dissipation in profit due to additional variety:

$$(42) \quad E(s, t) = \frac{E(t)}{N(t)}$$

where: $E(s, t)$ is the expenditure on good (or input) s at time t .

If the interest rate does not change, then the dissipation effect is exactly offset by the postponement of consumption in order to enjoy the greater variety of goods to be introduced. This leaves the expectation of consumer expenditure on each good unchanged by a change in the innovation rate. The shift of expenditure to the future due to an increase in innovation rate is shown by:

$$(43) \quad \hat{E}(t) = \dot{R}(t) - \rho + \hat{N}(t)$$

Where: R is the rate of interest

While firms find that an increase in the rate of innovation leads to a more rapid decrease in the expenditure per product, this is exactly offset by a decrease in the rate at which these associated profits are discounted. If the interest rate is flexible, an increase in the rate of innovation results in a decrease in the interest rate. So while future profit decreases when the innovation rate increases, that is offset by the rate at which it is discounted.

Demand for input v in production of final good s has a CES form:

$$(44) \quad x^D(v, s) = \frac{p(v)^{-\epsilon} E(s)}{\int_0^{\min[s\Theta, N]} p(v)^{1-\epsilon} dv} \quad \epsilon = \frac{1}{1-\alpha}$$

Where: $p(v)$ is the mark-up price of inputs $p(v)=[\alpha N]^{-1}$.

Therefore, the number of inputs is an index of the monopoly pricing power.

The partial (equilibrium) derivative of the resultant profit function gives:

$$(45) \quad \frac{\delta\pi(v)}{\delta N} = -\frac{\pi(v)}{N} - \frac{(1-\alpha)E(\Theta-1)}{\Theta N^2} + \frac{(1-\alpha)E}{N^2}$$

Where: $-\frac{\pi(v)}{N}$ is the loss of profit due to dissipation of consumption expenditure,

$-\frac{(1-\alpha)E(\Theta-1)}{\Theta N^2}$ is the loss of profit due to substitution of new inputs,

$+\frac{(1-\alpha)E}{N^2}$ is the positive effect of a new demand for v in the new final good.

Therefore, Θ is an index of the maturity of the market that determines the size of the market faced by an input innovation. If Θ is small, the market is immature and will be grown by subsequent final good innovations. If Θ is large the market is mature and the substitution effect of subsequent innovations will dominate. If it is expected that subsequent innovation behaviour will have a substitution effect stronger than the market creating effect, there will be no innovation.

1.5 Conclusion

More than three decades passed between when Solow (1956) recognised that technological change is the driver of growth and modelled per-capita growth driven by exogenous technological change, and when the new growth theorists succeeded in modelling sustained per capita growth driven by endogenous technological change. Although nobody really thought technological change was exogenous (Romer, 1994), it took several advances in theoretical and modelling tools to endogenise it as the driver sustained growth. The essential advances were the recognition that growth is an intertemporal optimisation problem, and the development of tools to model those dynamics (Cass, 1965; Koopmans, 1965); the recognition of the link between learning and technological change, and the introduction of external increasing returns associated with that learning (Arrow, 1962a); the recognition that learning is the deliberate outcome of costly investment (Romer, 1986); and the recognition that both non-rival and partially excludable inputs are necessary to create the non-convexities and to maintain the incentive, respectively, which are essential to sustained growth, and the development of tools to model those nonconvexities under conditions of limited monopoly power (Romer, 1990).

CHAPTER 2

Learning in Industry

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2.1 Introduction

There is a large body of literature on the nature and process of learning. This has been mainly developed, both theoretically and empirically, in psychology, sociology and education. Economists have an applied interest in learning and have tended to focus on the outcomes of learning rather than on its nature and process. The new growth theorists, as discussed in Chapter 1, link innovation, as the outcome of learning in industry, to growth. The importance of learning in industry warrants an understanding of the nature and process of learning that is applicable to industry.

Therefore, this chapter draws on literature from psychology and sociology to present a theoretical investigation of the nature and process of learning. The aim is to develop an understanding of the nature and process of learning that is relevant to innovation, and is applicable to the industrial context. The investigation begins

with a clarification of important terms in section 2.2. An analysis of the insights into learning in industry from the contributions to the new growth theories that were reviewed in Chapter 1 is presented in section 2.3. Section 2.3 concludes with a preliminary set of research questions. A selection of theories of learning are then considered in section 2.4 in order to develop an explanation of learning that suits innovation in industry. A summary of the key features of the accepted explanation of learning in industry is provided in section 2.5. A conclusion is provided in section 2.6.

2.2 Clarification of important terms.

The study of learning in industry encompasses many concepts including technology, technological change, innovation, learning, knowledge, the accumulation of knowledge, the spillover and diffusion of knowledge, which are also important to the new growth theories. The broad parameters of the usage of these terms in this thesis are provided here in the interests of clarity and of relevance to the study of learning industry. The interpretations are not intended as definitions, nor is it implied that they are the only interpretations of the concepts. The concept of knowledge, for instance, is the subject of broad discussions in philosophy, psychology and education. Alternative interpretations are not explored here.

Learning as used here relates to a broad range of processes leading to new knowledge, to new combinations of old knowledge, and to putting old knowledge into new heads (Johnson, 1992). Learning therefore includes the generation, discovery and development of knowledge, and its diffusion. Learning is often referred to in this thesis as the **learning process** to emphasise that learning is the outcome of a process involving decisions and choices rather than a simple event in time. The broad range of activities covered by the concept of learning is reflected in the breadth of the phenomena covered by the concept of knowledge.

Knowledge, as indicated above, is the topic of entire disciplines of study, and evades precise definition. Here a broad interpretation is required in order to relate to the range of phenomena included as learning, above. Glaser and Strauss's broad usage is followed here, according to whom knowledge includes:

'(1) facts, truths, or principles, often associated with (but not limited to) an applied subject or branch of learning or professional practice; (2) information or understanding based on validated, broadly convergent experience; (3) reliable identifiable practice, including unusual know-how; (4) an item of information that a person certifies as valid by applying one or more criteria, or tests, and (5) the findings of validated research. The knowledge may take the form of an idea, a product, a process or procedure, or a program of action' (1983: 2)

Accumulation of knowledge is another term for learning that reflects the early focus of neoclassical economists on the accumulation of capital, including the accumulation of human capital. However, the analogy of the accumulation of knowledge is, in general, limited because the nature of knowledge is fundamentally different to that of physical capital, and the way that they are accumulated is also distinct.

Technology as used here is knowledge used in the production process (Johnson, 1992). It relates to how production is done and organised as well as to the products.

Technological change is 'improved instructions for mixing together raw materials' (Romer, 1990: S72). It relates to instructions for new process and for new products.

Innovation is a novelty of economic value (Edquist, 1995b). It is the application of the outcome of learning. Innovation can be either new to an economy or new to a user. Innovation can be technical (new processes or new products), organisational (new organisations or changes to existing organisations), institutional (new

institutions or new impacts of existing institutions) or social (new relationships or old relationships with new partners). Innovation is broader than technological change as it includes institutional and organisational change as well as process and product innovation.

Diffusion of knowledge implies the spread of knowledge beyond its origin. It is therefore consistent with 'putting old knowledge into new heads'. That old knowledge, once in the new heads, may be valued and applied differently. Therefore, diffusion does not imply that knowledge is unchanged by the diffusion process.

Spillovers and externalities imply that the benefit or cost of an activity spreads beyond those who contribute to that activity. Learning poses three types of spillover benefits. One type of spillover is when the non-contributing party actually learns the knowledge that is developed. This is called the 'spillover of knowledge' in this thesis, and is a form of diffusion. The second type of externality arises when learning leads to innovation that impacts on the market for existing goods. This happens under conditions of monopoly power and imposes external benefits or costs depending on whether the innovation is a complement that expands the market for the existing or a substitute that decreases the market for the existing goods. The third type, pecuniary externalities, arises when parties that do not contribute to the cost of learning receive a financial benefit or disbenefit without actually learning the knowledge. This may be in the form of a decrease or increase in costs, and is not restricted to conditions of market power. This third type is the same as externalities ensuing from investment in physical capital.

Two points relevant to the extent, role and nature of knowledge spillovers, that is the first type of externality, warrant consideration. Firstly, some knowledge may not spill over easily due to its tacit nature (Nelson and Winter, 1982; Cohendet,

Heraud and Zuscovitch, 1993; Hall, 1994), or may require extensive prerequisite knowledge (Cohen and Levinthal, 1990).

The second argument is the degree to which the spillover of knowledge is external. That is, is not internalised within an organisation. Two issues relevant to the external nature of the spillover are that the firm may not be the appropriate unit of analysis, and that the short term may be too short to capture the strategic outcome of the spillover of benefits. The first of these issues is raised by Weder and Grubel (1993) who provide examples of how two types of private arrangements that operate in Switzerland and Japan to internalise the benefits arising from the spillover of knowledge. Those spillover benefits are then external to the firm but internal to the institutional arrangement. These arrangements are the cluster and the industry association. While Weder and Grubel do not dispute the importance of learning for growth, or the role of spillovers in that growth, they do dispute the assumption that such spillovers are not internalised - that is, that private arrangements are not made to capture them. They conclude: 'We believe that these activities of industry associations are capable of capturing for its members exactly the kinds of externalities emphasized by the NGT' (1993: 494). Two contributions associated with the new growth theories support the argument that such arrangements *could* internalise externalities. Prescott and Boyd (1987) and Romer (1993a) argue, respectively, that coalitions of colleagues and self-organising industry investment boards have the potential to 'encourage discovery and the free flow of ideas' (1993a: 356) in such a way as to internalise the spilled benefits and sustain growth (Prescott and Boyd, 1987). This is apparently at odds with Grossman and Helpman's (1991a, increasing variety model) finding that without externalities, growth cannot be sustained. However, Grossman and Helpman's finding is reliant on the institutional context in which a spillover from the firm is equivalent to an externality. Once it is acknowledge that institutional arrangements can internalise the spillover benefit, Grossman and Helpman's argument becomes that spillovers

(whether external or internalised) are essential to growth. This is not contradicted by Prescott and Boyd's finding that if internalised, spillovers can still drive growth.

The second issue relating to the external nature of the spillover is raised by Langlois and Robertson (1996) who argue that spillovers may appear to be externalities if a short term perspective is adopted, but that a more strategic analysis would indicate that the firm recoups much of those benefits. This happens when the customer develops a demand pattern to capture that benefit and this demand pattern is to the advantage of the provider of that benefit. In network industries where 'one customer's demand is a function of how many other people have already purchased the good' (Langlois and Robertson, 1996: 19) a knowledge spillover can shift the demand curve for the industry to the benefit of the original generator of the knowledge as well as for the recipients of the spillover. Active diffusion of costly and valuable knowledge may be the ideal strategy in order to develop relationships and institutions that will lock the market into that technology (Boisot, 1995). The benefits from the slipover of knowledge are thus largely internalised over time.

2.3 Learning in the new growth theories.

The contributions to the new growth theory that are reviewed in Chapter 1 are models of growth, rather than of learning in industry. As such, they focus on the impact of learning on growth rather than focussing on the learning process. Therefore, learning is specified in the models in ways that will generate growth without violating the neoclassical foundations of the models. As discussed in Chapter 1, that specification is often quite specific in order to avoid growth exploding or petering out, and supported by selective empirical evidence. An example is Lucas's specification of exactly constant returns to human capital ($\xi=1$), which is contrary to the empirical evidence that human capital is accumulated rapidly by young people, but not when they are older. This pattern could be explained in terms of decreasing returns to human capital, which would decrease

the incentive to keep accumulating human capital. However, these *apparently* decreasing returns can be explained by the finite human life span, which means that there is less time to reap the rewards of later accumulated human capital even though those rewards are *actually* subject to constant returns. The assumption of infinitely-lived individuals enables the assumption of constant returns to be made in a way that does not contradict the empirical evidence. Although the new growth theories do not focus on the learning process, the centrality of learning to their growth mechanisms suggests that the new growth theorists may have a contribution to make to the understanding of learning in industry. This section discusses the treatment of learning in the selected contributions to the new growth theories in terms of: how learning is done, why learning is done, what is learned, and the sector in which learning occurs. While each of those contributions deals with each of the learning-related issues, their treatments tend to be superficial and suggestive. In order to exemplify the schematic and suggestive nature of the treatment of learning by the new growth theorists, the learning in Arrow's model, which is treated by the literature as seminal, and is the most detailed and the most referred to by the others, is outlined first. Then follows a discussion of the treatment of learning in the other contributions to the new growth theories.

Learning in Arrow's model results from experience in designing new machines with higher serial numbers. The reason to undertake that design is to take advantage of the labour saving properties associated with machines of higher serial numbers. This incentive is reinforced by the expected exponential increase in the wage rate over time. Learning is the unintended outcome of the design experience. That knowledge spills over completely so that others are able to use that knowledge in subsequent designs of new machines. There is no learning by using those machines. There is no learning in the design process but that process creates a new environment that stimulates learning. Arrow does not deal with the learning process more explicitly than this, nor does he explain how the knowledge is diffused. Arrow's work does not explain the process and nature of learning, and it

does not bear close analysis and investigation of how the new design leads to learning and how that knowledge spreads to lead to more new designs. The other new growth theories discussed here are similarly schematic in their treatments of learning. The following summary of their treatments of learning is necessarily also schematic and superficial.

2.3.1 The learning method

Learning in the selected contributions to the new growth theories is restricted to learning by doing, research and formal education (for the accumulation of human capital). Learning by doing is a side effect that is stimulated by experience in designing better machines (Arrow, 1962a) and experience in production (Stokey, 1988). Romer (1986 & 1990), Grossman and Helpman (1991a both models) and Young (1994) have R&D as the learning method. R&D involves costly investment in a formal research process and requires monopoly pricing in order to fund its fixed costs, as discussed in Chapter 1. Lucas focuses on human capital accumulation rather than learning, and this he attributes to processes that absent the worker from production. Formal education is the cited example.

In both Arrow and Stokey, technological change stimulates learning, rather than learning stimulating technological change. Arrow introduces the nexus as technological change leading to learning to emphasize that learning stimulated by experience of a new environment. This was in contrast to earlier work by Lundberg (1961) on the role of repetition in increasing productivity. In Arrow, the learning-technological change-learning cycle is completed because the knowledge is embodied in new machines that provide the new environment that stimulates subsequent learning. Stokey has the causality from technological change to learning because technological change, in that model, is exogenously given. Once introduced, the technological change leads to cost reduction that makes the next innovation viable, and so the cycle is complete. In the models with R&D, learning

leads to technological change. In Romer (1990), Grossman and Helpman (both models) and Young this reduces the cost of subsequent learning. In Romer (1986) it increases the cost of subsequent learning, but the globally increasing returns to learning in production drive the next round of learning.

That Arrow links learning to investment in better machines, and others link learning to investment in R&D, are remnants of earlier growth models in which learning was driven by investment in physical capital. Learning is thus treated as the accumulation of knowledge, which is analogous to the accumulation of capital. The automatic link between learning and investment is modified by Grossman and Helpman's introduction of a probability distribution for success in R&D in their increasing quality model. As discussed in Chapter 1, treating learning as analogous to capital accumulation is problematic because knowledge is fundamentally different to physical capital in the way that it is accumulated and the nature of the spillover benefit. Stokey avoids these issues by linking learning to the introduction of exogenously developed technology in a model that has no capital. Lucas, by focusing on human capital and treating it as analogous to physical capital has a consistency that is not found in the other models. However, not acknowledging that human capital accumulation through formal education is learning is perhaps an evasion of the issues. Human capital also appears in Romer's (1990) model where it is counted as the number of years of formal education, but is not accumulated.

The diffusion of knowledge in all of the models in which knowledge spills over (all except Lucas) is unintended by the originators of the knowledge and is neither encouraged nor discouraged by them. The method by which diffusion happens is not generally discussed although Arrow attributes it to the lack of absolute secrecy and Grossman and Helpman (increasing quality model) attribute it to inspection of the state of the art product. This lack of attention to the process of diffusion was acknowledged by Arrow in the introduction to the 1985 reprint of his 1962 paper: 'the work should be redone with more explicit attention to the way the information

generated by experience is disseminated' (1985: 157). The lack of attention to the diffusion process is a serious omission from the models with limited monopoly power, because diffusion reduces market share (Romer, 1990; Grossman and Helpman, increasing variety model), destroys markets (Grossman and Helpman, improved quality model; Young) or creates markets (Young) for existing goods or inputs.

2.3.2 Why learning is undertaken

The reasons to learn are similarly restricted in the new growth theories. Each model presents an incentive structure to explain the learning behaviour. The learning by doing models (Arrow; Stokey) require no reason to learn because learning is the serendipitous side-effect of other economic activities that are undertaken in response to cost-saving incentives. While that activity is endogenous, the resulting learning cannot be said to be directly either endogenous or intentional. In Stokey the technological change that stimulates learning is also exogenous. In Romer (1986) R&D is deliberately undertaken directly in response to the profit motive. Learning in Romer (1986) is thus endogenous and intentional. Learning in the other R&D models is driven by monopolistic profit and returns on investment that accrue not to the learner in the R&D sector, but to the intermediate goods sector. This is the case for Grossman and Helpman's increasing quality model, except that in that case oligopolistic companies fight for survival as well as for profit. In models with monopoly power, knowledge, in the form of blueprints, is sold by the researcher at marginal cost (which equals the fixed cost for unique goods). Therefore, the incentive that drives the learning in these models relates to the investment in capital goods rather than directly to learning. Nevertheless, learning is endogenous to the models, and is intentional. The reason to learn in Young's model is strategic because of the role played by expectations about the impact of subsequent learning and innovation on profit. The accumulation of human capital in Lucas' model is driven by the incentive of higher wages linked to higher personal

human capital. Therefore, the incentive is directed at the individual who accumulates the human capital. The decision to accumulate human capital is both endogenous and intentional.

In Arrow's model, the design of better machines leads to learning. That learning enables the development of new labour saving machines. The knowledge is embodied in those machines and spills over to create learning opportunities external to the investing firm. Therefore, the learning benefit does not accrue to the investing firm. In Stokey's model the learning provides cost savings that benefit the original learner as well as the recipients of the spillover. In the models with appropriated benefits, and spillovers (Romer, both models; Grossman and Helpman, both models), learning leads to new technology in the investing firm. While the spillover of knowledge benefits others, the investing firm benefits from the appropriated knowledge as well as from the contribution to public knowledge. The spillover of that knowledge reduces costs of learning for all firms. This provides the inducement for the next round of learning.

2.3.3 What is learned

The issue of what is learned in the new growth theories is restricted to matters concerning product technology except for Stokey's model, in which product technology is exogenous, and learning leads to process technology change that saves costs, and Lucas's model in which the nature of the human capital that is accumulated is not specified but it appears to be process rather than product-related. The product technology outcomes of learning are better machines (Arrow), new capital goods (Romer, 1986), designs for capital goods (Romer, 1990), new variety of final goods (Grossman and Helpman), better quality final goods (Grossman and Helpman) and a paired new final good and input (Young). In the models with monopoly power, the focus is on innovation because of the impact of monopolistic and oligopolistic competition, which encourage product differentiation. Not only does learning in Young's model lead to a new input and final good pair, but also to

the creation of a new market dynamic that influences expectations about subsequent innovations. This strategic element in Young's model invites further development of strategy in new growth theories.

No attention is paid to the choice of what particular product or process results from the learning. The learning process appears destined to produce a given type of outcome (either process or product) the details of which are not relevant. This simplification is explained by symmetrical preferences in the perfectly competitive models, Romer (both models) and Grossman and Helpman's increasing variety model. Even Grossman and Helpman's increasing quality model, which has obsolescence, treats all goods that are the state of the art in that product range as symmetrical. In Young's model the loss of such symmetry calls for a more strategic argument about how particular innovations are chosen.

2.3.4 The sector in which learning takes place

Learning in the new growth theories is restricted to specific sectors. Learning is restricted to the capital goods sector (Arrow; Romer, 1986), the final goods sector (Stokey), the labour sector (Lucas), and the research sector (Romer, 1990; Grossman and Helpman, both models; Young).

In all but Lucas's model, knowledge spills over. The recipients of the spillover of knowledge are typically restricted to the sector in which the learning originated. The exception is Romer (1986), in which the knowledge spills from the research sector to the capital goods sector because disembodied knowledge was introduced without monopolistic appropriation institutions. In Romer (1990) and Grossman and Helpman (both models) knowledge in the form of designs is sold to a single company in the capital goods sector which learns in the sense of using the design to produce new goods, but not in the sense of developing subsequent designs. In Young, the idea for the new input is sold to a producer, while the idea for the new

final goods sector spills to the final goods sector. In the models with monopoly power, patents prevent the wider use of ideas in the capital goods sector. This does not prevent those companies from learning, but because of the assumed exclusive specialties of the sectors, they do not develop subsequent products. The lack of knowledge spillovers in Lucas's model is due to its focus on human capital which is not subject to reproduction at zero marginal costs. Nevertheless, there are pecuniary externalities in Lucas's model, and they extend to the production sector by increasing the productivity of the representative worker.

2.3.5 Conclusions from learning in the new growth theories

The contributions to the new growth theories that are analysed here can be seen to have used diverse but restricted treatments of learning and the accumulation of human capital in their models. While each has introduced a scenario that covers the practical issues of how learning is done, why learning is done, what is learned and in what sector learning takes place, those scenarios are schematic and aimed at introducing learning in a way that is compatible with the neoclassical modelling enterprise rather than at capturing the complexities of learning in industry. The schematic nature of their treatments is generally acknowledged by the authors who are focussed on modelling a specific argument rather than attempting to do so in a scenario that reflects the complexity of learning in industry. Nevertheless, together those scenarios suggest the following conclusions about the practical issues of learning (including human capital accumulation) in industry.

- Various methods of learning are relevant to industry. The new growth theories analysed here have restricted their treatment to one of learning by doing, research, or education, diffusion by inspection or lack of secrecy. While the authors typically argue that their selected method of learning is practically important to industry, none argues that there is not a range of other important methods, or that methods are not used in combination.

- Various reasons to learn are relevant to industry. Although some learning is the unintended outcome of learning in industry, other learning is the intended outcome of responses to market signals included in the model, and is therefore endogenous. The reasons to learn in the models are to seek monopoly profit, survival from the threat of obsolescence, to take advantage of strategic opportunities created by other's learning, and, indirectly, to save costs. Once again the diversity of these reasons suggests that the new growth theorists acknowledge the existence of a range of reasons to learn, but have selectively focused on reasons that suit their model. The lack of endogeneity in Arrow's model reflects the model's purpose of demonstrating learning stimulated by innovation. Therefore, it is concluded that the new growth theories indicate that learning is endogenous and undertaken for a variety of reasons that are both short term and strategic.
- Learning results in innovations of new processes, new products of greater variety and better quality, new markets and new dynamics of existing markets. The selective focus of the models on typically one innovation is consistent with their simple scenarios rather than implying that the author identifies particular innovations as uniquely worth modelling.
- Parties in various sectors learn, and that knowledge spills over more broadly. The selective focus of learning in a particular sector represents a choice to describe a particular scenario and to introduce limited monopoly power rather than to suggest that learning does not take place in the other sectors. Therefore, the reviewed contributions to the new growth theories indicate that learning and diffusion happen in any sector.

These findings are summarised Table 2.1.

However, as the new growth theories are theories of growth, not of learning in industry, these conclusions are only indications that give rise to the following

interim research questions. While the focus of the new growth theories has been on the sector in which learning happens, the relevant research question is: Who learns?, which is more general and consistent with the other three research questions.

- How is learning done in industry?
- Why is learning done in industry?
- What is learned in industry?
- Who learns in industry?

These questions require theoretical and empirical answers that are beyond the scope of the above analysis of selected contributions to the new growth theories. In search of an understanding suited to innovation in an industrial context, the next section of this chapter investigates theories of learning.

Model	Learning Method		Sector	Reason to learn or to let other learn		Innovation	What is learned
	Original	Diffusion		Initial learning	Longer term		
Arrow	Learning by doing	Lack of absolute secrecy	Capital goods	Unintended side effect	None, spillover unintended	Design of new machinery provides experience that stimulates learning	Labour saving machines
Romer 1986	R&D	Not specified	Capital goods	Cost saving	None, spillover unintended	R&D leads to innovation directly, the spillover of knowledge reduces costs throughout	New capital goods
Stokey	Learning by doing	Not specified	Final goods	Unintended side effect	None, spillover unintended	Technological change is outside the model. Diffusion suggests process innovation	Cost savings stimulated by innovation
Lucas	Absent from production (human capital accumulation)	No diffusion	Labour	Wages linked to learning	None	No technological change in the model, no knowledge creation	Not specified, education may teach process
Romer 1990	R&D	Not specified	Research	Monopoly profit	None, spillover is unintended	Central to monopoly competition, spillover stimulates next innovation as above	New design for capital good
Grossman and Helpman increasing variety	R&D	Not specified	Research	Monopoly profit (blueprint), general knowledge unintended	None, spillover is unintended		New variety
Grossman and Helpman improving quality	R&D	Inspection	Research	Oligopoly profit and survival	None, spillover unintended	Innovation is central, it accords monopoly profit and survival in the face of obsolescence stimulated by spillover	Next step up the quality ladder
Young	R&D	Not specified	Research	Monopoly profit	To exploit the expected impact of others' innovation	This is a model of innovation not growth. Learning influences expectations that lead to subsequent innovation	New input, new product and market dynamics

Table 2.1 The treatment of learning in the new growth theories.

2.4 Theoretical models of learning

This section presents a selective review of the psychology and sociology literature on learning. The review is undertaken in search of an account that is applicable to endogenous learning and innovation in industry. It is not intended as a comprehensive survey or review of the literature.

2.4.1 The instructional learning model

Thomas and Harri-Augustein (1985) provide a simple definition of learning. 'The acquisition of appropriate knowledge, skills and attributes to be measured according to publicly acknowledged standards' (1985: 1). This definition is associated with a model of learning that explains how an instructor can achieve a measurable change in the behaviour of the learner. Such behavioural theories are better described by Thomas and Harri-Augustein as theories of instruction.

In relation to the first of the preliminary research questions listed above, that is, how learning is done, learning in the instructional learning model is by instruction only. However, as the new growth theories have suggested, several methods of learning may be relevant to industry. This is supported by Malerba (1993) who presents a taxonomy that distinguishes six methods of learning in industry. Malerba's taxonomy is as follows:

- Learning by doing relates to production activity.
- Learning by using relates to the use of products, machinery and inputs.
- Learning from advances in science and technology relates to the absorption of new developments in science and technology.
- Learning from intra-industry spillovers is due to activities of competitors and other firms in the industry. This presumably would include the 'inspection' and 'lack of absolute secrecy' that are the methods of diffusion in Grossman and Helpman (improving quality model) and Arrow, respectively.

- Learning by interaction relates either to the interaction with upstream or downstream sources of knowledge such as suppliers or users, or to cooperation with other firms in the industry. The name of this method is perhaps unfortunate because it could suggest that no interaction is involved in the other methods of learning, which is not implied.
- Learning by searching relates to formalised activities (such as R&D) aimed at generating new knowledge.

Malerba's taxonomy does **not** include:

- Learning by internal interaction. The diffusion of knowledge within a firm may be similar in many respects to spillovers from an external source. This is particularly in the case of large firms with separate sections and departments.
- Learning by instruction.

Malerba's taxonomy of learning methods identifies what people are doing when they learn (learning by doing, using, interacting and searching) and the sources of knowledge (spillover and advances in science and technology). It does not explain how learning is done. Attributing learning to 'advances in science and technology', for example, does not indicate how the firm learns about such advances that are external to the firm.

Another contribution to the literature on learning methods is provided by von Hippel and Tyre (1995) who concentrate on learning by doing, which includes learning by using in Malerba's taxonomy. In a work studying the way in which learning by doing is done and how this reduces costs, von Hippel and Tyre argue that learning by doing (and using) is a method of iterative problem solving. Product and process development through learning by doing is 'more precisely, trial, failure, learning, revision and re-trial' (1995: 2). Use of machinery precipitates problem identification and stimulates reflection that suggests cost savings and stimulates

learning. Learning changes the environment and imposes a degree of instability that may result in continuous problems arising. This 'never getting it right', as von Hippel and Tyre refer to it, suggests strongly that innovation as the result of learning by doing may be a continuous process. Von Hippel and Tyre emphasise the link between production experience and learning outcomes. They then assume the application of that knowledge in the production process. However, in industry it may be that the user of the machine has no incentive to solve an identified problem, or has no authority to do so and has no appropriate interaction with those with that authority. Moreover, the perceived incentive structure may lead the machine user to identify a slow machine as an opportunity rather than as a problem. Such institutional impacts on learning suggests that how learning is done is integrated with issues of what is learned and why it is learned. This complexity is not addressed by the instructional learning model or by von Hippel and Tyre.

In addressing the second question of why learning is done, the instructional learning model is driven by the instructor, who also sets both the content and the method. The learning is not necessarily intended by the learner and is not endogenous to the learner's context.

In addressing question of what is learned, the instructional learning model is limited to that which is taught. Knowledge is unchanged through the learning process. In fact, a modification of the knowledge by the learner indicates that the process has failed. There is no mechanism by which new knowledge and innovation is generated. Silverberg (1990) describes such models as linear because they assume a linear progression between three distinct stages: invention, innovation and imitation/diffusion. The technology is not changed in this progression once it is invented.

In addressing the question of who learns, the instructional learning model identifies the learner rather than the instructor. That is to say, it is predetermined who will

teach and who will learn. Although several authors (eg Rogers, 1982; Triandis, 1971) offer considerable insight into the importance of the relationship between the learner and the instructor for the success of the instruction, the fundamental nature of the relationship is fixed by the dichotomy of roles between the learner and instructor.

The instructional learning model thus addresses all four of the practical issues raised by the treatment of learning in the new growth theories that formed the basis of the interim research questions. However, it does so in ways that are inadequate to explain learning and innovation in industry for four reasons. Firstly, only learning by instruction is included. Secondly, the learning is imposed by the instructor rather than being the deliberate and endogenous response to incentives. Thirdly, there is no innovation in the model. Fourthly, the learner is simply the person who is taught.

2.4.2 Creative learning

The essence of the inadequacy of the instructional learning model to explain intentional learning and endogenous innovation in industry is that the learner is the passive recipient of knowledge that is unchanged in the learning. Two models that give a much more active role to the learner, and focus on the innovative nature of learning are Thomas and Harri-Augustein's (1985) model of conversational learning, and Bandurra's (1977) model of observational learning. Learners in these models consciously organise their own experiences, define their learning purposes in relationship to available resources, and act in order to achieve changes that they value. Thomas and Harri-Augustein offer an alternative definition of learning: 'the construction, reconstruction, negotiation and exchange of personally significant, relevant and viable meaning' (1985: xxiv). The creation of a new mental construct by connecting two known but previously unconnected mental constructs to form a single new construct, that is bisociation, is an important aspect of creative learning

(Koestler, 1964). These models are termed 'creative' in this thesis to emphasise the fact that the knowledge may be modified, recreated or reinvented in the learning and diffusion process. Bandurra's and Thomas and Harri-Augustein's works are considered in combination here as the creative learning model. This model focuses on the cognitive learning process and so emphasises issues relevant to how learning is done, and to a lesser extent, why that learning is done.

In addressing the question of how learning is done, the creative learning argues that the cognitive learning processes are conversational and observational. In Thomas and Harri-Augustein's model the learning is conversational. Conversation uses the synergy from the contribution of knowledge from all parties to create knowledge that the parties individually value. Conversation has a dual nature. 'We reflect to ourselves as well as exchange with others, so that two conversations, one internal and one external, seem always to be taking place' (1985: xix). The conversational nature of learning is an important component in all of the methods of learning in industry identified above. Learning by doing and using, as explained by von Hippel and Tyre, are iterative processes based on reflection. Learning from advances in science and technology relies on verbal conversation and symbolic conversation as reading. Learning from intra-industry spillovers could be through conversation or through inspection. Learning through interaction and instruction are conversational. Learning by R&D is largely conversational, which is both reflection and external conversation. While conversational learning is important to all these methods of learning, they are not entirely conversational. The element of these learning methods that is not due to conversation is due to inspection or observation. Bandurra (1977) argued that learning is due to observation and modeling. Observation leads to learning because it suggests alternatives that may be of value to the observer. Learning by observation ranges from learning from a glance that suggests alternatives, and learning by imitating and modifying the complex behaviours of another person or mentor. A novice surgeon, for example, observes many surgical procedures before being allowed to practice. Observation

also teaches about the consequences of the modelled behaviour. Modeling is creative when imitation leads to innovative applications or, when an individual integrates elements observed from several models into an innovation. Together, it is argued here, the conversational and observational models of learning explain all the learning methods.

In addressing the question of why learning is done, learning in the creative learning model is driven by the learner in response to perceived values. The learner determines what to learn by firstly using internal referents to assess the validity and viability of new knowledge. This assessment is the basis of the selection of knowledge. Then, the individual monitors, constructs and reconstructs personal meaning over time in response to their changing knowledge. This then influences how they assess subsequent knowledge.

The creative learning model does not directly address the question of what is learned. While learning is deliberate and endogenous to the perceived values, the subject of that learning is not a focus of this model. However, it does acknowledge the complication that what is learned is not only influenced by the perceived value, but also by the accumulated knowledge of the learner. Therefore, the learning outcome from an apparently common experience will differ between learners because the process of 'construction, reconstruction and negotiation' will not be same. Thomas and Harri-Augustein offer the example of a public lecture. The infinite array of possible interpretations means that individuals take different knowledge and experience away, and in the future will have different histories and values that determine their search for the next learning-experience.

The creative learning model addresses the question of who learns by emphasising the social nature of learning. Relationships are essential to enable the learner to access potential knowledge and to assess its value in order to make a learning decision. The learner selects to learn from particular sources that it values. That

value is based either on previous experience with that journal or from comments from others with whom the individual has a learning-related relationship. The creative learning model is relevant to the learning group or organisation. The learning group can be seen in two complementary ways. It can be a locus of learning individuals, or it can be that the group itself learns in the sense that 'its behaviour changes in valued ways (and) its capacity to attribute meaning to people, things or events changes in valued ways' (Thomas and Harri-Augustein 1985: 283). The individual member's learning is influenced by the group, and influences the group in turn. The important issues for the organisation are whether members understand one another, whether those with common interests and complementary knowledge can find each other, and whether the total mind pool of members' knowledge can be harnessed to develop a valuable shared knowledge.

Thus, the creative learning model explains intentional learning in a social context that highlights the importance of social relationships for valuing and accessing knowledge. Moreover, that learning is driven by the learner who modifies knowledge in the learning process in order to achieve desired values. Learning is, therefore, essentially social and innovative. However, the creative learning model does not consider limitations on the interaction between parties and the impact that this would have on learning. Nor does it explain what determines the value of knowledge. It therefore does not adequately explain the determinants of what is learned. According to Latour (1987), these issues require an understanding of the dynamic and strategic nature of learning in industry as well as its social and creative nature.

2.4.3 The translational learning model

The strategic determinants of the selection of knowledge are emphasised in the translation learning model of Callon, Law and Rip (1986) and Latour (1987). The translational learning model focuses on long term strategic reasons to learn rather

than on the cognition of the learning process, and so complements the creative learning model. The basic argument is that learning and innovation are change, and that to understand that change it is necessary to understand the forces for and against change. Those forces develop because statements of knowledge are either complements or competitors for one another¹. Some knowledge is competitive in that two statements cannot be accepted at the same time. The choice to learn or accept one statement is a choice not to learn its competitor. If analog technology and digital technology are competitors, for example, the choice to develop digital technology may be a choice not to develop analog. Other knowledge is complementary in that one statement increases the value of the other. An example would be that the value of knowing how to make analog components is increased if someone has the complementary knowledge to use analog technology. The value of a statement is determined in combination with other statements in the social context in which it occurs. That social context is comprised of relationships between parties who seek to build the value of the knowledge that they accept, and institutions that limit the ways in which parties interact and the learning that they undertake. These institutions have historical roots as well as current influences from the market and the technology.

Those who accept competing statements become associated with power bases that compete for control of future learning and innovation. Acceptance of a statement has an external effect because as it becomes more widely accepted, the statement gains more value and power to influence which statements are subsequently accepted. As the statement moves closer to being generally accepted and the associated technology to being the standard, competing technologies fail and are forgotten. The firm's strategic choice of whether to diffuse its knowledge or to create institutions to prevent that diffusion can be understood in the light of that external effect (Boisot, 1995). In industries that are subject to technological path

¹ A feature of the language of the translational learning model is that a piece of knowledge is referred to as a statement. Accepting a statement implies learning.

dependencies, behaviour in one period is dependent on activity in the previous period. Thus, having a statement accepted earlier increases its prospect of becoming generally accepted. More extreme are industries in which technological 'lock in' arises when a set of conditions makes it difficult to move from one period to another in more than a narrow range of ways (Hall, 1994). The firm will commit resources to promote its technology and to develop relationships and institutions to control them so that the value of its knowledge is enhanced and maintained over time. The firm must identify the key players, how they can be interested in the firm's technology, and if possible how to have them develop complementary technology that will reinforce the value of the firm's knowledge. This means understanding the key players' strategic goals, their perception of their context including the institutions that determine their behaviour, and the relationships that give value to their knowledge.

The focus on the relationships and institutional context that determines the strategic aspects of learning is the great strength of this model for application to industry. Whereas the creative learning model assumes that a problem or opportunity exists and that learning is undertaken consequently, the translational model argues that the identification of a problem or opportunity can only be understood within the context of the other knowledge held and the relationship between those who hold that knowledge. Moreover, the availability of knowledge is limited by the learner's relationships, which are partly determined by the value of their knowledge. Applying the translational model to industry allows an appreciation that a trajectory is created by the interdependence of the market, the technology, the history and the institutional context. Therefore, consideration of what to learn cannot be separated from consideration of why learning is done.

The translational learning model does not directly address the question of the method by which learning is done, other than to emphasise the importance of interaction.

The translational learning model argues that questions of what is learned and why it is learned are integrated and can only be understood together. The issues of what is learned and why it is learned are embedded in the social context of the relationships and institutions that not only enable knowledge to be accessed and assessed, but also imbue that knowledge with value. The selection of knowledge is a dynamic longitudinal issue that not only impacts on the learner's position in the industry, but also influences the path for subsequent learning.

In addressing the question of who learns, the translational learning model emphasises the centrality of the social context to the learning process. It does more than facilitate learning; it provides the reason to learn and determines what is learned. Learning and innovation are not only creative in the technological sense, but also in the social sense. By altering the value of knowledge held, knowledge changes the relationships and creates new ones. This changes the dynamics of the industrial process and influences the path of subsequent innovation.

This focus on the social context of learning suggests a departure from the treatment of learning in new growth theories, which, consistent with neoclassical theory generally, lack an institutional content. As the social context has been argued theoretically to be central to learning, it appears that the fourth research question should be changed to focus the investigation on that context. Therefore, the fourth preliminary research question becomes: What relationships and institutions impact on learning in industry?

Combining the creative learning model with the translational learning model marries the creative learning model's focus on how learning is done with the translational learning model's focus on the integrated issues of the selection of knowledge and the reason to learn within a dynamic and strategic framework.

2.5 Conclusion

The analysis of the treatment of learning in the new growth theories indicated that though their treatments were diverse and schematic, they suggested four practical issues of learning in industry that required theoretical and empirical explanation. The investigation of selected learning theories yielded an explanation of learning that suits the innovative, strategic and social nature of learning in industry. The following summary of the key features of that explanation relates to the preliminary research questions. However, while each of these is referred to separately here, it is important to appreciate their interconnectedness, which implies that none can be fully understood in isolation from the overall context that is learning in industry.

How is learning done?

The learning process involves conversation and observation, both of which are social activities. The eight identified methods of learning (learning by doing, using, internal interaction, external interaction, searching and instruction and learning from science and spillovers) involve conversation and observation in various situations and in conjunction with various activities. The conversation and observation not only transmit existing knowledge, but also stimulate new knowledge. Therefore, diffusion is part of the process by which knowledge is generated. Relationships are important for all methods of learning because they enable knowledge to be accessed.

Why is learning done?

Learning is driven by the learner in order to capture short term and strategic values. It is therefore both deliberate and endogenous. Those values are determined by relationships and the institutional structure. Learning is undertaken in part to enhance relationships that will increase the value of existing knowledge.

What is learned?

The choice of what to learn depends on the value of knowledge, which is determined by the social context in which it is applied. The choice of what to learn can only be understood in the social and institutional context that provides the reason to learn. Learning is creative and the outcome is innovation. That innovation can be process, product, social or organisation.

What relationships and institutions influence learning in industry?

Learning is essentially social and relies on relationships between parties that not only give access to knowledge but also imbue it with value. Parties are not free to interact with any other party nor are they free to choose what to learn. Rather, their learning is restrained by institutions within society, the market, and the accumulated technology. Together relationship and institutions comprise the social context of learning. However, what relationships and institutions are important to industry is not indicated by the theories.

Without an understanding of the relationships and institutions that are important to industry it is not possible to understand the strategic interrelatedness of the practical issues of the how, the why and the what of learning. Therefore, the relationships and institutions that are important to industry are investigated in Chapter 3.

CHAPTER 3

The Social Context of Learning in Industry

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3.1 Introduction

The investigation of the nature and process of learning, which is presented in Chapter 2, concluded that in order to understand the practical issues of learning in industry it is necessary to understand the context in which that learning is undertaken. Relationships and institutions, which are central to that context, are the subject of a body of literature in economics. That literature comes largely from the evolutionary or institutional approach to economics which argues that individual behaviour is conditioned by the context in which it occurs. Therefore, an understanding of that context enhances an understanding of that behaviour.

This chapter investigates the institutions and relationships that comprise the social context of industry in order to understand learning and innovation behaviour. Firstly, institutions are introduced and discussed in section 3.2. Then, relationships

are introduced and discussed in section 3.3. Specific learning-related relationships and the institutions that regulate them are discussed in section 3.4. The national system of innovation approach, which argues that these relationships and institutions form part of a broader system that determines the rate and direction of learning and innovation, is introduced in section 3.5. A conclusion that sets out the final research questions is provided in section 3.6.

3.2 Institutions

Institutions take a variety of forms in the literature ranging from Williamson's (1975) concentration on the legal system to Sjostrand's (1993) emphasis on society's shared norms. According to Edquist and Johnson (1995) institutions may be described in terms of the following continuum:

- Formal (such as Government policy and codes of conduct) or informal (such as work norms and norms of cooperation).
- Basic (such as property laws) or supportive (such as norms of exchange and accreditation)
- Hard (a protocol that can never be broken) or soft (a normally adhered to guideline).
- Macro (such as a national professional protocol on knowledge sharing) or micro (such as an agreement between colleagues).

The definition of institutions that will be used in this thesis is in accord with this range and relies on the work of North (1991) and Sjostrand (1993). Institutions are humanly devised regulators of behaviour that limit the set of choices available to individuals and groups¹. That institutions regulate behaviour does not imply that they are simply constraints on choices and behaviour. While institutions may present barriers to some relationships and activities, they provide opportunities and incentives for others. An example is that learning-related interaction between colleagues may be encouraged and facilitated by seminars and journal publications,

¹Institutions are distinct from organisations, which are structures with explicit purpose such as firms, universities and professional associations (Edquist, 1995). North (1991) draws the analogy that the organisation is the team and the institution is the rules of the game.

while learning-related interaction between competitive firms may be banned by anti-trust laws. Not only do institutions regulate relationships and behaviour, but also the relationships and behaviour that they regulate shape the institutions (North, 1991; Giddens, 1984; and Sjostrand, 1993). This mutual determinism also applies to institutions and economic activity, 'current institutions influence the nature of current economic activity which in turn influences subsequent institutional forms' (Sjostrand, 1993: 760). Once this complexity is recognised, and it is acknowledged that, as discussed in Chapter 2, the social context creates knowledge and gives it value, institutions can be interpreted as channelling the development of knowledge, rather than as restricting it.

Nevertheless, there is considerable debate as to whether institutionalised behaviour is rational when breaking with the institution would result in a preferred situation. According to Sako, 'economists are prone to regard norms which are not consistent with one's self-interest as constraints. But norms are also capable of being the base for committed action' (1992: 17). Olson (1965) asked how commitment to institutions can be achieved when they are manifestly contrary to rational choice. His answer was that such commitment cannot be achieved if actors are self interested and rational unless there are selective incentives to prevent free riding. Myhrman (1994) disputes this by pointing out that Olson discounts the regulatory power of institutions because he ignores relationships and deals only with one shot interaction. When games are repeated, actions are remembered and so trust and reputation are important. That is, institutions regulate behaviour when repeated interaction has developed into a relationship.

3.2.1 The functions of institutions

According to North (1991) institutions provide information about how parties may be expected to behave. This provides a stable structure for interaction by allowing rules of behaviour to be established, enforced and predicted. Economics, as the study of the behaviour of economic agents, either individually or in aggregate, assumes the predictability of that behaviour. The importance of predictability in

economic theory was discussed at length by Marshall (1920). He wrote that economists 'deal with man as he is: but being concerned chiefly with those aspects of life in which the action of motive is so regular that it can be predicted and the estimate of the motor-forces can be verified by results, they have established their work on a scientific basis' (1920: 27). The more predictable the behaviour, the greater the predictive and explanatory power of the theory. Although neoclassical economics concentrates on the regularity of behaviour in response to price and quantity signals, there are other regular responses that Marshall called 'normal behaviour' and that others have called 'institutions'. One value of this regularity of behaviour is that it is a source of information. As Schotter says:

'Economies contain an information network far richer than that described by a price system. This network is made up of a whole complex of institutions, rules of thumb, customs and beliefs that help to transfer a great deal of information about anticipated actions of agents in the economy' (1981: 118).

The information in these institutional rules reduces problems of uncertainty and so enhances learning and knowledge exchange (North, 1991). The reduction in uncertainty enables problems to be solved. According to Ullman-Margalit (1978), there are three types of problems that may be solved by institutions: problems of coordination, problems of the prisoner dilemma type, and problems of inequality preservation. To these three, Schotter adds problems of a cooperative game type, each of which can be solved by relying on the information contained in the institutions. This information allows novices in each problem situation to act and predict the behaviour of others as though experienced (North, 1991).

Edquist and Johnson (1995) argue that institutions may promote (or retard) innovation by enhancing (or blocking) communication and interaction. The argument is that innovation results from interactive learning and that institutions, by regulating communication and interaction, affect both the rate and content of innovation. Institutions affect communication and interaction between parties to industry in three ways. Firstly, as conduits for behaviour-related information they

reduce risks of exchange and the information burden on economic agents. Secondly, institutions are valuable in the control and regulation of conflicts that arise from the change associated with innovation. Edquist and Johnson argue that 'an institutional set-up which effectively redistributes the costs of change and compensates the victims also supports fast rates of innovation' (1995: 23). Thirdly, institutions promote innovation by determining the rewards and punishments of economic life that provide incentives for interaction and communication. Included here are pecuniary institutions such as wage schemes, taxes, rules of inheritance and property rights to knowledge that affect the appropriation from innovation and interaction. Incentives that encourage opportunistic behaviour may affect the level of trust and so alter the level of cooperation and the flow of knowledge. Institutions thus simultaneously provide information, influence the generation of knowledge, give value to that knowledge and provide a social structure in which that knowledge can be used.

While some institutions may be intended in their context (for example, by a conservative authority) to retard innovation by blocking information, magnifying conflict over change, and punishing innovators (Edquist and Johnson, 1995), such impacts may also be the unintended outcomes of institutions with other purposes. This may occur for as least three reasons. Firstly, the unintended outcome may be the side effect of curtailing interaction for some other purpose. Examples of this are company norms that prevent line workers accessing senior management in order to prevent interruption, and anti-trust laws, both of which have costs in terms of interaction forgone. Secondly, the institution may be outdated, but still adhered to. An example would be the reluctance of a manager to type even in the age of computers. Thirdly, it may be that providing a privilege to one group constrains another. An example would be a practice of sharing information with domestic companies but not with foreign companies.

3.2.2 The regulatory role of trust in industry

The importance of trust in relationships is a recurring theme in the literature. While at one level, trust is an affect with emotional connotations, at another level it can be conceptualised as an institution because it regulates behaviour. Although the literature does not necessarily explicitly discuss trust as an institution, it is included as such here. The lack of anonymity between parties and the strategic nature of relationships make trust important to industrial activity. 'A reputation of trustworthiness is not just tangential to a good economic system: it is a commodity intentionally sought by - and a constant concern of - any one who aims at such' (Gambetta, 1988: 233). Sako (1992) finds that three kinds of trust are important to achieving commitment to exchange relationships. These are:

- contractual trust that both parties will keep promises.
- competence trust that both parties will perform their roles competently.
- goodwill trust that both parties will respond to opportunities to improve performance in the absence of explicit promises (contractual trust) or professional standards (competence trust) - that is, a commitment to take initiatives to benefit both parties and so enhance the relationship.

Trust can be a self-serving, and reciprocity building phenomenon that enables parties to develop expectations with confidence. Trust increases one's vulnerability to another's behaviour, which is not under one's control, and which may produce regrettable outcomes if that trust is abused (Lorenz, 1988). Trust only applies in situations in which it is possible to avoid that risk by choosing not to engage in the associated activity or interaction.

Gustafsson (1990) argues that asset-specific investment, which is innovative because it implies the investment in an asset that is unique to a specific transaction, is protected by trust and credible commitment:

'Whereas credible threats are designed to deter rivalry, those who make credible commitments are attempting to support exchange. Different investments will be made, better prices will obtain, and transactions will proceed more smoothly if cost-effective

credible commitments are made in support of asset-specific exchange' (Gustafsson, 1990: 15).

This is in contrast to the works of Williamson (1985) and Dasgupta (1988), who concentrate on the need to rely on contracts that create credible threats to protect asset-specific investment from opportunism. Without such credible threats, the investment in innovative assets that are specific to a particular transaction would be subjected to unacceptable risks. This is because there is no trust in exchange relationships, 'instead of commitment and trust there is malfeasance: a full set of ex ante and ex post efforts to lie, cheat, steal, mislead, disguise, obfuscate, feign, distort and confuse' (Williamson, 1985: 251). According to Alter and Hage (1993), Williamson's transactional cost approach is relevant to low-tech firms. Asset-specific investment in high-tech firms is argued by Lorenz (1988) to require a mechanism by which firms trust one another in order to develop technology over time rather than relying on threats specific to a single transaction. Hosmer (1994) argues that the increasing technological complexity and the pace of technological change mean that firms need to expand their trust relationships beyond the firm to external parties with complementary knowledge.

3.3 Learning-related relationships

Relationships are links between parties that enable those parties to specify roles and to capture and manage the strengths associated with those roles. These links are not instantaneous and anonymous, rather they continue over time to form stabilised interaction between selected and known parties. Maximising behaviour by a party to a relationship implies acting so as to improve their own status in the relationship, and also to improve the status of the relationship *vis a vis* third parties. Whether personal status or the status of the relationship is emphasised depends on institutionalised social norms (Sako, 1992). Relationships are important to innovation because innovation is not undertaken by companies or individuals in isolation, but rather:

'its initiation, formulation and diffusion depends on complex interactions between individuals and groups of people in the science-base and research organizations, firms acting as vendors, customers, partners and competitors, and the changing demands of governments and individuals as customers and regulators' (Dodgson, 1993: ix).

The literature identifies various reasons to form learning-related relationships. Two reasons are that, as discussed in Chapter 2, knowledge that does not spillover easily can be accessed within such relationships, and that the externalities associated with learning can be internalised by such relationships. Other reasons identified in the literature are to share costs of R&D (Dodgson, 1993), to exploit 'cognitive economies of scope' generated by the convergence of previously distinct technologies (Nooteboom, 1996), to share risks and uncertainty of R&D (Casson, 1995), to increase speed to market (Dodgson, 1993), and to create technological standards (Dodgson, 1993; David, 1993).

Learning-related relationships also have significant costs, which suggest that if the knowledge and the associated industrial power were available elsewhere at a reasonable cost, learning-related relationship would be avoided. The costs of being in relationships include resources committed to that relationship and opportunities foregone in order to establish a trustworthy relationship (Gambetta, 1988). The BIE (1995a) found that more than 50% of the surveyed high-tech firms operating in Australia gave the cost of maintaining learning-related relationships as a problem, and that 32% of such high-tech firms cited such costs as the reason for failure of learning-related cooperation agreements.

Relationships may be bilateral or may extend to a network of parties each involved in several relationships. The interconnection of relationships means that parties may be related directly or indirectly through intervening relationships. The complexity of the interconnectedness of relationships in industry makes the study of those relationships difficult. However, as Carzo and Yanouzas (1967) argue, the problem of complexity due to interconnectedness should not discourage investigation. A

great deal can be learned by parsimoniously focusing on a limited number of relationships and investigating their links and regulators.

3.4 Specific learning-related relationships and institutions

This section discusses learning-related relationships and the institutions that regulate them and the associated learning as identified in the literature. These relationships are within the firm and between the firm and external parties.

3.4.1 Intrafirm learning

The two most important institutions for determining the degree of generation, introduction and exploitation of technology within a firm have been argued to be the culture of the firm and its emphasis on learning, and the structure of the firm and its appropriateness for learning (Stoneman, 1995). These institutions are interdependent if the overall attitude to learning affects and is affected by both the culture and the structure of the firm. The company culture not only influences the conditions under which workers interact with one another, but also creates a common knowledge and protocol that eases communication, clarifies incentives and generally economises on bounded rationality (Creme, 1990). The stronger the introverted focus on establishing the common knowledge of the culture, and on developing the distinctive nature of that culture, the less encouragement there is to focus outside the firm, and the more difficult it is to communicate and learn from outside the firm. The importance of absorbing knowledge from outside is stressed by Cohen and Levinthal:

‘The cumulateness of absorptive capacity and its effect on expectation formation suggests an extreme case of path dependence in which once a firm ceases investing in its absorptive capacity in a quickly moving field, it may never assimilate and exploit new information in that field, regardless of the value of that information’ (1990: 136).

The impact of the structure of the firm on its ability to learn and to exploit knowledge is investigated by Solvell and Zander (1995) and by Weder and Grubel

(1993), respectively. Weder and Grubel concentrate on the advantages of multinational corporations and conglomerate structures in exploiting the zero marginal cost of reusing non-rival knowledge. Solvell and Zander argue that while ideally a multinational company can structure its operations in order to locate each activity in an environment that will enhance the learning specific to that activity, such a company runs the risk of not being an 'insider' in each location. The 'insider' firm has good connections, common institutions and long term experience with key economic agents, and is better able to innovate because it can harness the advantages of social norms through continuity and long-term relationships, well-established local networks, movement of employees across firms, quasi-family ties between firms, interlocking directorates, institutions for linking people and ideas, common language and symbols, and trust.

Aoki (1985 and 1990b), in a study of relationships internal to Japanese firms, found that innovation is served by relationships that foster participation and by intimate horizontal communication between divisions. Repetition, on the other hand, is better served by relationships and institutions that foster bureaucratic compartmentalisation of fixed functions such as in hierarchical firms with vertical communication of problems (up) and instructions (down). These innovation-enhancing relationships are said to be the same as those of the learning company. The learning company is one that organises operations so as to encourage learning by workers and captures that learning to facilitate subsequent learning. The costs of becoming a learning company include the fact that a large proportion of workers' time is devoted to communicating and processing information, and that learning is directed to improving communication skills and learning skills rather than to developing expert specialist skills (Aoki, 1985 and 1990b). Eliasson (1994a) argues that with appropriate institutions, workers' knowledge and competence can be harnessed, and the firm become a learning firm. 'What is more important than research, therefore, is the problem of writing effective labour market contracts that provide the right incentives for labour to perform and to reveal their competences, and promote flexibility' (1994a: 9).

3.4.2 Interfirm learning

The literature on relationships between firms identifies, among others, exchange relationships between supplier and customer, relationships between competitors, and other relationships, such as clusters, that exist between firms regardless of whether or not they are connected through the market.

3.4.2.1 Exchange relationships

Exchange relationships with exacting customers or innovative suppliers can be the most important stimulus to innovation. 'Sophisticated, demanding buyers provide a window into advanced customer needs; they pressure companies to meet high standards; they prod them to improve, to innovate, and to upgrade into more advanced segments' (Porter 1990b: 79). Although Eliasson (1994a) argues that simple (non-strategic) exchange relationships can lead to technological change, others argue that long-term, stable relationships promote innovation. Hallen, Johansson and Nazeem (1987) found in a study of innovation and relationships between companies in Scandinavia, that the degree to which a firm innovates in order to adapt to another firm's interests is explained by the degree to which it depends on that other firm.

The work of the Uppsala group (including Sharma, 1993; Snehota, 1990; and Gadde and Hakansson, 1994) refocuses the argument by positing that learning is the reason to engage in exchange, rather than the side effect of exchange. Exchange activity is undertaken to learn and to enhance status in a relationship more than for profit in the conventional sense. When knowledge is the key resource, and that knowledge is changing rapidly along with technological change, then the desired exchange relationship is that which offers greatest flexibility and heterogeneity of knowledge (Sharma, 1993). A network of stable exchange relationships between autonomous actors who are deliberately positioned and committed to exchange with only selected others, is said by Sharma, to provide the maximum flexibility and heterogeneity. The act of exchange, or even the preparation for exchange, provides learning opportunities that make the parties more attractive to further relationships

(Snehota, 1990). Parties to a network devote resources, not only to the current transaction, but also to gaining a comprehension of the network structure in order to identify that knowledge which will promote their status in the network, and the status of the network (Hakansson and Johansson, 1993a; and Snehota, 1990). A higher status in the network increases the value of the firm's knowledge. An innovation by a low status firm may be rejected by network members regardless of its superiority (Hakansson and Eriksson, 1993). The path of technological change is therefore dependent on the network position of parties. In order to maximise their status, firms must innovate and develop knowledge that is of value to other network members, they must be seen to do this, and they must be trusted to continue (Hage and Alter, 1991). Hakansson and Eriksson in a study of 123 small to medium Swedish firms concluded that: 'a company's achievements in technical development; in getting incentives and ideas to innovation; in pursuing development in a resource-efficient way as well as in getting innovations accepted, will ultimately depend on the network and the opportunities and obstacles it provides' (1993: 31).

3.4.2.2 Relationships between competitors

Learning-related relationships between competitors are contrary to the usual understanding of competition. An important question is: Why share knowledge with competitors when the costs and risks include the loss of autonomy, loss of technological superiority, loss of exclusive monopoly advantage from appropriable knowledge, political attention due to government interest in strategic alliances, and uncertainty over long term interests and intentions of the other parties? The answer, as provided by Alter and Hage (1993), is to develop technology common to the industry, to share the costs of that development and to fend off further competitors. This confirms the discussion of Romer 1993a, Prescott and Boyd, and Weder and Grubel's work on internalising knowledge spillover externalities (section 2.2). Baumol (1990) suggests technology-sharing cartels as another form of relationship to internalise the external benefits associated with the incomplete appropriation of knowledge and to exploit the zero marginal cost of non-rival knowledge. Such relationships are said to be both more stable and more in the public interest than

price fixing cartels because the benefits to their members accrue from long term cooperation, and because they encourage innovation respectively.

3.4.2.3 Other relationships between firms

The above learning-related relationships between suppliers and customers, and between competitors, are specific to firms thus connected through the market. Other relationships between firms are not restricted to firms connected in either of those ways. At least three types of such relationships are discussed in the literature: the cluster, the strategic alliance and the common directorate. The material on relationships based on common directorates indicates that this is an opportunity for directors to learn and to coordinate operations at a high level (Weder and Grubel; Aoki, 1985; and Sako, 1992).

The 'cluster' is a grouping of companies around a resource, a problem or an opportunity in order to capture an external benefit. Traditionally a cluster implied physical proximity to either a resource (often infrastructure) or a major customer. Technological change and the increase in role of knowledge in production mean that the external benefit is no longer restricted to a location. Although, physical proximity is less emphasised, the literature on clusters indicates that proximity remains important. Proximity enhances innovation by facilitating interaction upstream, downstream and horizontally. Such interaction is more important in high-tech industries than are the transport and communication costs of the conventional cluster (Porter, 1990a; Braunerhjelm and Svensson 1994; Williamson, 1975; and Krugman, 1991).

Dahmenian competence blocks are clusters of firms based on knowledge spillovers peculiar to an industry. These 'blocks of advanced firms operate as technical universities and research institutes, unintentionally providing free educational and research services, often in areas where such services are not supplied by existing educational institutions or where the nature of competence makes traditional educational institutions incapable of supplying them' (Eliasson, 1996: 125). The

catch is that to develop an innovative and internationally-competitive industrial cluster, a nation must have a producer that is an international leader in technology (Eliasson, 1994a).

Technical standard bodies may be interpreted as clusters of firms around the problem of developing standards (Dodgson, 1993; David, 1986). Standardisation is important to innovation because it provides structure and confidence (Reddy, 1990). According to the BIE, standardisation also provides a reason to diffuse knowledge:

‘The diffusion of new private knowledge and know-how amongst competitors in an industry is often a very open process. For example, where a new and radically different technology has been developed, the innovating firm may permit the use of this technology by its competitors for the purposes of gaining an industry standard. For these firms, it may be better to forego some competitive advantage in the market for the increased chance that its technology is adopted as the industry standard’ (1994a: 20).

The second type of relationship between firms not necessarily linked by the market is strategic alliances for the joint creation of knowledge. While in the case of joint ventures the relationship is cemented by equity involvement, a strategic alliance can be based on trust with no formal contractual basis. Ciborra argues that ‘alliances are the institutional arrangement that allows firms to implement strategies for organizational learning and innovation more effectively’ (1991: 51). Strategic alliances focus on the dynamics of innovation and competition rather than on short term response to price signals and may involve market creation or product innovation (BIE, 1995a; Mytelka, 1991a). The recent trend for more strategic alliances reflects a strategic response to the increasing demands on knowledge due to changing competitive and technological conditions that increase uncertainty and the need to access broad expertise (Hagedoorn, 1995; Mytelka, 1991c; Ciborra, 1991; and BIE, 1995a). This increasing technological interdependence requires and leads to more R&D from both parties because an own R&D effort is necessary to develop the competence to learn from other’s R&D (Beije, 1996; Cohen and Levinthal, 1990).

Alliance partners must be trustworthy and carefully selected for relevance, novelty, and meaning of information in order to enhance learning and innovation:

'Relevance means that they either demand or supply input technology. That is, they have complementary competence in technology. Novelty provides awareness, information, interpretation, evaluation that would be lacking without a relationship with that party. Meaning requires that the competence from the partner can be absorbed. These are associated with cognitive proximity, which is necessarily distinct from sameness. Sameness destroys learning, proximity enhances it. Interaction has a strategic aspect due to learning. Interaction may yield economies of cognitive scope. Together firms can learn that which they could not learn alone. If both parties cooperate in this learning, then mere imitation can be surpassed with learning that is accurate and low cost' (Nooteboom, 1996: 331).

3.4.2.4 The SKF case study

The strategic complexity of relationships between firms and within firms is exemplified by Lundgren's (1990) case study of the Swedish producer of precision steel, SKF. Details of that case study are provided here because it demonstrates that relationships within the firm can affect learning relationships between firms, and that institutions that favour one learning opportunity can deter another.

Early this century, SKF learned by using steel that their product could be improved if they could get cleaner steel. In particular, cleaner steel was essential for the development of the ballbearing. SKF stood to gain from these improvements but was unable to persuade the Swedish steel mills to pursue them. So, SKF bought the Horfors mill in order to capture their metallurgy and market knowledge, and then taught them about the desired improvements in steel production. Bringing the relationship in-house was also advantageous from the perspective of intellectual property rights because some of the processes for developing cleaner steel would be classified as 'obvious to a person skilled in the art' and so would not be patentable in Sweden. Moreover, the Swedish system offers no protection for process technology because while patenting publicises that process the cost of prosecuting for encroachment is prohibitive. The vertical integration option provided greater security because Swedish corporate law is well suited to protecting intellectual property from employees divulging secrets opportunistically. Thus, bringing an exchange relationship in-house was seen as a solution to both problems of intellectual property rights and resistance

to innovation. The effectiveness of one institution (company law) above another (patent law) radically influenced the relationship.

However, it was recognised as early as 1930 that the close relationship with SKF was preventing the Horfors mill from learning from their customers, who were also SKF's competitors. So, when the ability to make high quality bearing steel was no longer unique, 50% of the mill was sold to a Finnish steel producer. This remaining strong link with SKF is said to be responsible for the poor on-going development because it bars Horfors from access to user's opinions and knowledge.

In order to exploit the value of its knowledge of ballbearings, SKF initially undertook to educate the car industry in their use. In so doing, SKF learned about the car industry, and in 1935 SKF established Volvo as a subsidiary. It thus became one of its own major customers. This relationship was so damaging to SKF's relationships with Volvo's competitors that the company feared technological stagnation. Volvo was sold, and is now the only European car that does not use SKF's products.

3.4.3 Relationships with experts

The literature on learning-related relationships between firms and experts external to the firm relates to consultants and universities. Consultants have become more important as industry has become more technologically advanced and more knowledge based. There has been a 'shift from machine-embedded to organization-embedded knowledge. There is also evidence of a further step, from organization-embedded to individual-embedded knowledge' (Ekstedt, 1989: 11). Consultants provide a flexible source of knowledge that can overcome the rigid path dependence of organisation embedded knowledge. Therefore, firms that seek a flexible source of knowledge in order to innovate and respond quickly to market signals develop relationships with consultants who are committed to developing knowledge in support of the firm (Ekstedt, 1989).

In their research role, universities generate knowledge that may be absorbed by the firm. However, that absorption often takes more R&D effort than does absorption of spillovers from suppliers (Levin, Klevorick, Nelson and Winters, 1987). This is apparently because the academic norms and standards are not commercially

oriented. While the general tendency is that universities undertake the basic research that stimulates applied research in industry, Dasgupta and David (1992) and Rosenberg and Nelson (1993) argue that in some instances applied research stimulates basic research. Therefore, there is increasing potential for universities and firms to form strategic alliances for the joint development of knowledge of benefit to both. There appears to be very little relevant literature on learning-related relationships between firms and universities as education facilities.

3.4.4 The government and learning in industry

The government is in a unique position to influence learning in industry through its various roles as customer, legislator, and researcher. Firstly, the government can form relationships with firms in which it acts as a competent customer that demands innovative and quality goods. Such competent procurement practices have the capacity to drive technological change (Porter, 1990a and 1990b; Edquist, 1996a). The capacity for competent purchasing is reduced by long term 'overly close' relationships with industry in which personnel and programs are so intertwined that they stagnate. Recent moves towards privatisation and international tendering also reduce the Government's capacity to boost innovation through technical procurement (Edquist, 1996a). The government has great potential to encourage innovation through its impact on private demand (Dosi, 1988; Cohen, 1995). Demand patterns may be influenced by regulations that constrain legally admissible options, and by fiscal measures, including broadly based and targeted taxes and subsidies. The government may also be able to influence private demand through propaganda or programmes that award tax exemption points for buying national, 'green' or high-tech products (Dosi, 1988).

The government also impacts on learning and innovation through its sundry roles in the society that create the environment in which firms operate. Firstly, by creating the regime that determines the rules of allocation and association the government influences the nature and extent of interaction between firms (Pelikan, 1988). Secondly, the government influences the law, order and general harmony of the

economy, and in particular, it deals with the conflict arising from the change associated with innovation (Edquist and Johnson, 1995; Dosi, 1988). Thirdly, the government influences the balance between appropriation of returns as the incentive to develop knowledge, and the public benefit from the diffusion of that knowledge (Nelson, 1988). Patent laws are important intellectual property right laws. The patent system has two objectives: to reward innovators with limited monopoly, and to avoid R&D duplication by providing public access to their results (BIE, 1994a). Spence (1984) argues that while R&D intensity will rise with appropriability, innovation output may decrease due to a lack of spillover effects. Fourthly, the government can reduce the cost of innovation as well as influencing the direction of research by its own research, by subsidising and sponsoring private sector research, and by disseminating or subsidising the dissemination of knowledge developed in its own laboratories and elsewhere (Cohen, 1995). Fifthly, the government may be able to influence the level of competition, and this may boost the rate of innovation. While Porter (1990a and 1990b) finds the level of competition to be a crucial factor in innovation, this is not universally agreed. Nooteboom (1996) and BIE (1994a) argue that although increased competition heightens the need to share knowledge in order to maintain a competitive advantage through technological advancement, it also reduces the willingness of innovative parties to share that knowledge. An increased level of competition may increase innovation if it breeds cooperative relationships between those who are aligned in competition with a third party.

3.4.5 At the individual level

While the above discussion of learning-related relationships focuses on relationships at the firm level, relationships at the individual level between individuals within the same firm and in different firms are perhaps the most important for learning and innovation (von Hippel, 1988). According to von Hippel, 'informal know-how trading is essentially a pattern of informal co-operative R&D. It involves routine and informal trading of proprietary information between engineers working at different firms - sometimes direct rivals' (1988: 6). According to Cohen (1995) the

area of intrafirm relationships, especially at the individual level, has been inadequately researched.

In conclusion,

'The socio-institutional framework always influences and may sometimes facilitate and sometimes retard processes of technical and structural change, coordination and dynamic adjustment. Such acceleration and retardation effects relate not simply to market 'imperfections', but to the nature of the markets themselves, and to the behaviour of agents (that is, institutions are an inseparable part of the way the markets work)' (Freeman, 1988: 2).

3.5 The system of innovation approach

While the above investigation of relationships and institutions in the literature indicates how each impacts on learning and innovation, it does not indicate how those relationships and institutions together impact on learning in industry. Several of the referred to works (eg Pelikan, 1988; Sako, 1992; Edquist, various) come from a school of thought that argues that relationships and institutions are interrelated in a systemic way, and that to understand their combined impact on innovation it is necessary to understand that system.

The system approach to innovation follows von Bertalanffy's (1968) work on the systems approach to organisations. That approach argues that the elements of an organisation are interdependent and behave in an orderly and predictable way. This 'steady state' behaviour results from the system's ability to influence, if not control, its members through the power structures that develop within and between the elements in the system. The balance in the power structure is due to mutual interdependence, the lack of certainty of the relevant power of each element and mutual awareness that each element is part of a coalition, the strength of which may not be assessed by outsiders. Understanding that suprastructure, of which the individual is part, makes sense of the operations of the individual in a way that may not be clear from the analysis of the part (Carzo and Yanouzas, 1967).

There are three general approaches to systems of innovation (Edquist, 1995b). Firstly, there is the technological systems approach of Rosenberg (1982) and Dosi (1988), which focuses on technological innovations within the social context of science and technology. Secondly, there is the industrial cluster approach of Porter (1990a and 1990b) and Dahmen (1989), which explains economic performance in terms of the interaction of groups of technologically advanced firms. Thirdly, there is the system of innovation approach proper, as Edquist calls it, which focuses on the environment in which the firm operates as a system that determines the rate and direction of innovation. As Smith argues:

‘Systems approaches vary in emphasis and level, but they share a common core idea: the overall innovation performance of an economy depends not so much on how specific formal institutions (firms, research institutes, universities, etc.) perform, but on how they interact with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (such as values, norms, legal frameworks, and so on)’
Cited in Hofer and Polt (1996).

While these three approaches to the system of innovation are often treated separately in the literature, their similarities are sufficient to warrant addressing them under the general banner of the national system of innovation approach (Lundvall, 1992a; McKelvey, 1991). The national system of innovation is defined by Lundvall as ‘all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring’ (1992a: 12). There are two major interdependent parts of the national system of innovation: the social context and the production context (Lundvall, 1992; Edquist, 1995a). The production context is what is produced and sold within the economy and the characteristics of the firms, and funding arrangements. The learning-related relationships and institutions discussed above comprise the social context in which industry operates and innovates. Therefore, the national system of innovation approach argues that the impact of the relationships and institutions on learning and innovation can be understood within a broader system of innovation.

There are no natural boundaries to delineate what to include within a study of the national system of innovation (Lundvall, 1992a). Contributions to the literature on the national system of innovation have included the following elements: Pelikan (1988) examines the political regime, Lundvall (1988) considers firm behaviour, Edquist (1993) concentrates on social norms, and Sako (1992) considers the degree of dependence between firms in exchange relationships.

While the national system approach is inclusive and can accommodate each of these disparate elements in explaining innovative behaviour, it does not seek to make a coherent interpretation of that behaviour. Rather, it allows for the coexistence of contradictory and apparently incompatible elements. Such coexistence may be an essential characteristic of cultural complexity. As Ramseyer (1987: 40) argues:

‘Cultural orders seldom constitute coherent logical systems and the Japanese order is no exception. True, the Japanese intellectual tradition has long emphasised harmony, loyalty, and consensus. That same tradition, however, has also long celebrated the misanthropic swordsman who slashes for art, the wily merchant who cheats his way to riches, and the amorous prince who hops from bed to bed. Like any other cultural order, the Japanese tradition is an unstable set of conflicting and manipulable norms.’ Cited in Gerlach (1992: 26)

Moreover, it is not normally possible to investigate all these disparate elements of the national system of innovation. Lundvall (1992a) argues that flexibility should prevail in deciding what subsections and processes should be studied. The guiding objective should be the purpose of the study. In this thesis the emphasis is on the relationships and institutions that were argued in the creative learning model and the translational learning model (Chapter 2) to be central to learning in industry.

3.5.1 The national system of innovation and economic performance

Not only does the national system of innovation approach adopt a systemic approach to the understanding of the rate and direction of innovation, but it also posits that that innovation is central to economic performance, including growth

(Lundvall, 1992a, Edquist, 1995a). Centring the analysis of economic performance on learning and innovation is said to be essential if two assumptions are accepted. The first is that knowledge is the key to economic performance, and accordingly, that learning is the most important activity. The second is that learning is interactive and socially embedded in the institutional context in which it takes place (Lundvall, 1992a).

Authors have explained economic performance in terms of various elements of the national system of innovation. These works have not modelled growth in a formal way, nor have they comprehensively investigated all salient features and their connections. Rather, they have focused on selected qualitative elements of the national system of innovation, which they argue to be central to innovation, and have explained how those elements separately and together influence economic performance. These explanations are specific to a particular national system because they rely on contextual material that is peculiar to each nation.

Two works that have focused on different elements of the national system of innovation to explain economic performance can be discussed as examples of this body of work. The first work, Porter (1990a and 1990b), focuses on the rivalrous and cooperative behaviour of large businesses in determining the nation's economic performance. Porter's work is not couched in the language of the systems of innovation approach. Rather, it deals with the 'four attributes of a nation that individually and as a system constitute the diamond of national advantage, the playing field that each nation establishes and operates for its industries' (1990b: 77). The diamond, which determines the barriers, incentives and capacity of industry to 'innovate and update', is entirely consistent with the national system of innovation approach (Lundvall, 1992a; McKelvey, 1991). The four points on Porter's diamond are: factor conditions; demand conditions; related and supporting industries; and firm strategy, structure and rivalry. Of these, rivalry is the most important for creating 'the pressures on companies to invest and innovate' (1990b: 77). Rivalry encourages firms to form cooperative relationships that will facilitate innovation and enhance the ability to compete with rivals. These cooperative relationships are with

third parties not directly involved in the rivalry, typically with suppliers and customers. This innovation enhances the competitive advantage of the company, and in aggregate the nation. The government has a role to play in enhancing the degree to which local competitors press each other on costs, quality and variety to create a dynamic and innovative inter-relatedness. That role is to enhance competition by removing barriers to rivalry, and by providing incentives to cooperate among customers and suppliers.

In the second work, Sako (1992) investigates the differences between British and Japanese business relationships for exchange, and their impact on industrial development. Sako's overall argument is that historical factors have led to radically different norms and relationships predominating in the two nations that are peculiar to each national system and cannot be fully understood in isolation from that system. In particular, the level of trust and the degree of desired dependence between firms are said to be crucial differences in determining the economic performance of each nation. According to Sako, both parties to exchange in the British system seek low dependence and rely on contractual trust based on the legal system's 'fiction' that both parties have equal bargaining power. Overall, relationships between British firms are based on the assumption of opportunism mediated by contract and independence to exit from unsatisfactory relationships. Contracts that detail every aspect of the exchange relationship mediate against product innovation during the terms of the agreement, but encourage price cutting innovation to annex the rent. In the Japanese system both parties seek a high level of dependence because they rely on good will trust that the other party will not behave opportunistically even given unequal bargaining power. Although Japanese contractual law imbues contractual trust, parties prefer to rely on goodwill trust, which is also fostered by the legal system. Overall, relationships within and between Japanese businesses are regulated by institutions that favour mutual dependence by fostering long term commitment and risk sharing that encourage transaction specific investment and innovation. Commitment establishes expectations that the individual and the company will continue to improve their performance, will be flexible and will diversify to keep up with technology in

pursuit of common goal (Aoki, 1985). This flexibility and credible commitment to exchange are said to enhance business development and growth more than the British system based on credible threats. Sako attributes Japan's relatively greater success in innovation and growth to these norms and relationships.

3.5.2 National system of innovation and the new growth theories

The above discussion of the national system of innovation approach and its contribution to the understanding of the link between learning, innovation and growth is vastly different to that in Chapter 1 of the contribution of the new growth theories to the same topic. Superficially, the difference is due to style and the comprehensiveness of the variables included. Stylistically, the new growth theories are mathematically rigorous in modelling the link between learning and growth in a generalised and stylised situation. In so doing, they take an exclusive approach that limits the domain of their models to factors that are central to the modelling exercise, and limits the circumstances to those that are compatible with the general thrust of the neoclassical enterprise. Stylistically, the national system of innovation approach explains the link between learning, innovation and growth through descriptive exemplification. The national system of innovation takes an inclusive approach that argues that historic and current factors constitute a system of institutionalised social structures that affect the learning and innovation that are associated with growth. The entire system needs to be understood in order to understand either innovation or growth. However, perhaps the greatest apparent difference, from the perspective of this thesis, is the degree of attention paid to the nature and process of learning. The national system of innovation approach views learning and innovation as issues to be explained as an integral part of the explanation of growth. The new growth theories treat learning and innovation as an element in their growth models. If that learning is explained by other elements in that model, it is said to be endogenous.

The differences are radical in that they go to the root of the theoretical paradigms to which the two approaches belong (Hofer and Polt, 1996). The new growth theories

belong to the neoclassical school that explains economic outcomes in terms of the behaviour of maximising firms and individuals responding to market signals. Rationality is assumed to reflect self interested action undertaken in conditions of perfect knowledge and with parties not constrained from acting in their own interest. Choices result in instantaneous outcomes that are not subject to path dependence. The national system of innovation approach, on the other hand, is couched in the evolutionary and institutional schools of thought that argue that individual behaviour can be explained in terms of historically and collectively determined structures that limit behavioural choices. Choices are further constrained by the path created by previous choices. Those choices and that path modify the constraints, and so behaviour is evolved by collective influences. Even within the culturally and path-bound options, calculated personal maximisation is largely irrelevant because outcomes of choices accrue over the long term and are subject to uncertainty due to the impact of choices made by others (Dowrick, 1995a). While firms and individuals may still act so as to maximise their interests, those interests and those actions are both constrained and shaped by the social context to such an extent as to render the neoclassical model of unconstrained maximising behaviour with perfect knowledge irrelevant. Overall, the national system of innovation approach seeks to describe learning, innovation and growth through exemplification of a real situation in a real period, while the new growth theories model growth within a highly stylised and regulated theoretical context. Therefore, the behaviour modelled by the new growth theories and described by the national system of innovation approach is different in nature as well as content.

While these approaches are different and often treated as rivalrous (Tisdell, 1995a), there are at least two other ways to treat them. That is, to attempt to combine them, or to treat them as distinct but complementary approaches. The option of combining them would imply that either the new growth theories incorporate institutional and evolutionary arguments in their models, or that the national system of innovation approach formalise its arguments into mathematised models. There is evidence that the new growth theorists acknowledge that their models would be more powerful if they included variables that captured what the national system of innovation

approach perceives as salient institutional factors. Moreover, it appears that in a limited way such factors have been included in models. For example, in Grossman and Helpman's (1991a) increasing variety model, it was found that non-instantaneous diffusion reduces the rate of growth even though all the knowledge is eventually diffused. If the question were asked: What determines the rate of diffusion?, the answer would seem to necessarily include institutional factors. Therefore, it appears that some unspecified institutional effects have been modelled.

However, to extrapolate and attempt to model institutional factors fully would involve the inclusion of variables that represent each of the key institutional factors of the system and how they interact and evolve over time. The peculiarity of each national context would require that these models be tailored to each nation and to each period if they were to capture the realism of the system of innovation approach. Moreover, those who subscribe to the national system of innovation approach would undoubtedly argue that their findings cannot be annexed in this way because models cannot capture the evolutionary nature of the system, even if they could succeed in piece-meal adding variables to represent the institutional context. The two approaches cannot be reconciled by adding more variables to the new growth models, nor by introducing mathematical solutions to the national system of innovation approach, because they are based on fundamentally different conceptualisations of behaviour. Therefore, the limitations on reconciliation are paradigmatic rather than practical and are unlikely to be solved by further advances to modelling techniques, including simulation.

The third option, that of treating the two approaches as complementary sources of insights into growth and the learning and innovation that they agree drives growth, remains. The new growth theories in modelling the links between learning and innovation and growth have raised the profile of learning in industry. The national system of innovation approach by explaining the links between social structures and learning have provided insight to both innovation and the growth process. If the enterprise at hand is to develop neoclassical growth theory, then the contributions of the national system of innovation approach may be limited. If the enterprise is to

understand learning, innovation and growth, then both approaches have a valuable contribution to make, but the objectives and limitations of each programme must be kept firmly in mind.

3.6 Conclusion

This chapter has investigated the learning-related relationships and institutions that comprise the social context of industry. Those relationships were argued in Chapter 2 to be central to the rate and direction of learning in the dynamic strategic context of industry. Many relationships and institutions were identified in the literature and each was shown to impact on learning and innovation in industry. However, it was argued that to understand how they jointly impact on learning and innovation it is necessary to understand how they interact within the broader context of the system of innovation. While the national system of innovation approach argues that each industrial context provides a unique environment that determines how firms interact and innovate, it does not identify how, at the company level, relationships and institutions separately and jointly determine learning behaviour in industry.

Therefore, an empirical study was undertaken into learning in industry in order to understand learning at the company level. The research sought to understand that learning within the social context of the relationships and institutions that were argued in Chapter 2 to impact on the practical issues of how learning is done in industry, why learning is done and what is learned. Moreover, it sought to place that learning within the broader context of its industrial and national environment to understand how relationships and institutions jointly and separately determine the learning that is undertaken within industry. The research consisted of two interrelated parts: an investigation of the relationships and institutions that create the social context in which industry operates and innovates, and an investigation of the practical issues of learning in that context. The research, which is presented in the empirical component of this thesis, addresses the following research questions.

- What is the nature of the relationships that influence learning in industry?
- What is the nature of the institutions that influence learning in industry?

- How is learning done in industry?
- Why is learning undertaken in industry?
- What is learned in industry?

The empirical component of this thesis was designed to address these questions in the context of a company learning in the face of a major change to its regulatory environment.

CHAPTER 4

Background to the Case Study

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4.1 Introduction

This is the first of five chapters that report on an empirical investigation of the social and institutional context of learning in industry. This chapter explains the choice of the case study method and provides background information to that case study. The background material is provided in order to set out the context in which the selected case study (Ericsson) operates. Therefore, the background material covers: the telecommunications industry in which Ericsson operates, and relates to both telecommunications service provision and equipment supply; the history and operation of the case study company; elements of the Swedish and the Australian national systems of innovation that are particularly relevant to the case study; and the telecommunications industry in Sweden and Australia with a particular focus on Ericsson's activities. This information is drawn from available sources and provides an overview relevant to the case study rather than an analysis of any of the elements covered by the background.

The plan of the chapter is that the choice of the case study method is explained in section 4.2. The selection of the particular case study is explained in section 4.3. The background to the case study is presented in section 4.4. Conclusions are provided in section 4.5.

4.2 Choice of case study method for this investigation

The selection of the case study method was based on its suitability both to the purpose of the investigation and to the nature of the data to be collected and analysed. Firstly, the purpose of the investigation was to produce a rich description that would cover the variety of issues arising from the theoretical component of this thesis, and so enhance the understanding of learning in industry. Specifically, the purpose was to gain an intimate understanding of the breadth of learning in a particular setting by investigating the practical issues, the relevant relationships and institutions, and the broader influences that determine that learning. The case study approach 'examines a single social phenomenon or single unit of analysis' (Singleton, Straits and Straits, 1993: 317) in order to give meaning based on both the tacit and the explicit knowledge of those who experience that phenomenon (Bailey, 1996). Three types of case studies can be distinguished: descriptive, explanatory and exploratory. The descriptive case study approach produces a rich description of a phenomenon in its context. The exploratory case study builds theory, and therefore suits situations where there is inadequate theoretical basis. This was not the case in this investigation because the material in Chapters 1, 2 and 3 was accepted as providing an acceptable theoretical basis for an understanding of learning in the industrial context. An explanatory case study approach is suited to situations where cause-effect explanations are sought. This investigation aimed to use empirical evidence to describe learning in industry through exemplification, rather than to explain the causes and effects of that learning. Therefore, the descriptive case study was ideally suited to the purpose.

Secondly, the nature of the data indicates a case study approach because the social and institutional context in which learning takes place is central to the investigation.

Yin (1993) states that the case study method is appropriate when the data is integral to the context in which it occurs, and where the contextual data introduce too many variables to be handled by other methods such as a survey. Therefore the descriptive case study method was chosen as appropriate to the purpose and nature of the investigation, and as superior to alternative methods.

4.3 The selection of the particular case study.

The selection of the particular company as the subject of the case study involved the selection of the industry and then the selection of a company in that industry. The emphasis of the new growth theories on technological change indicated that the company should be in an innovative industry. The potential importance of relationships for creative and strategic learning suggests that the case study company should be in an industry that is stable enough to have developed learning-related relationships, if they are relevant. The telecommunications equipment industry, which is both innovative and comprised of parties that are well known to each other, was selected because, as is discussed below, it is important and warrants investigation. The company was chosen as the unit of analysis for the research as consistent with the unit of industrial decision making in economics, and because the investigation in Chapter 3 indicated a need for an investigation of learning at the company level, in the industrial context. It was therefore decided to study learning in a telecommunications company. It was determined for practical reasons to study a company operating in Australia with a presence in Melbourne. Furthermore, in order to capture the international nature of the learning process in the telecommunications industry, it was desirable to investigate linkages between a subsidiary and its parent company. As there are no Australian-based multinational telecommunications companies, it was decided to investigate learning in an international telecommunications equipment company with a subsidiary in Melbourne. Ericsson was identified as a possible case study because of its range of activities in Australia, which include a large R&D facility in Melbourne. Initial approaches to both Ericsson Australia and the parent company (LM Ericsson) in Sweden indicated that they would be supportive of, and make their staff accessible

for this project. Another attractive feature, which would facilitate data collection, was that although the Ericsson parent company is based in Sweden, English is the company's official language. Therefore, it was decided that the case study would be of learning in Ericsson in Australia and Sweden.

4.4 Background to the case study

This section presents material on the range of topics listed in the introduction to this chapter as being important to the understanding of the operations of Ericsson in Sweden and Australia

4.4.1 The telecommunications industry

Two elements of the telecommunications industry are of interest here: the provision of services to the public, and the manufacture and supply of telecommunication equipment. These two functions are undertaken by two separate groups: the service providers (including Telia in Sweden, and Telstra and Optus in Australia), and the telecommunications equipment companies (including Ericsson). Historically there has been some overlap with service providers undertaking R&D and manufacture of selected items, typically in conjunction with favoured equipment suppliers, but this has been limited. While the case study is of Ericsson, a telecommunications equipment company, this section provides information on both the service provision aspects and the equipment aspects of the industry because both are important to an understanding of Ericsson's operations.

The supply of telecommunications services and the associated infrastructure are central to economic, commercial and social development of both developed and underdeveloped nations (Melody, 1996 and 1997). A well developed telecommunications industry promotes economic performance by promoting innovation and the use of innovations, enhancing communication, creating spillovers of knowledge, and reducing the trade deficit (BIE, 1994a). The strategic importance of telecommunications service provision was recognised early and led to the historic regulation and nationalisation of the industry (Joseph, 1996). While

formal regulation was historically at the national level through legislation, functional regulation has been common at both the national and international level through standardisation (Hawkins, 1997). At the national level, formal legislation of the licensing of the provision of telecommunications services was undertaken on the grounds of national security, public service provision responsibility, and the belief that the economies of scale in infrastructure establishment led to a natural monopoly (Melody, 1997; Hawkins, 1997; Karlsson, 1995). The outcome was generally state-owned or controlled monopoly service providers that were required to meet social objectives of quality and universal service through cross subsidisation of domestic, residential and rural services by commercial and international services (Karlsson, 1995). Several factors combined in the 1980s to render the model of government-established and government-protected telecommunication service monopolies less acceptable. These factors included a surge in the popularity of user-pays arguments, and in the belief that competition generally enhances efficiency and lower prices, the increasing internationalisation of commerce and consequent dissatisfaction with cross-subsidisation and different regularity arrangements between nations, and the convergence of telecommunications with previously unregulated distinct technologies (Karlsson, 1995).

The consequent change to the national regulation of telecommunication service provision allowed for the granting of new licenses to competitors. However, the increase in competition in local service provision has not generally been significant, apparently because the previous monopoly service providers retain sufficient monopoly power to exclude entrants (Melody, 1997). The General Agreement of Tariff and Trade's (GATT), General Agreement on Trade in Services (GATS), and the Negotiation Group on Basic Telecommunications (NGBT) have called for this monopoly power to be reduced by allowing new entrants interconnect to the infrastructure. Although only eleven countries were signatories to that agreement as at April 1996 (Hudson, 1997) similar requirements have been included in national regulations (including both Sweden and Australia). However, according to Mansell (1997) the former monopolists power is maintained only partly by closed systems that preclude connection to the infrastructure (which is addressed by the NGBT and

national legislation). That power also rests in the former monopolist's ability to exclude access to customers by establishing closed systems in the provision of new electronic services. Rather than excluding at the point of access to the infrastructure, the converging technologies allow for exclusion at the interface where the customer, multimedia provider and telecommunications provider meet. Further, networks of established firms from the converging technologies share information on customers and their demands. This at once increases the prospect that investment in innovation by those established companies will succeed in the market place, and reduces the chance of successful entry by new comers (Mansell, 1997). The value of this exclusion to the company supplying equipment is enhanced because telecommunications technology is a technical system in which the demand for any component depends on previous demand for that component and for complementary components, and the capacity to supply a component depends on the complementarity of that component with previously supplied components. A decision to buy a component locks the customer into the closed system of that component (Antonelli, 1993). This modifies their future choice options. This lock-in applies to end-users locked into service providers, and to service providers locked into equipment companies. This exclusion of new entrants reduces the impact of changes to national regulation to allow competition in the provision of telecommunication services.

Functional, rather than formal regulation of telecommunications equipment is provided by technical standards (Hawkins, 1997), which ensure the interconnection and interoperability of different national systems internationally, and different proprietary systems nationally. Under the old monopoly regime these standards were voluntary, and effectively the procurement specification for the national carrier (Hawkins, 1997). The main international telecommunications standard setting body, the International Telecommunications Union (ITU) argues 'there should be no international regulations enforceable on individual countries' internal communications regimes and that international standards would be recommended and should be applied wherever possible, but that individual countries could form 'special arrangement' in interconnecting their networks' (Hudson, 1997: 418). However, the ITU does impose binding regulations on the international sharing of

the radio spectrum, and on harmonising public telephone services, on signatory countries (Hawkins, 1997). Moreover, national standards are typically mandatory on issues of network security and quality, areas of particular policy interest and national security. This includes the use of the radio spectrum, electromagnetic capability and protection, terminal equipment approval and power supply specification (Hawkins, 1997). Otherwise, standards indicate the technical solutions that *should* be adopted. In practice, the distinction between standards and regulations is becoming less clear with the European Union, for example, commissioning the European Telecommunications Standards Institute (ETSI) to develop technical standards as the basis for mandatory regulation (Hawkins, 1997).

The monopoly service providers were active in standardisation, and in the R&D to develop that technology (often in conjunction with preferred equipment company). The introduction of competition means that the service provider no longer invests in that R&D and takes less interest in the standardisation process, preferring to focus on immediate commercial interests. Therefore, the influence on the standardisation process has moved upstream to the equipment companies who focus on issues of strategic market positioning rather than on cost minimisation through variety reduction, which was the main function of the technical standards. This reduction in the level of involvement of the service providers reduces the ability of the national telecommunications regulator to influence those standards because they have less control over the multinational telecommunications equipment companies than over service providers operating domestically (Hawkins, 1997).

The regulatory framework is further complicated by convergence of technologies that are subject to different regulatory regimes. The convergence of voice, data and media technologies renders the distinction between telecommunications, information processing and broadcasting industries increasingly irrelevant (Hudson, 1997). According to Hudson, in Singapore, for example, video on demand is regulated by Singapore Telecom, while cable television is regulated by the Telecommunications Authority of Singapore. To the consumer they do not represent different industries. Rather, they are simply two ways to deliver multiple

channels of video to the home. As such it may be anomalous to subject them to different regulatory regimes.

Although a single network can now carry telecommunications, data and cable television, Mansell (1997) argues that the introduction of these networks is delayed by the uncertainty in consumer demand for the new products, and uncertainty among telecommunications service providers about the best structure to adopt. That is, whether to adopt a vertically integrated approach to serve all technologies within a single company, or to adopt a federated approach with small flexible companies under the umbrella of a parent company. In the mean time, they are continuing to rely on a web of alliances in order to meet customer requirements (Mansell, 1997). These alliances may effectively capture the market by locking the customers into the interface jointly created for those technologies.

Therefore, recent changes to provide a greater role to the market in the operation of the telecommunications industry, especially the introduction of licenses for competitive service providers, have led to an industry in which continued regulation is considered to be important, but is becoming more difficult due to increasing internationalisation and convergence. Moreover, it is an industry in which technological change is increasingly important and increasingly uncertain, and in which relationships between equipment suppliers and service providers and companies with converging technologies are in a state of flux that makes locking the other parties in to a particular technology an increasingly attractive option.

4.4.2 Ericsson

Ericsson has a one hundred year history as an innovator with an increasingly-global focus (Ericsson, 1996a). Ericsson's best known innovations are the desk telephone (1892), the AXE computer controlled exchange system developed in conjunction with Ellemtel (1975), and the GSM standard for digital mobile telephony, in conjunction with Nokia (1988) (Karlsson, 1995). The prosperity of the company is generally attributed to the flexibility of the AXE that has been modified by software updates to accommodate mobile, digital and Asynchronous Transfer Mode (ATM)

technologies. Net sales in 1993 were approximately \$10¹ billion and in 1994 \$13 billion. This increase of 31% is attributed to mobile sales (73% increase) and associated increase in demand for AXE (Ericsson, 1993a and 1994a). More than 60% of the 1994 sales were for products and services that did not exist in 1991. In 1993, Ericsson's global work force was 70,000 of which 14,000 were in R&D. In 1993, Ericsson global R&D expenditure was \$1.6 billion, or 17% of their net sales. Total development costs, including tailoring products for specific markets were \$2.1 billion, or 21% of net sales (Ericsson, 1994a).

Ericsson is vertically integrated for the production of cables, switches, exchanges and handsets, together with their installation and maintenance. It has divested itself of some of its horizontal activities including TV and radio for entertainment while retaining radio for telecommunications (Ericsson, 1996a). Ericsson also retains some diversity, for example it continues to work in areas of advanced RADAR technology. This is in response to an historic defence obligation with the Swedish Government and because it stimulates advances in radio for telecommunications (Ericsson, 1993a).

In 1993, the company's share of sales between the business units was Radio Communications 41%, Public Telecommunications 30%, Business Communications 20%, Components 6% and Defense (Microwave) Systems Business Unit 3%. In 1993, sales by the Radio Business Unit exceeded those for Public Telecommunications for the first time. Radio is expected to continued to increase its share of the company's sales due to the rapid growth in demand for mobile radio technology (Ericsson, 1995a). The success of the Radio Business Unit is, to some extent, due to good staff rather than good management in the view of some analysts. According to Eliasson (1996), Ericsson's mobile telephony was developed clandestinely contrary to the intentions of top management, and was almost closed down.

¹ Conversion from the Swedish kronor to Australian dollars is approximate only and has been at the rate of \$1=6kronor.

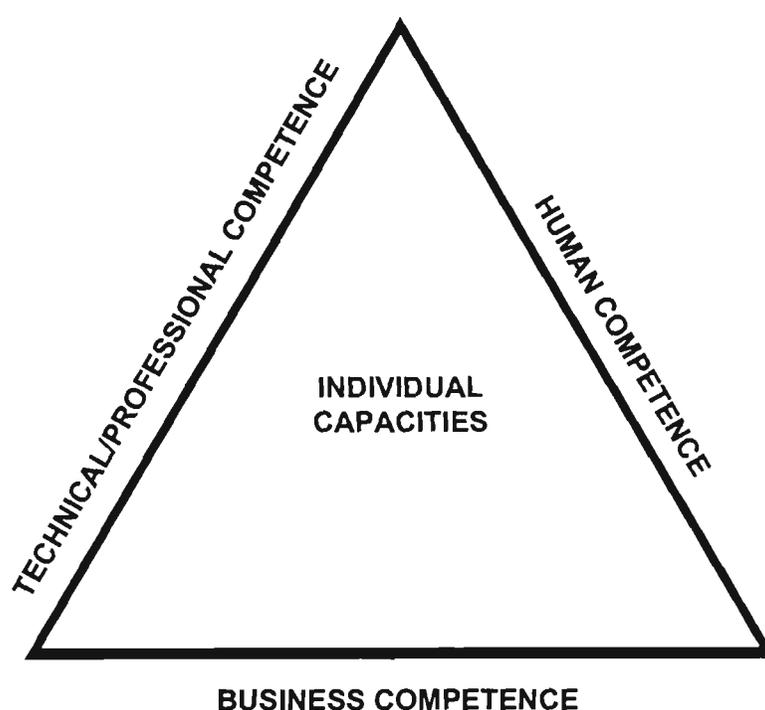
Ericsson's international operations are undertaken through local companies established in over 100 countries. Of these, nine are major local companies with responsibility for identifying and meeting the needs of its local market, with Ericsson Australia being one such major local company. The geographical distribution of sales in 1993 was Europe 56% and declining (of which Sweden 10% points), Asia 13% and increasing, North America 12%, Latin America 11%, Oceania 5% (of which Australia 4% points), Middle East 2% and Africa 1% (Ericsson, 1993a).

According to Ericsson (1996c) the key to Ericsson's future success lies in the development of competences that will enable it to be sensitive to its customers' requirements and to respond quickly to new business developments. Competence management is being introduced as a core management function in support of the Ericsson Strategic Plan. It is the individual's responsibility to safeguard their employability by developing their competence in accordance with the needs of the company, and the company's responsibility to provide enough information for the individual to make the right learning choices. Competence management therefore involves the cooperation of individuals and managers to identify required competences, to assess current competences, to recognise the gap, to plan to fill the gap and to act accordingly. The introduction of competence management was facilitated by the development of a company-wide competence model in which 'competence is to acquire, use, develop and share knowledge, skills and experience (Ericsson, 1996b: 4). The model highlights the responsibility of the individual and the role of the company in the development of competence through learning and the sharing of that knowledge to the maximum benefit of the company. The Ericsson competence model is depicted as a triangle (see Figure 4.1) that gives equal importance to:

- Technical/professional competences that are specific to certain operations, occupations or tasks and include technical design, product knowledge and finance.

- Human competences that are required for appropriate interaction both outside and inside Ericsson. They include teamwork skills, communication skills and cultural awareness.
- Business competences that are ‘related to the understanding of the Ericsson business and objectives in the context of its market, customers and competitors, as well as in the political and social environment’ (1996b: 7).
- Individual capacities that are not normally subject to development within the company and include self-esteem and intellectual abilities. They influence the ability to develop competences, and accordingly they are considered during recruitment and promotion (Ericsson, 1996b).

Figure 4.1. The Ericsson Competence Model



The purpose of developing competence is to succeed through better service to the customer in the competitive marketplace. Ericsson believes that ‘the winners in the battle for the telecommunications market will be companies that have the best relationships with large operators’ (1994a: 16). Therefore, competence development is focused on the market. The purpose of technical/professional and human competence is to support the knowledge gained from business competence.

The development of understanding of these challenges is recognised to be of great importance to Ericsson (Ericsson, 1994a). Operators seek close cooperation and secure relationships in order to cope with the pressures of technological change. Those who anticipated that deregulation would mean a discounting of relationships are said to be wrong. Operators do not seek the cheapest solution. Rather they seek cooperation in order to develop the right technology in terms of market sensitivity and long term development strategies. Ericsson limits its relationship with major customers by refusing to become a carrier in order that it will not be seen to be in competition with other operators (Ericsson, 1994a).

4.4.3 The Swedish national system of innovation

This subsection considers elements of the Swedish national system of innovation that are relevant to learning in Ericsson. Following Edquist and Lundvall (1993) elements that lack direct relevance to learning in industry, the financial system for example, are not discussed. The elements of the Swedish national system of innovation discussed here are:

- Swedish social conditions
- research and development activity.

4.4.3.1 Swedish social conditions

According to Carlsson and Jacobsson (1993), social conditions in Sweden were historically attractive for the development of high-tech industries and automation. These conditions include persistent labour shortages and high wages, a highly educated labour force and a trade union movement with a positive attitude to technology. The 'Swedish model' was characterised by an interplay of three equal parties: efficient and concentrated capital focused on engineering and paper products; strong, centralised trade unions, and the Social Democratic government that practiced consensus politics. The push for technological advancement was equally strong from all three parties. Companies saw it as a chance to overcome labour shortages. The union movement saw it as an opportunity to annex the

increased productivity in higher wages. The State saw indigenous military technology as the basis of armed neutrality, and the opportunity for enormous infrastructure projects to fulfil its social obligations in energy, transport and communications. State technical procurement was used as a tool to direct firms to develop engineering technology. The recent and on-going internationalisation of capital has changed the balance in Swedish society by reducing commitment to indigenous innovation by companies that now access technology through their overseas arms. This has reduced the unions and government's power to push for technological advancement. Sweden has been unable to move away from its now-outdated mechanical engineering trajectory and along an electronics trajectory even though it is one of the highest density users of 'mechatronics'. Such technological impactedness is said to be partly responsible for the stagnant growth rate and the high and rising unemployment with a society that is locked into non-competitive, high wages. Thus, Edquist and Lundvall (1993) argue that the social institutions that served Swedish innovation well in the industrialisation era are less appropriate to the present era. The stubbornness of these institutions is reflected in the on-going social and technological path that now hampers economic development and innovation.

Another aspect of the Swedish social conditions for business is Sweden's low and historically homogenous population with common schooling and religious roots. Swedes, as individuals, are committed to social issues and belong to many associations. Through these associations they meet each other repeatedly and in varied ways. This provides opportunities to build the reputation that is the basis of small business dealings (Stenberg, personal communication). Lundgren, (personal communication) confirms this, and adds that universal national service for men leads to contacts that are developed in their initial training period and renewed during subsequent refresher stints. These contacts form the basis of networks for the sharing of knowledge.

4.4.3.1 Swedish research and development activity

According to Edquist (1995b) there is inadequate data on innovation because of the OECD's historic focus on the R&D system rather than the system of innovation. This focus measured inputs to R&D in terms of manhours and money rather than innovation outcomes. It also ignores innovation outside R&D, including learning by using and learning by doing. While the national system of innovation is much more than the R&D system, R&D data is often the only data available. Moreover, the data on the R&D inputs do not reliably reflect the innovative status of a national Sweden, for example, spends a lot on R&D but has a low level of innovation. Furthermore, research in Sweden and of Sweden has been largely focussed on the Swedish social and political model, rather than on technology. Sweden's recent contribution to the global pool of knowledge might be 'socio-organizational rather than technical' (Edquist and Lundvall, 1993: 285). This accounts for Sweden's poor performance in product innovation, and good performance on process innovation (Edquist, 1995b)

Government expenditure on R&D at 3.02% of GDP in 1996 was the highest proportion in the world (OECD, 1997b) Nevertheless, there is concern about the distribution and focus of this R&D. Eighty five per cent of the R&D in the business sector was development undertaken by manufacturing firms rather than research, *per se*. Excluding the research-intensive pharmaceutical industry, only 8% of the R&D undertaken by industry is research, the rest is development (NUTEK, 1996a). About half of the R&D undertaken by public authorities (including universities) is research, and half development (Edquist and Lundvall, 1993). The cautious conclusion is that Swedish industry invests less in research than the industry of its major rivals (NUTEK, 1996a). This section looks at the R&D activities of business, Government and universities in Sweden and the role the National Board for Industry and Technological Development (NUTEK) in addressing the inadequacies of the system.

R&D undertaken by businesses

Historical engineering activity in Sweden led to the growth of a few large successful companies including Alfa-Laval, SAAB, Volvo, Electrolux, Ericsson and ABB (ASEA). Swedish engineering has been very concentrated with the top five firms producing one fifth of the value added in manufacture in 1982 (Edquist and Lundvall, 1993). These companies form an innovation block that demands highly trained engineers from the universities, and technological advancement from their suppliers. In robotics, for example, the Swedish customers are considered to be the most sophisticated in the world and to be pushing the domestic robotics producers to become world leaders (Carlsson and Jacobsson, 1993). Transport equipment (mainly motor vehicles and aircraft) and telecommunications industries account for half of the R&D person-years of the Swedish manufacturing industry. A further quarter is accounted for by pharmaceutical and machinery industries. R&D intensity, the ratio of R&D to value added, is the greatest in telecommunications and pharmaceutical industries. R&D is dominated by 25 corporations that spend more than \$15 million per year. One third of these spend more than \$150 million per year. The firms with the largest R&D expenditure include Ericsson, Volvo, Astra, Celsius, Scania, SAAB Aircraft, SAAB Automobile, Telia and Sandvik. Foreign based ABB and Pharmacia&Upjohn are also large spenders on R&D in Sweden. The 20 largest Swedish firms perform 34% of their R&D abroad, mainly in the USA (Edquist and Lundvall, 1993).

A survey of Swedish firms with more than 500 employees investigated the contacts outside the firm that were considered very or extremely important sources of knowledge for innovation. The findings were that more firms reported such relationships with suppliers and competitors in the rest of Europe than in Sweden, and almost as many firms reported such relationships with customers in the rest of Europe as in Sweden (NUTEK, 1996a). This is said to provide firms with learning opportunities that lead to indigenous innovation.

University R&D

More than 85% of the public funding of non-military R&D goes to universities, which are state-owned in Sweden. This reflects the policy decision to avoid splitting

the research resources. This support creates an obligation for the universities to provide the results to aid Sweden generally. Making good use of universities is an important strategy for Swedish industry that implies a need for collaborative research between industry and universities (NUTEK, 1996a). The relevance of this strategy is heightened because Swedish firms tend to form relationships with Swedish universities rather than internationally. While 60% of the large firms had extremely important relationships with Swedish universities and research institutions, only 25% had them in the rest of Europe, 29% in North America and 5% in Japan (NUTEK, 1996a).

Government role in R&D

The Swedish Government support of private R&D has largely been a side effect for the national defense program. Some 80% of Government direct funding of R&D in the business sector has been focused on defense issues (Statistics Sweden, 1996). Sweden devotes a smaller share of public R&D funding to non-university Government R&D institutions than any other OECD country (OECD, 1997b). Moreover, this is largely for non-technical R&D. Funds for technical research have been provided with Sweden's entry to the EU and participation in the EU research programmes (NUTEK, 1996a)

Furthermore, the Swedish Government's long standing policy of being a competent and demanding customer has been an important factor in the ongoing development of technology in Sweden. This policy has been made powerful by the large proportion of the GDP spent by the Government. However, the recent escalation in the level of technology in many industries, including telecommunications, renders the Government unable to continue in its role of competent customer because it no longer has the expertise necessary to push technological advancement among its suppliers (Lundgren, personal communication). Moreover, the Swedish Government is committed to adhering to the GATT and EU regulations that limit the Government's ability to use procurement policy to support domestic industry (Stenberg, personal communication; Karlsson, 1995).

A major contribution from the Swedish Government to R&D has been the establishment of 'bridging institutions' (Carlsson and Jacobsson, 1993) that connect large firms with academic institutions, Government agencies and small firms. Two major bridging institutions are Swedish National Board for Industrial and Technical Development (NUTEK), which is Sweden's central public authority for matters concerning the growth and renewal of industry, and the Swedish Institute of Production Engineering Research (IVF), which is a private research organisation operated jointly by NUTEK and the Swedish engineering industry. NUTEK (1996a) aims to address three obstacles to industrial renewal and growth:

- the proportion of R&D undertaken in industry is small,
- the level of collaboration between industry and university researchers is inadequate,
- the infrastructure for research in small and medium sized businesses is poor.

The approach to overcoming these obstacles is to bring together leaders of industry, academics and smaller companies in research and knowledge sharing projects. NUTEK therefore has a large role in developing, maintaining and improving relationships between actors in industry in order to ensure that diffusion brings the full benefit of the knowledge to Sweden. NUTEK supports long term technical research that is strategic to the advancement of Swedish industry, and that would not otherwise have been undertaken or exploited fully (NUTEK, 1996a and 1996b, Stenberg personal communication). There are three major elements to their approach. Firstly, they identify common interests of academics and business, and bring the parties together as a group. Secondly, they help fund research. Thirdly, they publicise findings in order to stimulate ongoing learning as well as to benefit all Swedish industry. These activities are planned in close cooperation with approximately 1000 people from industry, academic institutions, industrial research institutions and public agencies. These experts from industry and academics have the responsibility to cooperate in determining the extent and direction of research undertaken in the interest of industry.

NUTEK's activities that most directly affect Ericsson are its competence centres, industrial research institutes and industrial research consortia. NUTEK has established thirty competence centers to encourage collaboration in R&D between universities and industry that are of strategic importance to the development of Swedish industry. The centres bring together users, producers and designers to contribute complementary expertise to get the best result in terms of its contribution to the companies involved and to Swedish industry in general (NUTEK, 1996a and 1996b). The aim of the cross disciplinary research consortia is to build up knowledge that will benefit industry as well as science through domestic and international cooperation.

Ericsson is in a position to gain from much of NUTEK's encouragement of industry-relevant research. Ericsson is especially interested in telecommunications technology and information technology applications that together received 34% of NUTEK's research disbursement. Ericsson is also involved in some of the materials research and materials consortia that together received a further 17%. Ericsson is involved in competence centers that receive funding of \$10 million. NUTEK funds industrial research institutions in areas of interest to Ericsson to \$12 million (NUTEK, 1996b). An analysis of the NUTEK R&D programme expenditure for 1995 indicates that \$29 million is directly relevant to Ericsson's interests. This is not to indicate that Ericsson is the only company whose interests are met by those expenditures by NUTEK, just that the national system to support industry and technology is well matched to Ericsson's needs. Moreover, Ericsson is in a position to benefit from NUTEK's role of bringing parties together for exchange and generation of knowledge.

4.4.4 Ericsson and the Swedish telecommunications industry

The telecommunications industry in Sweden has been dominated by a single equipment supplier (Ericsson) and a single service provider (Telia). Although Telia's effective monopoly dates back to 1918, it was never enshrined in law (Kaijser, 1995). National support for the bilateral monopoly in the interest of

enhancing a strong neutral defense and the social goal of universal service led to massive investment in a national telecommunications infrasystem (Kaijser, 1995). The scale economies involved in the relatively simple technology of the massive network establishment favoured the natural monopoly argument for continued state ownership (Karlsson, 1995). Telia (and its predecessors Telegrafverket and Televerket) remained a largely unregulated monopoly. The government used suasion rather than regulation to have Telia operate in a way consistent with the pursuit of national goals. The effect was to encourage technological advancement and expansion. Just as the Swedish telecommunications industry was seen as a policy arm of Government rather than as a business (Karlsson, 1995), the nurturing of internationally competitive companies (such as Ericsson) was part of the policy approach of the Social Democratic Government during much of the post war period (Edquist and Lundvall, 1993).

Thus supported, relationships between Ericsson and Telia were very close and focused on technological advancement rather than commercial concerns and market satisfaction. Long-standing, informal arrangements for joint product development were formalised in the early 1970s when Televerket joined Ericsson in a cooperative development company, Ellemtel (Karlsson, 1995). Ellemtel, Telia and Ericsson jointly developed the AXE automatic telephone switching system that revolutionised switching technology (Swedish Institute, 1996). Telia established facilities to manufacture AXE for its own network. In 1993, when Telia rationalised to focus on service provision Ericsson agreed to take over Telia's production facility (Teli) and to supply AXE equipment to Telia (Ericsson, 1993a).

The erosion of the unregulated bilateral monopoly telecommunications regime began in the early 1980s with the introduction of competition in modems that unite data and voice technology. The OECD (1992) found Sweden's telecommunications market to be the most liberal in the world, the OECD (1995a) found that only New Zealand and Sweden had competition across both telecommunications services and equipment. Deregulation of telecommunications in Sweden has not only involved exposing Telia to competition, it has also involved separating service provision

from the regulating authority (1989), and the formation of a company structure for Telia (1993) (Karlsson, 1995). The logical next step, according to Karlsson, is privatisation, which has been delayed for ideological reasons by the Social Democratic Government. Freese (1995) argues that the Swedish telecommunication's market has not been deregulated; it has gone from an unregulated monopoly to a regulated free market.

Ericsson (1993) lists 38 Ericsson companies based in Sweden. These include the parent company Telefonaktiebolaget Ericsson (LME), Ellemtel (the joint venture to research with Telia), Ericsson Hewlett Packard Telecommunications AB and miscellaneous arms of Ericsson such as finance and treasury along with the local Swedish business units. Interviews for this research were undertaken in LME, Ellemtel and Ericsson Hewlett Packard Telecommunications AB and in two business units. One of the business units was Ericsson Telecom AB, which as the developer and producer of public telephone equipment, represents the traditional heart of the company. The other, Ericsson Radio Systems AB, represents the current driving force in global telecommunications sales and technological development. One other interview was undertaken in the Components Business Unit to capture the experiences of the only Ericsson employee who is at the same time a full time consultant to the company. Interviews were also conducted with parties external to Ericsson as detailed in Chapter 5.

4.4.5 The Australian national system of innovation

Research on the Australian National Innovation system is generally less advanced than that in Sweden. The work that has been undertaken historically focussed on the research and development activity in accordance with the OECD's focus on the R&D system (Edquist, 1995b). However, recent works by the Australian Bureau of Statistics (1994) and CSES and SIRF (1996) have identified and analysed innovation in Australia.

This section once again follows the lead of Edquist and Lundvall (1993) and focuses on those aspects that are directly relevant to the telecommunications industry. This section discusses:

- Australian social conditions
- Australian research and development activity.
- innovation in Australian manufacturing

4.4.5.1 Australian social conditions

The attractiveness of Australia to multinational corporations in the information technology and telecommunication industry is due to factor conditions, demand conditions and other factors (BIE, 1994b). The factor conditions that Australia offers include well educated and cheap engineers (BIE, 1994b), a quite well educated work force (OECD, 1997b), well-developed telecommunications and infrastructure, and until recently a 150% tax concession for R&D expenditure. The annual cost of doing R&D in Australia is low relative to the USA (70%), Singapore (70%), and Japan (40%) but high relative to Malaysia (115%) (CSES and SIRF, 1996). The domestic demand conditions include the fact that Australian consumers are considered demanding, and are early buyers of technology (Johnston, 1996; BIE, 1994a). The other factors include: proximity and time zone similarity with Asia's growing market, and extension of global competition among firms. However, the unions are strong and are often opposed to technological change, which they consider to be job destroying.

Australians are said to be the second most individualistic of the 39 peoples studied in the world (Hofstede, 1980 cited in Dodgson, 1996). The commitment to individualism suggests that Australians have a culture of loosely knit people, who avoid cohesive networks and groups. There are, therefore, not many ways for people, often from different backgrounds, to develop close relationships. This may prevent them forming the reputations of trustworthiness that are argued to be essential to inter-firm learning-related relationships and innovation. Dodgson contrasts this with the cohesive networks based on trust that are said to be the basis

of business relationships in Asia. This lack of cohesion in the Australian population may be associated with the segregation at school according to class and religion.

4.4.5.2 Australian research and development activity.

According to the OECD (1997b), Australia spent 1.61% of GDP on R&D in 1994, which is below the OECD average 2.13% for that year. Of this, 48.3% (OECD average 34.5%) was funded by Government and 45.7% was funded by business (OECD average 58.8%). Government performed 26.8% (OECD average 12.4%), business performed 46.2% (OECD average 66.9%) and the higher education sector performed 25% of research in Australia (OECD average 17.8%). Therefore, there is a reliance on the Government to fund R&D, and to a lesser extent, to perform R&D. The business enterprise sector is poorly represented in the funding of R&D, and to a lesser extent, in its performance. Australia's inventiveness coefficient, that is the number of patents granted to residents per 10,000 population is 4.67 compared to an OECD average of 5.51 and Sweden's 4.58.

An international comparison of manufacturing value added as a per cent of GDP shows that Australia has relatively little value added through high, medium high and medium R&D intensive industries. According to Dodgson (1996), the Scandinavian example of Sweden progressing from wood and iron ore resource based technology, to designer furniture and robotics (Patel and Pavitt, 1995) indicates that Australia could build on its strengths in relatively low-tech industries by linking them to higher-tech industries and to technologically dynamic neighbours in Asia.

R&D undertaken by business

Australian business undertook 46.2% of R&D in Australia in 1994. In so doing they spent 0.74% of GDP on R&D (OECD, 1997b). This is low by comparison with the OECD averages of 66.9% and 1.42% respectively, but has been growing rapidly in recent years. The proportion of business R&D that is performed in non-manufacturing industry is high in Australia at 43% compared with 7.9% in Sweden (1993). The proportion of business R&D in electrical/electronic industries is low in

Australia at 12.1% compared with 25.9% in Sweden (1993). Ericsson's Broadmeadows plant in suburban Melbourne houses Australia's largest private R&D facility (Ericsson, 1993d).

According to CSES and SIRF (1996), foreign firms dominate manufacturing in Australia, particularly in industries with high and medium high R&D intensity. Foreign firms have a higher propensity to have undertaken R&D in the past three years, but do so at a lower level. In high R&D intensity industries, Australian firms have a higher propensity to undertake R&D and do so at a higher level. However, even in high R&D intensive industries a small number of foreign firms control a high proportion of sales. Australian firms are presented as small scale but performing well in R&D, especially in high technology industries.

4.4.5.3 Innovation in Australian Manufacturing.

A recent publication by the Australian Bureau of Statistics (1994) investigates innovation in Australian manufacturing. The data contained therein has been analysed and interpreted by CSES and SIRF (1996). CSES and SIRF report on the strategic and operational objectives of innovation by Australian manufacturers. The findings included that the main strategic objective was to increase market share, and that this was pursued through the operational objectives of increasing quality and extending the product range within the existing product field. Creating new markets internationally was not a major strategic objective, nor was extending the product range outside the main product field a major operational objective. Reducing energy consumption and environmental damage were unimportant.

'Innovation in Australian manufacturing seems to be primarily directed neither at new goods and new markets nor at processes or other efficiencies in production, but at improving product quality and evolving new products within the existing product set so as to maintain or increase the firm's share of existing markets, both in Australia and overseas' (1996: 19).

Interestingly, in industries with high R&D intensity, the importance of the objective to lower production lead times was low and less than the industry average, and the importance of the objective of improving product flexibility was only equal to the average of all industries. The objective of meeting government standards was an important reason for high R&D intensive industries to innovate, but not for the others. The composite ratings (with zero for not important and 5 for crucial) for the main deterrents to innovation by Australian manufacturers on average (with figures for high R&D intensive firms in brackets) were: lack of finance 3.0 (2.7), high costs 2.8 (2.5), high risk 2.3 (2.7), lack of skilled personnel 2.4 (2.3), regulation etc 2.5 (2.6). The following were not important deterrents: lack of information, lack of cooperative partners, resistance to change, lack of technical opportunities, lack of customer acceptance. So the view that Australian industry and society deters innovation through conservatism and lack of opportunities does not seem to be correct.

CSES and SIRF also report on the sources of ideas for innovation in Australian manufacturing firms. Sources internal to the firm were not as important as some commercial sources external to the firm. The composite index for the important sources of innovative ideas for manufacturing on average (with figures for high R&D intensive firms in brackets) were: internal R&D 2.9 (3.7), internal other 2.4 (2.6), within industry 2.9 (3.4), suppliers of material 2.5 (2.7), suppliers of equipment 2.4 (2.1), clients or customers 3.3 (3.6). Government laboratories, universities, professional journals, consultants and patent disclosures were all unimportant for manufacturing in general as well as for high R&D intensive industries. Overall, customers drive innovation ideas, but in high R&D intensive industries internal R&D is a slightly more important source. The lack of importance of pure research as a source of ideas suggests that R&D in Australian industry is dominated by development rather than research.

4.4.5.4 Government role in R&D and innovation

According to CSES and SIRF (1996), the diversity of Australia's science base is a national asset that needs to be applied to industry to drive growth. Australia therefore must have policies to pursue the difficult task of forging a closer fit between Australian science and the nation's business enterprises. There appear to be three aspects to the poor fit between Australian science and Australian business: Australian science tends not to be applied, it is often undertaken in topics in which Australian industry is not strong, and there are poor links between those research institutions and industry. To some extent, this problem is different to that in Sweden where the universities have a strong applied focus in support of the development of industry, but where the links between business and universities are deemed to be inadequate.

The practice of Government is also important for innovation in particular its own R&D efforts and its purchasing practices. Sheehan, Pappas, Tikhomirova and Sinclair (1995) comments that the Australian Governments' operations provide little incentive for innovation in their relationships with industry. However, the Partnership for Development scheme links Government procurement to commitment from multinational companies to increase innovation and development of the Australian information technology and telecommunications industry.

The Australian Government is active in R&D with world class research being undertaken in the public sector science and technology institutions. As a percentage of GDP, R&D expenditure on those institutions is fourth in the world. The output of publications from Australia's science and technology institutions in three key areas of direct relevance to advanced industry (engineering, computer science and material science) reveals slow growth relative to Asian neighbours. Although business sector R&D in computer software has shown particular strong growth since the mid 1980s and exports have risen dramatically, the Australian share of the world's output of computer science research has not grown. This suggests inadequate linkages between Australian universities and the business activity (DIST, 1996b).

The links between Australia's public research activity and innovation in industry are generally poor, and there is said to be potential for greater exploitation of public research findings. To address this, the Government established Ausindustry as a single agency to administer support for business research. This support includes: tax concessions for R&D, facilitation of R&D cooperation, and funding of R&D. This common administration is said to provide an holistic approach that is consistent with the national system of innovation concept (DIST, 1996a and 1996b).

In an attempt to bring together industry and Australia's strengths in basic research, Ausindustry has several programs for cooperative research, including the Cooperative Research Centres and Centres of Advanced Engineering. The Cooperative Research Centres aim to increase the competitiveness of Australian industry through cooperation in research between business and universities in order to enhance the commercial application of research. The DIST website² lists eight Cooperative Research Centres that are relevant to computing, voice or data communication and manufacturing. Although the budget for these Cooperative Research Centres is in excess of \$300 million, and other voice, data and computer companies such as Fujitsu, Telstra, NEC, Siemens and Sun Microsystems participate, Ericsson is not involved in any. That is, Ericsson does not seem to take advantage of these opportunities offered by the Australian Government.

The Commonwealth Government is the main source of R&D funding in Australia. The Commonwealth support for major science and innovation programs in 1996-97 was predicted to be \$3.75 billion (0.84% of the GDP) and state Governments provide another \$0.63 billion (0.14%). Of the Commonwealth's funds \$1.25 billion is for commonwealth agency research, \$1.79 billion (0.42%) was for R&D undertaken through universities, \$0.71 billion (0.16%) is for business enterprise (DIST, 1996b).

² <http://www.dist.gov.au> (September, 1997).

Tax concessions for R&D are intended to encourage Australian industry to invest in R&D in order to become more innovative and internationally competitive. In the 1996-97 Budget the Australian Government made a number of decisions to reduce spending in the area of support for innovation. The tax concession was reduced from 150% to 125% and targeted to R&D with commercial relevance. It was replaced with a system of targeted loans and grants (DIST, 1996a). In addition, the telecommunications industry was generally dissatisfied with the Government's decision in 1996 to abolish schemes such as the tariff concession scheme (TCS), the development import financial facility (DIFF) and the computer bounty. These are estimated to involve a cost disability of 8% for the industry from loss of TCS, and an estimated reduction of sales of 10% due to DIFF being abolished. The combination of the TCS loss and the loss of the computer bounty is anticipated to close many small producers and eliminate 1600 jobs in the industry (Connolly, 1996).

4.4.6 Ericsson and the Australian telecommunications industry

The Australian market is important to the telecommunications industry, and the telecommunications industry is important to Australia. The Australian telecommunications market is the eighth largest in the world and accounts for 2% of the global telecommunications equipment budget (ATIA, 1995; BTCE, 1995). The rate of penetration of mobile communication was 12% of subscribers in 1994, which was second only to the Nordic countries that had mobile many years before Australia (Ericsson, 1995d). Australian exports of telecommunications equipment exceed \$1 billion a year, or 40% of the exports of information industry, partly due to our proximity to booming Asia (Connolly, 1996).

Historically, the Australian telecommunications industry was comprised of a single service carrier and several telecommunications equipment companies all of which have been foreign owned multinational companies since the collapse of the Australian equipment company AWA. The monopoly carrier, now called Telstra, is Government owned and became a corporation in 1975 when it was separated from

the postal service. Its operations have involved a mixture of profit seeking, fulfilling service obligations such as universal service and cross subsidisation of rural communication and a commitment to technological advancement (Joseph, 1996). Ideological commitment to the privatisation of Telstra has waxed and waned over the last two decades. The current conservative Government is proceeding to sell one third of Telecom in 1998. Competition for Telstra was introduced in 1991 when Optus was granted second carrier licence. In 1992 a third mobile licence was granted to Arena GSM (Vodafone). In July 1997 licensing was opened to broad competition.

Applications for carrier licences are assessed by the Government on how the proposal would impact on the development of the telecommunications industry in Australia. Each carrier must have and implement an industry development plan. Telstra's plan, for example, included commitment:

- to enter into long-term agreements whenever there is a continuing predictable and significant demand for a product;
- to cooperate with the Government to assist Telstra's major suppliers to comply with the Government's industry development policies;
- not to purchase from overseas firms without first considering Australian firms that it knows to be suitably qualified;
- to invest more than 1.5 per cent of its sales revenue in R&D; and,
- to assist its suppliers to meet world's best practice (BTCE, 1995: 69).

In these plans, the carriers offered local content targets by registering a preference for the procurement of capital equipment, products and services from specific Australian-based companies. Telstra and Optus agreed to reach a target of 70% on capital equipment. Vodafone has agreed to use partnership companies to subcontract and these are identified in their licence agreement. These partner companies are required to have a 60% local content (BIE, 1994b).

To enhance the competitiveness of Australian information technology and telecommunications industry equipment suppliers, the Government introduced the

Information Industry Strategy of 1987 to improve skills formations and education, the operational environment of local firms, the international integration of local firms and product development. Industry Development Agreements were introduced in 1988. Under the agreements, suppliers earned points for R&D, local manufacturing and exports. If a supplier falls below a minimum number of points, they are not permitted to supply equipment the following year. Exemptions have been introduced for companies that either join the Partnership for Development Program (for companies with sales greater than \$40 million) or the Fixed Term Arrangements (for smaller companies). In June 1994, of the 36 telecommunication equipment companies 18 were exempted because they had entered one or other of these agreements (BTCE, 1995). Ericsson has joined the Partnership for Development scheme that commits them to achieve within seven years:

- exports equal to at least 50% of imports,
- local value added content in their exports of at least 70% on average,
- expenditure on R&D equal to at least 5% of annual turn-over.

Partnerships for Development encourage international companies in information technology and telecommunications to commit to strategic business activities in Australia. They encourage firms to work closely with local companies that are said to benefit from access to technology, equipment, management expertise and global distribution channels (BTCE, 1995). In return, the Commonwealth Government undertakes to notify procuring agencies at the national and state or territory level of the Partnership for Development and Fixed Term Agreement status of companies. The objective is to obtain value for money in procuring the most suitable goods and services at the right price and time using an open and effective competitive process. Given this, the objective is to maximise opportunities for New Zealand and Australian suppliers to compete for Government business. Partnerships for Development and Fixed Term Arrangements mean that multinational companies are treated the same as Australian and New Zealand firms because of their local industry development activities. The BIE (1994b) estimate that the Partnership for Development program has been successful in encouraging the development of activities of multinational information technology and telecommunications

companies in Australia, stimulating exports and import replacement and developing relationships between the multinational companies and local suppliers and research institutions.

Ericsson has three companies operating in Australia: Ericsson Australia (EPA), Ericsson Data, and Ericsson Defense Systems. Ericsson Australia, as the largest and the one directly involved in telecommunications, was chosen for this case study. Ericsson Australia's organisational structure was modified in 1995 to include five business units that focus on marketing, installing and maintaining equipment and services to specific markets (public, business, international, mobile and Vodafone), and two functional units that support the business units: system design and engineering, and supply (Ericsson, 1995d). While Ericsson Australia is said to be autonomous and responsible for the Australian market, the business units are directed by their respective branch in Sweden. Ericsson Australia is important to Ericsson globally because of the dynamics of the Australian market and Australia's strengthening role in the Asia and Pacific regions (Sorme, 1995). Interviews for this research were conducted in the areas of public telephony, business telephony and mobile telephony, as well as with parties outside Ericsson. Details of the interviewees are provided in Chapter 5.

Ericsson Australia employs over 2,200 people, almost one third of whom are directly employed in product design and development. Ericsson Australia dedicated 10% of turnover to R&D in 1994, which was double its Partnership for Development commitment (Ericsson, 1995d).

Ericsson Australia is one of four multinational companies that dominate public telephony equipment sales in Australia. Together with Alcatel, they account for 34% of total domestic telecommunications market and with Nortel they account for the entire public network switching market (BIE, 1994b). The other major public telephony equipment supplier is Siemens, which mainly supplies transmission equipment, and so is not directly a competitor to Ericsson in public telephony. Most

of the global telecommunication equipment suppliers are active in the Australian mobile telephony and private exchange markets.

Deregulation has led operators to seek closer relationships with suppliers in order to develop the best solutions for the competitive market (Ericsson, 1994d). In 1993 Telstra embarked on the Future Mode of Operation (FMO) program, which has two chief aspects. Firstly, to invest funds and resources to develop an ultramodern network that will provide Australia with a high quality telecommunication infrastructure in support of business. Secondly, to help develop the Australian industry through local sourcing. Ericsson was selected for a strategic alliance that involves a joint marketing agreement that includes risk and reward sharing (Ericsson, 1996d). The relationship with Telstra commits Ericsson to develop and share process as well as product technology. An example is the 1993 agreement to help Telstra achieve world's best practice in network performance. The introduction of Ericsson processes and standards of practice enabled Telstra to reduce down time from 40 minutes per exchange per year to a new world's best practice of 5.4 minutes down time in 1994 (Ericsson, 1994d). Ericsson also has a strategic alliance with Vodafone. A separate business unit was established in Sydney in 1993 to deal with Vodafone. Vodafone's GSM network is supplied by Ericsson. A close relationship with Vodafone is said to have been achieved quickly and now includes joint funding of university research (Ericsson, 1996d and 1995d).

4.5 Conclusion

The selected case study, Ericsson, is thus a telecommunications equipment company operating in an industry that has recently been the subject of rapid and ongoing technological and regulatory change. The focus of national regulation in both Australia and Sweden is to ensure the success of the telecommunications industry in accordance with objectives of encouraging innovation and price reduction, while maintaining a commitment to service and quality. However, the convergence of technologies makes those formal regulations, and the functional regulations imposed internationally by technical standards, more complicated and subject to anomalies.

Moreover, relationships within the industry between suppliers and customers develop methods to reduce the impact of regulations and so maintain the monopoly power of the established firms.

The objective of the empirical investigation is to understand Ericsson's learning and innovation within the general environmental context described in this background material. The specific research question to be addressed by the case study is: How can the learning undertaken by the multinational telecommunications company Ericsson in the face of liberalisation of the service market be understood?

CHAPTER 5

The Empirical Method

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5.1 Introduction

This is the second of the five chapters that report on the empirical investigation of learning in Ericsson in Sweden and Australia. The investigation was introduced in Chapter 4, where it was explained that the chosen method was a descriptive case study.

The purpose of this chapter is to describe the method of the investigation including data collection and analysis. The plan of this chapter is that qualitative research is discussed in section 5.2. The research design, including the design of the investigation, data collection and analysis, is described in section 5.3. A conclusion is provided in section 5.4.

5.2 Qualitative research

This research is concerned with abstract concepts of learning, knowledge, relationships and the institutions that regulate learning-related behaviour. These concepts are not suited to quantification because measurement and enumeration are

not critical to their worth. Rather, their worth is determined by the context in which they occur and how they are perceived. The worth of knowledge, for instance, does not lie in the number of things known, but rather in how that knowledge is valued in the context of the industrial setting in which it occurs. To reduce knowledge to a numerical value would be a crude reduction in the potential richness and value of the findings. The qualitative nature of the concepts required that the research method, including data collection and analysis, be designed to capture the contextual information that gives meaning and value to those concepts rather than to enumerate them. Qualitative research has the capacity to do so, and so was chosen in preference to quantitative research for this investigation.

While the value of qualitative research has been recognised in other social sciences, its use in economics has not had the popularity of quantitative data in recent years. The reluctance to use qualitative research in economics stems partly from the domination of the neoclassical model in which rigour is often equated with mathematisation. The dominance of quantitative data to the exclusion of qualitative data has been recognised by Romer (1994) as restricting the understanding of learning.

‘Looking back, I suspect that I made this shift toward capital and away from knowledge partly in an attempt to conform to the norms of what constituted convincing empirical work in macroeconomics. No international agency publishes data series on the local production of knowledge and inward flows of knowledge. If you want to run regressions, investment in physical capital is a variable that you can use, so use it I did’ (1994: 20).

Moreover, qualitative research has been criticised as ‘vague, impressionistic, records disconnected or skimpy, not rigorously sampled or collected, small scale, of dubious origin, partial, and perhaps most significantly, not objective and distorted by researcher’s perception....Qualitative researchers have done little to confront the accusation, tending to confirm it with reports couched in vague terms and presented as pilot studies’ (Richards, 1992:1-2).

Therefore, rigour was a central concern in the design of this research. Rigour was sought through systematic and detailed attention to principles of data collection and analysis. These principles are drawn from a variety of references (Yin, 1993; Miles and Huberman, 1984; Lincoln and Guba, 1985 and 1986; and Toulmin Rieke and Janik, 1979) and provide a 'quasi-judicial case study method [that applies] rigorous reasoning in the interpretation of empirical evidence systematically collected' (Toulmin et al, 1979: 9). The aim was to produce trustworthy conclusions that are unbiased and compelling (Robson, 1993), in that they are credible, transferable, dependable and confirmable (Lincoln and Guba, 1985).

'Credibility' means that the research should be trustworthy in the sense that the reader may be confident that the findings are true to the context in which the study was undertaken. Credibility is analogous to internal validity in quantitative research. Credibility in this study was enhanced by two methods. Firstly, multiple sources were used to confirm reports. Comments were checked with other interviewees who were in a similar or corresponding situation and therefore would be in a position to know. They were also checked with interviewees outside the area in order to assess their generality. Care was taken in this process because the contextual basis of the comments by the first party may not be relevant to the second party and so distort their understanding. Secondly, the data, findings and interpretation were checked by a review panel. The purpose of this check was to check for factual accuracy and interpretational logic, in order to assess in order to enhance the credibility of the research. The panel comprised of two well-experienced engineers in the telecommunications industry, one of whom is an employee of Ericsson, neither of whom took part in the research. Statements of credibility from both panel members appear in the appendix.

'Transferability' implies that the findings from one research context can be applied to another context. It is analogous to external validity in quantitative research. Whereas external validity is determined by the quantitative researcher through confidence levels, transferability cannot be determined by the researcher. The qualitative researcher provides the thick description or database that will enable a

reader, who is interested in applying the findings to another context, to decide whether such application is reasonable. The investigation reported here aimed to facilitate decisions about the transferability of the findings by collecting, analysing and interpreting a broad range of data in order to provide as much relevant information as possible.

‘Dependability’ implies that if the study was repeated in the same context it would yield the same findings. It is analogous to reliability in quantitative research. Dependability is ensured by the same process as ensured credibility because, as Lincoln and Guba (1985) argue, findings cannot be credible if they are not dependable. As discussed above, dependability was enhanced at the data collection stage of this investigation by multiple sourcing. An audit of the processes was performed to ensure dependability at the analysis stage. The audit was undertaken throughout the analysis and involved double coding of data to ensure accuracy, and checking findings for bias and comprehensiveness. Moreover, the interview tapes were checked to ensure that the interview style produced quality outcomes in the sense of full and unbiased responses. The audit report appears in the appendix.

‘Confirmability’ is the degree to which the findings can be attributed to the subjects rather than the biases of the researcher. It is analogous to objectivity in quantitative research. Confirmability was ensured in this study by the establishment of an audit trail and by member checking. Member checking involves the interviewees in reading the findings to confirm that their responses have been appropriately reported. This was undertaken in this research by the findings being sent electronically to each interviewee. A covering note indicated that if they were satisfied with the findings, that is that they confirmed that their comments had been appropriately reported, they need not reply. There were no replies arguing that the work could not be confirmed, or that the findings in any way misrepresented any comments. The cover note for that process appears in the appendix. The audit trail includes the raw data and transcripts, notes on reducing that data to a summary format, the summary output, notes on the analysis, the analysis output and notes on interpretation. This material is available for inspection.

5.3 Research design.

There are four elements of the research design of the investigation reported here: the selection of the method, the design of the investigation, the data collection process and data analysis techniques. A description of the last three of these follows, the first having been discussed in Chapter 4.

5.3.1 Design of the investigation

The essential elements of the investigation design are the choice of data collection strategy, the choice of the unit of analysis and the selection of the particular case for investigation. Firstly, a one-time data collection strategy was selected, rather than the longitudinal alternative, because the type of data to be collected was suited to a single interview with each source. The object is to gain an understanding of learning in industry as experienced by the interviewees. While changes in that learning over time are of interest, it was believed that the experience of changes over time could be relayed by the interviewees in a single meeting. Therefore, a longitudinal study was not necessary to capture the interviewee's experience of change in learning. Secondly, the company was chosen as the unit of analysis because it is at the company level that innovation and technological change happen. While learning is personified and occurs at the individual level, in industry the individual is embedded in the company and learning is largely undertaken in the interest of the firm. Thirdly, the selection of Ericsson as the particular case study was explained in Chapter 4.

5.3.2 Data collection process

The evolving nature of qualitative research means that sampling, data collection and analysis are part of a single iterative process. In this investigation, the data collected from the subjects interviewed early in the research was based on points drawn from the theory. The preliminary analysis of that data suggested further aspects of data to be collected from subsequent subjects. Similarly, the data collected early in each

interview was based on points drawn from the theory, or suggested by the data collected from previous subjects. These early responses by the subjects suggested other aspects that were of interest to the thesis, and to which they had the capacity to contribute. At each stage of data collection the data was analysed for meaning in order to determine subsequent data collection. This iterative process was undertaken to ensure that the final data collected provides as much information as possible. Therefore, in describing the data collection process it is essential to introduce some elements of the analysis.

Six important elements of the data collection process of this research are described in this section: the selection of interviewees, the sample, the in-depth interview style, the preparation for interviews, the interview content and confidentiality issues.

5.3.2.1 The selection of interviewees

The purpose of the sampling was to include respondents who could contribute information on the breadth and richness of learning in Ericsson. Therefore a sample that would maximise the variation between the subjects was chosen. A non-probability sampling technique that involved dimensional and snowball sampling was used. Non-probability sampling involves the purposeful selection of each respondent using a criterion other than probability. In this investigation the criterion was to include subjects who could contribute information on particular dimensions of learning in Ericsson.

Dimensional sampling has some features in common with the quantitative technique of cluster sampling. Cluster sampling is used in quantitative research to increase the precision of inferences about populations where the population is divided into reasonably homogenous groups. Stratification is an attempt to include contextual data in the sampling technique. The more precisely the stratification can be made, the better the inference (Lincoln and Guba, 1985). In dimensional sampling, the context of each subject in the sample is considered individually rather than clustered around a common context. Dimensional sampling marries well with the qualitative

nature of this research because it enables the social and institutional context in which learning is undertaken to be investigated. To 'cluster' to a particular level of precision would lose the information available through full contextual consideration.

The first step in the dimensional sampling was to identify dimensions of the populations that were likely to contribute valuable information. The initial dimensions were suggested by the company structure and through general knowledge of the industry. These dimensions included design engineers and training professionals. At the outset of the data collection many of the relevant dimensions were unknown to the researcher. Some became known through the preliminary analysis of the initial data collection. Some suggestions of possible dimensions were initiated by interviewees, for example, individuals with a personal mission to bring about change in the organisation. Others were suggested by interviewees in response to direct questions as to what other factors they considered important to learning in Ericsson. These included profession representatives to the standards bodies. The process was simplified because the interviewee who suggested a particular dimension was often in a position to recommend a suitable interviewee. In cases where no subject for a dimension had been recommended, the researcher contacted the relevant company or section by telephone, discussed the issue and sought a recommendation.

Thus, snowball sampling was used in support of the dimensional sampling. In snowball sampling initial subjects are asked to suggest subsequent subjects who would be in a position to contribute particular information. Snowball sampling therefore relies on the 'insider' knowledge of subjects (Minichiello, Aroni, Timewell and Alexander, 1995). Discriminating snowball sampling enabled the interviewer to identify and access subjects who were considered by their peers to be in a situation to contribute on a particular dimension. Requests for suggestions of subjects sought those who did not support the position held by the interviewee as well as those who held more detailed information. The researcher guarded against allowing the process to become chaotic and led by the subject without critical

direction from the researcher, or to rely on the convenience of subjects. In this way the sample is believed to be both representative and broad.

The sample size was determined by redundancy. That is, that the sampling and data collection continued until all the dimensions that were identified had been sampled and the data collected became repetitive, indicating that all the relevant data had been collected. Further sampling and data collection was deemed unlikely to provide additional insights.

5.3.2.2 The sample

A total of 73 interviews were undertaken. Of these, 28 were of Ericsson employees in Sweden and 21 in Australia. Of the 28 in Sweden, 12 were in engineering positions and 16 were in non-engineering positions. Of those in non-engineering positions, 10 were qualified engineers. Of the 21 in Australia, 9 were in engineering positions, and 12 were in non-engineering positions, of which 6 were engineers.

The other 24 interviewees were not employed by Ericsson. Of these: two were consultants, both in Sweden; five were with universities or academic research institutions, three of whom were Australian; three were from companies with compatible technology, the one from Sweden was on secondment to a joint venture between Ericsson and Hewlett-Packard; eight were from customers of whom two were in Australia, one of the Swedes was in a joint venture between Ericsson and Telia; two were from industry associations or groups, one in each country: three were from Government agencies, the two Swedes were from NUTEK, the Australian was from the Telecommunications Industry Development Authority (TIDA), and one was from a competitor in Australia.

The response rate was high at just over seventy five per cent. Of the fourteen people who were contacted, but were not interviewed, only one (a Swedish manager with Ericsson's parent company, LM Ericsson) refused to participate. The other thirteen were not interviewed for a variety of reasons, including travel commitments and a

belief, shared by them and the interviewer, that they were not suitable, usually due to short duration in the position of relevance. In all thirteen cases these were able to recommend someone else with more time or more information to contribute.

5.3.2.3 The in-depth interview technique

Case studies typically rely on interviews or written text because the rich, contextual data cannot normally be collected in other ways such as surveys and questionnaires. The primary data for this investigation were collected through in-depth interviews that used conversational techniques to draw out the interviewee's contribution. The recursive nature of the conversational in-depth interview provided the opportunity to explore responses in order to assess their importance, their generality and their meaning. In-depth interviews were chosen in order to explore the contextual richness of the respondents' insights that would have been missed if a survey method were employed or if an interview protocol had been followed.

A semi-structured interview format was chosen over unstructured interviews because a set of question topics had been developed from the theoretical material presented in Chapters 1, 2 and 3. These topics are discussed below. The need for flexibility to explore responses or to leave out topics irrelevant to the progress of the interview or to the dimensions of the particular interviewee's context, led to the choice of the semi-structured format over a fully structured format. The objective was for the interviewer to retain control and direct the interview by introducing topics to which the interviewees responded. This was preferred to the alternative where the interviewee is treated as an informant who directs the conversation, in order to direct the conversation to the pre-identified discussion topics. However, in line with the flexibility of the unstructured interview, the interviewee had opportunities to inform on topics not directly raised by the interviewer. Where these appeared fruitless, control remained with the interviewer to redirect the conversation. Strict adherence to ex-ante determined questions would have limited the domains covered. This would have implied an unacceptable restriction on the data.

The interview style aimed at full and frank responses. Full response were achieved by ensuring that questions were simple and clear, and by allowing sufficient time for the response. The language of the questions was simple and devoid of jargon. This was considered to be just as important with the Australian respondents as with the Swedish respondents. The first questions in each line of investigation were general and led to more specific questions and perhaps to more global questions. An example would be a string of:

- ‘What do you mean when you say you are an inventor?’
- ‘How did you learn to do that?’
- ‘When you say that you learned to do it here in the group, what does that mean?’
- ‘I’m trying to understand what your experience tells me about learning in Ericsson.’

In this way the respondent had the opportunity to embellish their story in order to provide explanatory or contradictory details. They had the opportunity to talk about themselves and their own learning in the context of the company.

Frank responses were achieved by framing questions in a neutral and unthreatening way. This implies not only that the questions were not leading, but also that the questions were not biased. Furthermore, frank responses required that the interviewer maintained a neutral stance when listening. That is, that all comments were welcomed with interest. An appearance of displeasure or boredom with responses, for instance, could have led respondents to adopt a less frank approach that was perceived to be more acceptable to the interviewer. Neutrality was achieved by the interviewer becoming aware of her prejudices, viewpoints and assumptions regarding the phenomena under investigation and guarding against them influencing the interviewee’s responses (Katz, 1987). Careful listening and mindfulness of the interviewer’s own paradigm enabled the interviewer to understand the speaker’s perspective and to avoid overlaying it with her own perspective. While neutrality was accepted as an aim, the extremely neutral stance of a detached interviewer was

rejected in favour of one in which the interviewer welcomed all responses positively but without collusive encouragement.

The interviews were undertaken in person wherever possible. The exceptions were four cases in which the individuals were too far away to visit in person, and were interviewed by telephone. These were Australians located in Canberra who were employed by the Government or industry association. One Australian engineer employed by Ericsson was also interviewed by telephone because he was flying to Sweden later on the day he was contacted. The interviews were undertaken in the office of the interviewee except for an employee of a data company who was interviewed in a restaurant because his office was being renovated. An air of informality was achieved by preliminary chat irrelevant to the topic. The purpose and content of the study was then reiterated, and the interviewee was invited to ask questions to clarify concerns. The desire to establish a warm and relaxed atmosphere in which to have a conversation about learning was balanced by the researcher's appreciation of the time commitments of the interviewees. Moreover, the non-confronting nature of the topics covered were deemed to require less confidence between the parties than would more sensitive issues.

The early interviews were recorded by hand because it was believed that this had two advantages over electronically recorded interviews. Firstly, sensitive material may not be forthcoming if the interviewee knows that there is 'hard' evidence of their responses. Secondly, the researcher likes to 'flick back' over the interview to draw points for later discussion. This was considered to be particularly important to take advantage of the recursive element in the in-depth interview style. However, it was subsequently decided that these advantages were at the expense of details not recorded during rapid discussion. Attempts to slow the discussion were either unsuccessful or else disrupted the conversation. Therefore, the great majority (68 of the 73 interviews) were recorded on a small unobtrusive cassette recorder, with the consent of the interviewee. Hand annotation was made in support of these recordings. The cassette was turned off at the interviewee's request when the material was considered by them to be unduly sensitive. Reluctance to contribute

sensitive information was overcome by reassuring the interviewee of confidentiality and their right to preview the findings. An advantage of the conversational style and semi-structured format was that if the interviewee avoided issues early on, they could be re-addressed later when the interviewee had 'warmed'.

Documentary material used in this investigation was of two types. Firstly, the material used in preparing the background to the case study presented in Chapter 4 was typically contained in formal documents intended for an audience either internal to the source organisation or more public. This included annual reports and newsletters as well as books and journal articles. The material gathered in support of the interviews was typically intended for internal use within the organisation. This included workshop notes, overhead slides, and copies of questionnaires used internally. Some of this material was provided by interviewees because it presented arguments not easily conveyed in an interview, either because they were diagrammatic or because they were too lengthy and detailed to cover in a single interview. They were accepted on the proviso that they could be discussed in a subsequent interview if necessary.

5.3.2.4 Preparation for interviews

Both the interviewer and the interviewee were prepared for the interviews. The interviewer prepared by improving her interview skills to facilitate the collection of quality data. The quality of the data collected through interview relies on the experience and skill of the interviewer. The interviewer was experienced in conducting both structured and semi-structured interviews. Nevertheless, the researcher sought to enhance interview skills by undertaking intense training in in-depth interviewing. This training was conducted by a professional interviewer with extensive counselling experience who also lectures in research methods. The training emphasised techniques to control and direct the interview, and conversational strategies to achieve full and frank responses. Before each interview the researcher prepared a set of question topics that were compatible with the dimensions on which it was anticipated that the interviewee would be able to

contribute information. Through introspection, the interviewer identified her own perceptions on these topics in order to avoid imposing them on the interview.

Preparation of the interviewees began with an initial telephone contact in which the purpose and style of the research was explained. Preliminary discussion of their knowledge of that area indicated their relevance to the particular dimension. If they were relevant to that dimension they were invited to be interviewed. An interview appointment was then made. The early discussion on the telephone gave the respondents the opportunity to reflect on their learning experiences and behaviour. This was followed by a common letter explaining the study and outlining the areas of particular interest, which appears in the appendix. The letter did not indicate any theoretical position in order to avoid establishing a mind frame for responses. The decision to inform subjects of the content and purpose of the interviews was made in the interest of increasing their ability to provide considered response in a single interview.

5.3.2.5 Interview Content

As discussed above, the interviews followed a framework of question topics rather than a protocol in order to enable the personal insights of the interviewees to be investigated. Separate frameworks were developed for each interviewee. However, there were two basic types. One was for Ericsson employees, while the other was for interviewees with parties that were believed to have had a learning-related relationship with Ericsson.

The Ericsson Interview Framework. There were two basic aspects of the framework for interviewing Ericsson staff. One was to gather data on the interviewee's own learning in Ericsson, and the other was to gather data on the company's professional development programmes and policy from those with a responsibility for professional development. Therefore, staff with a primary role in professional development were to respond to both aspects, while other staff were to respond to the aspect on their own learning only.

Those with a professional development responsibility were asked to report on several general areas relevant to their role. The emphasis on each area varied between respondents depending on the material that they were able to contribute.

Interviewees were asked to report on:

- their role in the company
- Ericsson's approach to professional development including formal training
- the selection of content, method and students or members for professional development programmes
- staff (student) attitudes to learning
- relevant internal and external relationships
- the limits to their teaching role.

In relation to their own learning, respondents were asked to report on themselves as learners in their own right. The interviewees were asked to report on the following:

- how they go about learning
- Ericsson's approach to their learning
- personal attitude to learning
- selection of content and method for learning
- internal and external relationships important to their learning
- the limits to their learning behaviour

The conversation was repeatedly drawn to practical issues regarding the how, the why and the what of learning. These outlines facilitated a free ranging discussion that would encourage conversation to cover all the relevant issues, without asking questions out of context. A framework that focused more directly on the research questions would not have succeeded in generating conversation that is rich in contextual matter.

It was initially envisaged that the second aspect of the framework would form the framework for interviews with Ericsson staff who did not have a primary responsibility for professional development. However, it became apparent that such a distinction was not always relevant because many staff take on a role of teacher

irrespective of their formal responsibility. Therefore, it was decided to allow all interviewees the opportunity to discuss themselves as teachers as well as learners. The semi-structured interview allowed the emphasis to vary in accordance with the responses.

Other company framework There were two aspects to the interview framework to collect data from parties with whom Ericsson has a learning related relationship. One aspect related to their interaction with Ericsson and covered the following topics:

- the nature of the relationship
- their policy about exchanging knowledge
- their policy about generating knowledge jointly
- the limits to the relationship

The other aspect related to their own learning and covered the areas listed above for learning in Ericsson. Once again, interviewees tended to discuss their professional development role within their own organisation. The interviewer directed the conversation away from this area, because it was only indirectly relevant to learning in Ericsson.

5.3.2.6 Confidentiality issues

Confidentiality was a concern because some respondents disclosed material that they considered to be sensitive. It was therefore essential to protect the identification of the respondents, particularly in cases where it would be possible to identify the respondent by their comments, as is often the case with dimensional sampling. Frank disclosures were encouraged by the promise that any relevant written material would be available for review before publication. The power of veto on these issues remained with the interviewee. In other cases, interviewees offered responses on the understanding that they would not be published nor used in the thesis. They were offered in order to provide an insight to the internal politics of the company. These arrangements have been kept and the material presented in this thesis is approved.

5.3.3 Data analysis

The objective of the data analysis was to show how the collected data added to the understanding of learning in industry and, specifically, to address the research questions. The challenge of the qualitative data analysis was to 'make sense of massive amounts of data, reduce the volume of information, identify significant patterns, and construct a framework for communicating the essence of what the data reveal' (Patton, 1990: 371-372). The data were read interactively in order to understand them within a paradigm of substantive issues that were drawn from the theory and that related to the research questions (Dey, 1993). The objective was to find meaning within the bounds of the theory. In this way the theory not only produced the research questions and directed data collection, it also guided the analysis.

The analysis technique involved three steps: preparing the data for analysis, classifying the data, and finding links and patterns in the data. The preparation of the data involved transcribing the interviews in full, and reading the transcripts several times in order to become intimately familiar with the material. Intimate familiarity with the data is necessary for the next step of classification.

Classification of the data involved the separation of items of data provided by individuals and organising them into common categories. Several attempts were made to develop an appropriate coding scheme. The criteria for 'appropriate' were that the coding scheme should fit the data and aid in understanding learning in industry. The final classification system, see Figure 5.1, was generally drawn from the theory presented in Chapters 1, 2 and 3. In cases where these suggestions were at a high level only, more specific sub categories were obtained from the data itself. One high level category, for example, is 'how learning is done'. The subcategories for this category were drawn from the literature and included searching, experience and instruction. The category 'what was learned' was also drawn from the theoretically derived research questions. Some of its subcategories were drawn

from the general thrust of the literature, such as learning about technology (both process and product). Other subcategories were not identified as central by the literature, and so were not originally included on the coding scheme, however, they were indicated by the data to be central, and so were added to the coding scheme. An example of this was that although the theory suggested that institutions and relationships play an important role in influencing learning in industry, the literature did not indicate that learning about those relationships and institutions would be an important component of what was learned.

There are three sections to the coding scheme. The first relates to the collection of demographic data about the interviewees. The second relates to data about the learning undertaken. This section classifies data on the practical issues of what is learned, how learning is done and why. The third section covers the moderators of that learning, that is, relationships and institutions. The final coding scheme is shown in Figure 5.1.

The coding scheme was entered on NUD*IST a software package that enhances the understanding of qualitative data by facilitating the classification of the data and by enabling links between those classifications to be investigated. It also facilitates the search for patterns in the data. The transcripts from the interviews were coded onto NUD*IST. This means that each unit of text in the transcripts was classified and recorded at the relevant nodes in the coding scheme. This process involved interactive reading and rereading of the transcripts to identify the meaning of each text unit and to determine how that meaning related to the coding scheme. Each text unit was coded to all relevant nodes. Some units were coded to up to fifteen nodes. The complexity of this classification reflects the tendency of the respondents to link concepts in a way that indicates their interdependence.

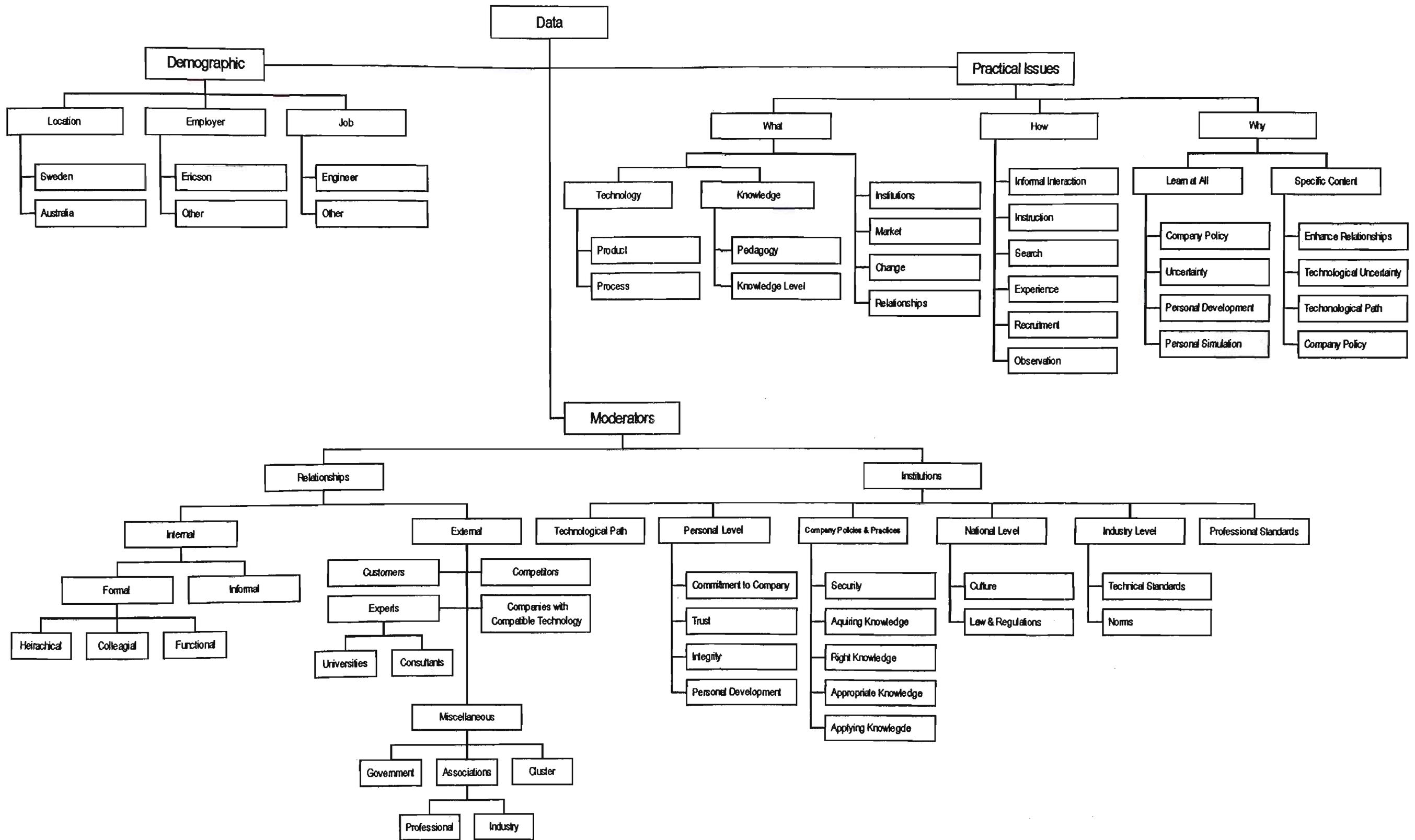


Figure 5.1 The coding scheme

The linkages and patterns were either indicated by the theory (such as between institutions and learning) or by the data (such as the link between the profession and learning behaviour). The links and patterns emanating from the data were identified by repeatedly reading the transcripts and the output from the classification. The search for patterns, themes and categories required judgement about what was significant and what was not. When a relationship between concepts had been tentatively inferred, the data in the original transcripts were reconsidered to understand the context and so accept the plausibility of the inference, or reject it. There are no statistical tests for significance in qualitative work, rather, the decision must rely on the intelligence, experience and judgement of the researcher to avoid the equivalence of type one and type two errors (Patton, 1990). The experience of the researcher in designing the investigation, collecting the data, interactively reading and undertaking ongoing analysis led to considerable familiarity with the data. This made it possible to read for meaning and connections within the context of broader issues. The great strength of NUD*IST is that it facilitates the investigation of linkages suggested by reading. The decision to use such a program for the analysis was based on the quantity of data collected, which made it impossible to store sufficient detail mentally to make linkages and find patterns. A disadvantage with using NUD*IST is that it produces vast amounts of output that then must be reduced. The reduction of the output was undertaken with great care to prevent the introduction of bias and to emphasise the major themes and important arguments.

5.4 Conclusion

This chapter has detailed the method that was chosen for the investigation of learning in Ericsson, which was introduced in Chapter 4. The qualitative descriptive case study method was chosen as the most suited to the nature of the issues to be investigated, and to purpose of the study. There are three key elements of the selected method, it is qualitative, it is descriptive, and it is a case study. These

elements were chosen because the issues to be investigated were by nature qualitative and contextually important. No other method would have produced the desired rich description of the nature and process of learning in industry. The techniques for data collection and analysis were chosen in order to capture the maximum amount and variety of relevant data, and to analyse it rigorously to produce trustworthy and compelling findings that would add to the understanding of learning in industry. These findings are summarised in the next three chapters.

CHAPTER 6

The Findings on Learning-Related Relationships

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6.1 Introduction

Learning-related relationships, as described in Chapter 3, are stable interactions that influence the process and outcome of learning. This chapter summarises the data on those relationships and addresses the contextualised research question: What is the nature of the relationships that influence learning in Ericsson consequent to the liberalisation of the telecommunications service market.

The plan of this chapter is that a summary of the data on relationships with parties external to Ericsson is presented in section 6.2. A summary of the data on relationships internal to Ericsson is presented in section 6.3. A conclusion is presented in section 6.4 where the research question is addressed.

6.2 Data on the relationships with parties external to Ericsson

The data on relationships with parties external to Ericsson related to customers, companies with compatible technology, competitors and miscellaneous parties. The data on these relationships are summarised here.

6.2.1 Relationships with customers

This summary of the data on relationship with customers focuses on public telephony customers: Telia in Sweden, and Telstra and Vodaphone in Australia. Ericsson's other customers, for instance in private telephony, are companies that each represents only a small part of the market. The data indicate that relationships with those customers tend to be simple exchange relationships with after sales service. Although modification of the product in line with contract specifications is routine, the associated learning is not central to the relationship. Therefore, they are not included here.

Ericsson had close relationships with the national telecommunication service providers during the monopoly regime in both Australia (Telstra) and Sweden (Telia), as described in Chapter 4. The data indicate that the introduction of competition among service providers has altered the relationship between Ericsson and the service providers. Due to the importance of those relationships, Ericsson's operations are being overhauled. In particular, there is a new focus on developing the products that the market demands rather than advancing the technology, per se. Technology was previously determined by negotiations that were typically engineer to engineer discussions about technical possibilities in isolation from the end-user market. An interviewee from Telia said:

'I say that it was a Telia-Ericsson culture and it was a protected world and that it was profitable. That is to say, that pure technology was supplied to the market. Now we have to be more business like and listen to the market. It is not enough these days to say that this is a fun technology so implement it. It is not a good argument. It used to be a good argument but not so any more.'

Now, Ericsson is committed to developing the technology that will enable its major customers to meet their market demands. Ericsson has strategic alliances with Telia, Telstra and Vodafone that commit it to be proactive in developing technology and introducing products that will benefit them. These relationships provide the opportunity for the frank, intense and ongoing discussions necessary for each party to learn how to benefit the other in both the short and long run. An Ericsson marketing professional commented:

‘The basis of it is, really really the whole relationship is so that we can introduce products into Telstra and we can help them grow their business. Our product is designed to help them grow their business and make their business more profitable.....Under the strategic alliance they’re currently looking at investing, some research is being undertaken into.... the make-up or buying patterns, the socio-economics of customers, etcetera, etcetera. That would be something that is done under the banner of the strategic alliance so money is then dedicated to that.’

Whereas the monopoly service providers treated the market as a mass market with no choice other than to adopt the products that the service provider made available, there is now a focus on the end-user as Ericsson’s market, rather than that market being just Telia and Telstra. Consequently, the service providers now demand products targeted to niche markets. In partnership with their major customers Ericsson is involved in a race with their competitors and their major customers’ competitors to learn about the fragmented end-user market and to develop methods for targeted product design. A Swedish engineer commented:

‘We have designed for Ericsson, the consumer lab. They are building up the knowledge around consumers. How to structure customers, how to measure consumer behaviour, how to... let us say it is a very difficult task. We have a profile, we have to profile the population that is one thing, this is a structure thing. And then to connect the resources of time and money to this profile. Our old research was, more or less, almost pure technical research, but now it is focused on consumer behaviour.’

A major characteristic of Ericsson’s customers’ demand is speed to market in order to capture the first mover advantage with end users. The new commercial

imperative makes it necessary that Ericsson learns to get targeted products to market quickly and cheaply.

The monopoly national service providers were supported by their governments to provide the infrastructure for universal services. This meant that funding issues were not given a high priority in negotiations between Ericsson and Telia and Telstra. Now, the need for commercial funding imposes a focus on the financial aspects of the relationships. A Telia engineer said:

‘When I started in Telia we just lifted the phone and said we need some new exchange in Stockholm. OK and Ericsson went in and put it up and afterward we start to discuss should we pay something for this. It was that kind of relationship.’

In Australia, the joint marketing relationship between Ericsson and Telstra includes a reward and risk sharing arrangement. This is said to imply a closer and broader-based relationship than the previous relationship that focus only on technology. This new relationship directly links Ericsson Australia’s success to that of Telstra.

The erstwhile monopoly national carriers, Telia and Telstra, have rationalised their operations to focus on their core functions. In Sweden, Telia has disentangled itself from activities that grew out of the old relationship with Ericsson but are incompatible with their competitive commercial interests. Telia has, for example, stopped manufacturing the telecommunications equipment that was designed by their joint venture with Ericsson (Ellemtel), and has sold the factories to Ericsson. The outcome is said to be a ‘more normal relationship similar to that shared by Telstra and Ericsson in Australia.’

Since Telstra and Telia have redefined their roles, Ericsson has reacted to complement those roles. In Australia, for instance, Ericsson has now provides training to Telstra staff. Training is said to cement the relationship in three ways. Firstly, training that is compatible with the Ericsson system helps ‘lock’ the customer into Ericsson technology. Secondly, training leads to the optimal use of

Ericsson products and services. This increases their perceived ability to meet market demand. Thirdly, the additional contact with the customer during training enhances the relationship. An Australian training professional said:

'There is not much difference between the equipment companies. Ericsson has good technology and so do the others. So, we have to see other ways to compete. There is nothing left now in the price. Competition has really cut that to the bone. I see this in terms of training.'

Competition among service providers is said to have increased security considerations in the relationships. Ericsson has had a single direct competitor in Australia since 1992 when Telstra entered strategic alliances with both Alcatel and Ericsson for the provision of switching equipment. This is reinforced by Telstra's Partnership for Development agreements with both companies (see Chapter 4). Ericsson faces no major competition in public telephony equipment in Sweden. However, both Telstra and Telia face competition in their respective markets. Ericsson commits resources to ensure that all of its public telephony customers in Sweden and Australia, that is Telia and Telstra and their competitors, have confidence that Ericsson will not breach confidence. An engineer in Sweden commented:

'Yes, with Telia, Telia and Ericsson can't be so open with each other. I can remember not more than 5 years ago we used to go to joint meetings and more or less treat each other as though we belonged to the same company. That doesn't happen so much any longer because you know some of our customers with whom we are dealing, especially the new opportunity customers, they are all new operators who intend to set up operations in Sweden. I mentioned one before in another connection, XXX, they are trying to put an exchange in Stockholm and capture some of the corporate telephone business so we can't tell Telia what they are planning to do and we can't tell them what Telia is planning to do. Although in reality we are probably going to sell fairly much the same equipment.'

In summary, Ericsson has traditionally had close relationships with major customers. Those relationships have impacted on Ericsson's operations, including technology development. External factors (deregulation and the introduction of

competition) have impacted on those major customers and changed their operations. This has changed the relationship with Ericsson and thus changed Ericsson's operations. The crux of the relationships with their major customer appears to be based on the mutual recognition that their survival is jointly dependent on their ability to understand the market and get viable, targeted products to the market quickly.

6.2.2 Relationships with companies with compatible knowledge

Ericsson's commitment to provide technology in support of its major customers is increasingly difficult to meet due to the rate of technological change and the convergence of technologies. It was said that the telecommunications equipment companies are no longer able to develop all the technology quickly enough to meet market demands. When Ericsson cannot develop a technology of the standard demanded by the market quickly enough, they enter into relationships with a company that has compatible technology. Combining the technologies enables the companies to approach the major customers from a strong position. An Ericsson business strategist commented:

'The strength comes from being able to go to a customer and say that we can guarantee that these two pieces work powerfully together. So we will take responsibility that these two pieces work powerfully together.'

Nevertheless, Ericsson considers partnerships to be a second best option that weaken their independence and confuses the relationship with the customer. When the technology is wanted long term by Ericsson, they prefer to buy the company rather than to continue with partnerships. When the company can not be bought, formal strategic alliances or joint ventures are formed. Both partners are then keen to be seen by the customer to be the central supplier. An Australian engineer commented:

'We want a long-term relationship with the customer. We want to be seen to be a key supplier. They do too. We want Telstra to think of this as Ericsson with some support. We

want our components to be in there. We want to work on developing those components because that will develop our business. It is not just the profit on this project, it is the long run business of the company.'

These partnerships are strategic because they commit both parties to develop technology in support of the alliances. They also commit both parties not to develop technology in direct competition with the partner for the life of the agreement. They therefore push the company to learn that which will support the partner, and bar them from learning that which will compete with the partner. However, they do not oblige the parties to develop the next generation of the technology, nor do they bar either party from doing so. The business analyst commented:

'And that would have certain constraints and certain obligations for both parties. Like, they would have obligations to continue their development as the market changes. But, not necessarily any obligations to make any major transitions in technology. We would have obligations not to simply use anything that we have learned about their technologies to develop our own technologies. So we could probably learn that we could do the next technology transition, but we couldn't start rushing out and making a 'me too' product and then tell them that we don't need them any more. Certainly not within the multi-year life of the agreement.

[Does a strategic alliance cover things like that they have to develop technology that is compatible with yours?]

The strategic alliance would say that both parties will work together to maximise the integration of technology. So yes, both parties have an active responsibility, they can't stop and say that they have done their bit and that they don't feel like doing it any more. They would have obligations and so would we.'

The data on specific relationships with companies with compatible technology related mainly to two examples, each of which is based on learning about both technical and soft technology, and arises because of the merger of voice technology with data, media and computing technology. One of these relationships is a strategic alliance between the data router company Cisco and Ericsson Australia, in which

data and voice technologies are integrated and the benefits of market knowledge shared. The other is a joint venture with Hewlett Packard in Sweden in which computing solutions for telecommunications are developed and Ericsson learns about the computer industry's open system.

In the strategic alliance with Cisco, each partner gains advantage from the other's knowledge without learning it *per se*. The basis of this alliance is that Cisco wanted access to Ericsson's market knowledge and relationships with private network customers, and Ericsson wanted to integrate their voice technology with data technology in end-user units. While Ericsson is a bigger company and is better connected in Australia, the power base of the relationship is balanced by the shortage of data skills in Australia. Ericsson cannot afford the time to develop data knowledge in-house because the market is demanding access to data communication now. Confidence that neither party will behave opportunistically is boosted by the global alliance between Ericsson and Cisco for the development of cordless computing networks. Furthermore, each company recognises the importance of reputation in the industry and the need to maintain an honourable reputation in order to attract other parties for subsequent alliances. However, Ericsson's relationships with other data router companies, and Ericsson's efforts to develop its own data router technology, are said to dampen the relationship by increasing the likelihood that the alliance will not continue beyond its current term.

The global joint venture between Ericsson and Hewlett Packard, EHPTC, was entered into because of the increasing use of computers in telecommunications equipment. Both companies sought to integrate the other's knowledge in the development of solutions for the market. EHPTC combines the technology of both parent companies through actually learning that technology, not just using it. Ericsson is also said to have been interested in learning about the marketing implications of the computer industry's 'open system' that enables components from different companies to be mixed and matched in one system. This is fundamentally different to the closed system in telecommunications in which entire systems are proprietary and their connection relies on standardised interfaces.

Institutional issues associated with the closed system institution are discussed in Chapter 7.

The actual learning of each other's technology requires that the relationship between Ericsson and Hewlett Packard is completely open, so that all required knowledge is made available. However, a Hewlett Packard respondent reported that Hewlett Packard has not learned as much about Ericsson's technology as Ericsson has about their technology. The perceived imbalance is said to be due to Ericsson's previous experience in joint ventures based on the exchange of knowledge, which were new to Hewlett Packard. The experience with the relationship with Ericsson is said to have provided experience that has enabled Hewlett Packard to learn more from subsequent relationships.

The joint venture with Hewlett Packard provided Ericsson Australia with the confidence to enter a strategic alliance with Hewlett Packard in Australia because the global relationship would preclude Hewlett Packard from behaving opportunistically in Australia. That strategic alliance has stimulated learning in Ericsson Australia that enables it to meet Telstra's demands. An Australian engineer said:

'Telstra encourages that. They encourage suppliers to work closely together to get synergy from sharing knowledge resources and technology. They want synergy to get the best outcome rather than competition. The fact is that with technology today no single supplier can supply everything. It has to be a multi supplier solution. This is especially when you consider how the technology is growing and the variety demanded. Rapid technological change makes relationships such as with HP crucial. There will be the need for more of these with other suppliers in the future.'

In summary, the data on learning-relationships with companies with compatible technology indicates that they are entered into in response to market demand for technology that Ericsson cannot develop quickly enough to meet market demand. While these relationships are essential for the provision of technology in the short run and so reinforce Ericsson position as a reliable supplier, they present strategic

risks. These risks are due to the fact that another company has been brought into the relationship with Ericsson's major customers. While the technologies remain distinct, those companies are not competing with Ericsson for the relationship with the major customers. However, convergence could render them direct competitors, and so relationships with companies with compatible knowledge are a second best alternative to meeting the demand with technology that is entirely Ericsson's. Risks of opportunistic behaviour within relationships are reduced by mutual recognition of each other's power in the industry and the need to maintain a reputation as an honourable company.

6.2.3 Relationships with experts

The data indicates that Ericsson has extensive learning-related relationships with expert consultants and universities. The data on these relationships are summarised here.

6.2.3.1 Relationships with Consultants

The data indicate that Ericsson has had learning-related relationships with consultants for many years. There appears to have been a trend increase in their use, and a tendency to use them in different ways over the last few years. The evidence suggests that previously Ericsson mainly had relationships with technical consultants who became entrenched, full-time consultants dealing exclusively with the advancement of Ericsson's technology. Although their role was indistinguishable from Ericsson employees, they appear to have had expertise that Ericsson valued highly enough to pay the consultant a premium above the wage. More recently, consultants have been used increasingly in softer areas, such as human resources and training, that is, they have been used to help Ericsson improve its processes and overall operations including technical advancement. Now, the trend is for consultants to support Ericsson to learn methods for fast, targeted product development and to develop better relationships with customers. In one reported example, Telstra was believed to have used a consultant with different human resource technology to that used by Ericsson. According to an Australian

engineer, that consultant was subsequently engaged by Ericsson in a bid to improve the relationship with Telstra:

'The more HR side. I think that Telstra was using them and I think that that had something to do with it. Because our last big culture change was actually driven by Telstra and I think possibly, that was a few years back, it is possible that Ericsson panicked and went to them as well. And went 'Oh Telstra is using these guys and we should use them too because we want to be like them'. That is the goal, we want to look like, we want to be like Telstra which will make them happy.'

The data suggests that there are two types of relationships with consultants: generic and Ericsson specific. In generic relationships with consultants, Ericsson buys generic services that do not require the consultant to have particular knowledge of Ericsson. These tend to be in niche areas where skills evolve outside Ericsson that can be acquired by irregular injection from consultants, such as in human resources and training. The provision of Microsoft Word word-processing skills to Ericsson Australia is an example where a relationship has developed over time with the consultant buying the right to deliver courses of particular interest to Ericsson. Relationships for the provision of generic consultancy services tend to be in the softer technologies rather than technical areas, because Ericsson's technical matters tend to be integrated into the closed system that requires intensive understanding of the Ericsson proprietary products and services. As such, they are less subject to generic outsourcing.

The second type of consultancy relationship, those that are specific to Ericsson, requires the consultant to develop an in-depth knowledge of Ericsson. Such consultants are selected because they are visionary and can act as a catalyst. They are given access to all the knowledge that they require and to people at all levels in the company. Moreover, because they are expected to make recommendations, there is a forum in which they can speak. Broad experience of the systems of various companies enables the consultant to stimulate learning that prevents Ericsson from becoming unduly locked into a technological path for both product and process technology. Ericsson personnel are less able to act as catalysts because they are said

to become 'enculturated' to Ericsson's processes and attitudes. An Ericsson human resources professional said:

'So they bring part of their influence in other organisations to us as well and they challenge us all the time and so that, it means that you are never still, you have to keep on modifying. But I think that they are a good injection for us. We could do a lot more of that. We get locked into, we have just had a planning meeting last week, we get very much locked into delivering programs versus offering development opportunities. So we need to do a lot more of that. And we know that, so I guess they help us.'

While consultants were acknowledged as a valuable source of knowledge, the data indicates two problems. The first, is that it implies that the in-depth knowledge is held outside the company. The consultant is said to provide the solution or program requested but not to provide the understanding that leads to that solution. This may become a more serious problem as Ericsson sticks to its core functions and contracts out for other knowledge. A technician with a data company said:

'Contracting reduces costs but it doesn't enhance the overall organisation. Your knowledge is held outside the firm. Hive of knowledge of how things work. The core business is fine but what is it, and how can it function without support knowledge?'

The second problem relates to Ericsson's use of the consultant's recommendations. Two consultants claim that Ericsson frequently has research undertaken in both human resources and engineering and then does not follow the recommendations unless they match their previously held intentions. This is said to weaken Ericsson's capacity to take advantage of the stimulation provided by the consultant's alternative perspectives.

6.2.3.2 Relationships with universities.

Ericsson has extensive relationships with universities in both their teaching and research capacities. These relationships, which have been established through many years of interaction, are now said to be changing as a result of the increasing focus on the market.

Ericsson has a long history of involvement in curriculum design in engineering courses at Swedish universities. In this way, they have ensured that not only do the graduates have knowledge that Ericsson requires, but also Ericsson knows what it is that the graduates have been taught. While Ericsson has been successful in having courses relevant to telecommunications taught in Swedish universities, there is no guarantee that the universities will comply with their requests. The Royal Technical University (KTH) has not complied with Ericsson's request to reintroduce training in analog technology. Although Ericsson is said to have argued that the future of telecommunications is in analog due to the convergence of voice with data and media technology, the professors at KTH disagree and are not interested in developing courses to train students in technology that they believe is outdated and soon to be replaced. This conflict is said by Ericsson staff to reflect the academics' lack of awareness of commercial applications, and their excessive focus on technical advancement that was better suited to the monopoly regime than to present conditions.

Interviewees at Ericsson expressed interest in other possible modifications to Swedish engineering courses that suit the new focus on speed and market demand. The suggestions are that engineering students be taught pedagogy so that they will know how to learn fast and to teach others, that they be taught to communicate at a non-technical level about marketing issues, and that they be taught about patenting. It is not known if the universities will accommodate these requests.

Similar relationships exist between Ericsson and some universities in Australia, but Australian universities are said to jealously guard their independence. An Ericsson human resources professional said:

'I am on the RMIT Advisory Committee for Communication and Electronic Engineering. We meet every three months to talk about the first semester next year's undergraduate courses. We discuss new degree and subject proposals. We tell them what is relevant and what is not. What they teach is up to them, but we give pointers.'

Ericsson provides the Royal Melbourne Institute for Technology (RMIT) with valuable switching equipment for use in practical sessions. Ericsson staff lecture at universities and run seminars for post-graduate students. These seminars are said to be essential because the university staff are no longer able to keep up with the diversity and complexity of the technology. Therefore, the graduates have exposure to the Ericsson system in a practical as well as a theoretical way.

Ericsson's historic focus on technology was reflected in its relationships with engineering courses rather than courses in other disciplines. While a human resource professional indicated that though he personally wasn't involved, he was confident that Ericsson was increasingly involved in non-engineering courses. The data from other interviewees did not corroborate this. Recent recruits with marketing and business qualifications said that they had no knowledge of such involvement. At the post-graduate level, Ericsson supports staff to undertake studies in non-engineering disciplines. Support for an MBA in the management of technology run by an Australian university in association with the engineer's association, APESMA, was a reported example. Further, the Ericsson Management Institute, in Sweden, has a strategic alliance with a university in Fontainebleu, France. Staff with executive potential are sent to courses at the Ericsson Management Institute and at Fontainebleu in order to develop relationships with the elite in the company and in Europe more broadly.

Ericsson also has extensive relationships with universities and other academic research institutions through research funding and participation in projects. An interviewee from Telia stated that these are the most important relationships for the future of telecommunications companies. Not only does Ericsson undertake joint research projects, and joint ventures with universities, but also individual academics act as research consultants on projects inside Ericsson and take sabbatical leave at Ericsson. As relationships with individual academics appear to be the same as with consultants, this section focuses on research relationships with universities rather than individual academics. The data reported on a joint venture between Ericsson

Australia and Melbourne University, the Advanced Services Applications Centre (ASAC). ASAC undertakes applied research into issues of interest to Ericsson. The data reports uncertainty as to why Ericsson has this relationship, which is apparently costly, when the work performed is the same as is done elsewhere in Ericsson (globally) and could be done in-house by Ericsson Australia. The interviewees believe that it is related to the issue of the distribution of research projects within Ericsson. Ericsson Australia was not selected to participate in an intelligence network (IN) research project even though Telstra was demanding that technology, and Ericsson Australia had the necessary research capacity. However, Ericsson Australia has the autonomy to undertake an R&D project in conjunction with a university, but it does not have the autonomy to do such a project on its own. The relationship with Melbourne University has thus enabled Ericsson Australia to strengthen its relationship with Telstra by demonstrating the capacity and will to develop IN technology.

In Sweden, Ericsson has research relationships directly with universities and via the consortia organised under the auspices of NUTEK, as discussed in Chapter 4. The data on the relationship with the Swedish Institute for Computer Science (SICS) is summarised here, although technically SICS is not a university. SICS is jointly owned by Ericsson, Telia, Swedish Railway, IBM and Sun Microsystems to do applied research into advanced software topics. The projects are initiated by SICS senior personnel rather than by the funding companies, but are subject to approval by a board of those companies. The projects are said to be a compromise between the university model of pure research and the industry model of development and application. Ericsson is said to have little interaction with SICS other than through funding and board membership. That is said to limit the learning value of the relationship for Ericsson. A scientist from SICS stated:

‘That is the only way to really communicate. If you are talking about knowledge that is the only way for a company to get any lasting value out of the collaboration. That is through personal contacts, through really interacting. Just to commission research and to say OK go away and do something, that doesn't work for new knowledge. It might work for a research to be evaluated for a product that is already known, but not for new knowledge.’

The lack of intimate contact between SICS and Ericsson is said to lead to Ericsson being unable to appreciate recommendations that do not follow Ericsson's current technological path. Academics attribute Ericsson's lack of acceptance of alternatives to its narrow exposure and lack of time for the reflection required for creative thought. While Ericsson personnel agree with much of this, they also attribute it to the academic's focus on the optimal configuration irrespective of the existing system.

The relationships between Ericsson and the universities are becoming more commercial and legalistic as they both face competitive market conditions in which intellectual property rights must be determined. There is a new focus on patents and contractual arrangements for the appropriation of the benefits from learning. While the associated increase in commercial awareness among academics may be reducing the degree of mismatch of culture between them and industry, the contest for commercial and patent rights sought by both parties is said to create other problems. In Sweden, where relationships with universities have previously not considered intellectual property rights, problems in addressing the commercial outcomes of research has meant that some relationships have broken down and some proposed research projects have not been undertaken. A patent manager said:

'And it has happened a few times and I don't know how many because I have not been in this position very long, that we have failed to reach an agreement and we have had, been forced to not enter into a project because of this.'

In summary, the learning-related relationships with experts enable Ericsson to benefit from a variety of knowledge inputs that is broadened by the expert's links with other companies. These relationships tend to be focused on learning in support of Ericsson's overall and long term operations rather than directly focused on rapidly satisfying the market is current demand. They have thus been less affected by the introduction of competition among service providers than were relationships with companies with compatible knowledge. The external changes have not altered

Ericsson's need for stimulation, and so have not markedly changed relationships with experts. However, the nature of those relationships has been changed by the new contractual base for the appropriation of benefits for learning. Ericsson appears to need to learn to use its relationships with experts better in order to exploit the potential stimulation to be obtained from them.

6.2.4 Relationship with competitors

The data on learning-related relationships with competitors indicates that the relationships are weak, and dampened by six issues. Firstly, Ericsson wants to be seen by the customer to be central to the provision of telecommunications equipment, as discussed above. However, their commitment to providing what the customer wants sometimes involves them in cooperative relationships with competitors. This includes their major competitor for Telstra's business in Australia, Alcatel. The need to cooperate with a competitor on a contract with a customer was seen as both a failure to have the right technology at the right time, and a failure to have locked the customer into Ericsson technology exclusively. There is said to be no sharing of knowledge beyond that necessary to complete the contract. An Australian engineer said:

'We are forced to work together with Alcatel to supply Telstra (or the customer) with a solution. This is not working closely, it is not more closely. It is just interfacing to get compatibility of product to sell. That is not a relationship.'

Secondly, the industry is said to be very competitive. Although it was widely recognised by the interviewees that there are common industry problems and issues that could be addressed jointly, the industry is said to be too competitive for such interaction. An Australian business analyst said:

'People know each other, but I wouldn't call it in any way a close community. I think because people are too competitive again. I think that they are busy creating opportunity for their own company. So I well, you have to think what is the purpose of meeting with them? People are very precious of their time.'

The third reason that learning-related relationships with competitors are weak is that peculiarities in the technical system of each company make competitor's technical knowledge largely irrelevant. Head hunting of personnel in order to obtain technical secrets, for instance, is not a common practice mainly because system-specific knowledge is irrelevant outside the proprietary system of each company. Head hunting is said to be more successful between customer and supplier, where it is frowned upon in the interest of maintaining relationships.

Fourthly, human resource professionals in Ericsson expressed the belief that Ericsson's human resource knowledge is as good as any, therefore Ericsson would not stand to gain as much as it gave in a knowledge sharing relationship with competitors. A Swedish human resources professional stated:

'Why, it is more fear of sharing best practice. It shouldn't be, but there is considerable resistance. Often you need to prove the outcome before you can get the opportunity to do that. It is always a fear, it is probably more a fear that if you go to someone and ask for information you must be prepared to give in order to get something back. It is probably more a fear of what you are going to give versus what you get back.'

The fifth reason for weak learning-related relationships with competitors is that the competitors' processes are believed to be no better than Ericsson's. All telecommunications equipment companies have developed their processes in an environment protected from competition. Therefore, there is no reason to expect that the other telecommunications equipment companies have better methods that would be worth learning. According to a senior design engineer in Sweden, comparison of Ericsson's and its competitors' processes would be a 'race among pigs'. Both companies would do better to learn from companies with highly regarded process technology, such as Microsoft.

Sixthly, the lack of competitors in Sweden was a dampener for interaction for many Swedes. They tended to use Ericsson employees located in countries where

competitors operate in order to learn about the competitors. Ericsson people in Finland, for example, were used as sources of knowledge about Nokia.

Other opportunities to interact with competitors are presented by the standards forums, where experienced representatives claim that they can discern knowledge about competitors from the position taken by their representatives and the arguments that they make. Relationships between competitors at the standards meetings are said to be generally distant because the setting of the standard is crucial to future operations. They therefore, are not forthcoming with knowledge about their operations. However, there can be cooperation at the standards meetings between competitors in circumstances when they have more in common with each other than with their customers. The data indicate that the information fed back from the representatives at the forums is highly valued within Ericsson.

In the absence of close relationships, Ericsson learns about competitors' activities through its Competitor Intelligence Group that compiles and analyses publicly available data on competitors' activities. A respondent from this group commented that this resource is under-utilised by decision-makers, partly because they do not know how to value data that is linked to the market rather than to their own technology.

The data suggest that the convergence of technology means that Ericsson does not know who its competitors will be in the future. This uncertainty is a potential dampener on learning-related relationships with firms that are not currently competitors. In a recent example, Ericsson's competitor Nortel bought a company that supplies components to Ericsson. This happened six months into a relationship that required considerable knowledge sharing. The company still provides the component to Ericsson. Ericsson's concerns are that there is no labelling to indicate Nortel's involvement to the end customer and that there is no evidence of abuse of the knowledge gained from Ericsson. According to a marketing professional, Ericsson is 'keeping an eye on the exit clause.'

In summary, the weakness of the learning-related relationships between competitors is due to an industry culture of independence and the limited value of the competitor's knowledge to Ericsson. Ericsson knows well how to learn from the standards forums but appears to lack methods for using that knowledge and the knowledge from its own Competitor Intelligence Group.

6.2.5 Miscellaneous learning-related relationships.

This sub section summarises data on relationships with the government, industry association, professional association and cluster relationships.

6.2.5.1 Relationships with government

Governments interact with Ericsson in a variety of ways that impact on learning in Ericsson. Both Telia and Telstra are government enterprises, and Swedish and Australian universities are generally state owned. Moreover, governments create the regulatory and policy environment in which Ericsson operates. In fact, the shift from the introduction of competition in service provision in both Sweden and Australia was due to a change in government policy. That policy change was responsible for many of the changes in relationships and learning discussed above. The Australian Government, as a regulator, does not have a direct learning-related relationship with Ericsson. The interaction of the two is limited to Ericsson lobbying through the telecommunications industry association (ATIA), and advising the Government on issues such as broadband management. The Government as regulator does influence learning behaviour in Ericsson through the Partnerships for Development and Industry Development Plan schemes (see Chapter 4), that are intended to maintain R&D and manufacturing activity in Australia so that benefits will spill over to smaller Australian companies. The data indicate that the interviewees fear that the abolishment of these instruments could destroy the research and manufacturing base of the industry, as was said to have happened in New Zealand and the UK. This would drastically reduce learning in Ericsson and the spillover to other industries. The data indicate that other than the role of the government in R&D, as discussed in Chapter 4, the Swedish Government does not have a relationship with Ericsson that is important to the learning undertaken.

6.2.5.2 Cluster relationships

The data relate to clusters both in the sense of being physically located in a cluster and of being part of a group seeking a common solution. While these two are interrelated, they are quite distinct in the data. In the physical sense, Ericsson Australia's main location for R&D and manufacturing is not part of a cluster. No competitors, customers or suppliers are located nearby. However, the public telephony marketing section is located adjacent to Telstra in the Melbourne central business district. The site was chosen in order to develop the relationship through face to face contact that is said to enable both parties to learn undefined, tacit things and to develop rapport. A physical cluster of information technology and telecommunication research exists in the area between Melbourne University and Royal Melbourne Institute of Technology (walking distance). Proximity to one another enables researchers at the universities and at the joint venture between Ericsson and Melbourne University (ASAC) to attend seminars and meet for discussions. There is said to be no physical cluster of other telecommunications companies in Melbourne. The industry is said to be too competitive for competitors to want to be near one another. Moreover, the emphasis on software in the telecommunications industry was said by an Australian engineer to distinguish it from mechanical industries in which observation of operations, for example test driving cars, provides valuable knowledge.

Many Swedish high-tech companies are located in Kista, an outer suburb of Stockholm. Kista appears to be a cluster in both the physical and group seeking a common solution senses. Therefore, it has the potential to provide learning-related benefits to the member companies of that cluster. Some interviewees attributed the physical clustering of high-tech companies to a vintage effect in that the area is new with available office space; the companies are new and seeking office space. Ericsson's Radio Business Unit dominates Kista in terms of employment and area occupied. While Ericsson is not a new company, the importance of radio due to the growth of mobile telephony is new. In fact, the data indicate that the Radio Business Unit was located at Kista in order to insulate it from the old practices of the other business units, especially Public Telephony. Others attribute the clustering

of high-tech firms in Kista to companies seeking the highly trained work force located there. Neither of these constitutes a learning relationship as the basis for the cluster. The presence of the Royal Technical University (KTH) Masters in Engineering course in Kista was said by an academic to be a draw card with seminars and chats in corridors providing opportunities to exchange knowledge relevant to the various companies. However, the data suggests that Ericsson staff do not frequent these seminars and do not chat in KTH corridors. Another argument was that companies cluster in Kista because Ericsson radio is there, is growing rapidly, and requires input from other companies. While this interaction could form the basis of a learning relationship between the members of the cluster, as Ericsson Radio grows it takes over the leases of other companies and forces them out. So although there may be a learning-related cluster relationship around Ericsson Radio because of its position in a growth industry, that growth is destroying the cluster.

The data indicates the existence of several clusters in the sense of companies seeking a common solution. The standards bodies, as discussed above, bring industry representatives together to determine the standard technology that, if adopted, will ensure connectability. NUTEK's consortia (as discussed in Chapter 4) and SICS are examples of Swedish clusters around the search for basic solutions. The Australian industry association, ATIA, provides a service that connects small Australian companies so that they can jointly bid for large contracts with multinational companies such as Ericsson. Ericsson deals with these clusters as one company through the auspices of ATIA. Otherwise, the data indicates that the independent nature of the companies in the telecommunications industry drives each to seek its own solutions. This is particularly so with less basic, market-focussed solutions. The obvious exceptions are the strategic alliances with companies with compatible technology that are discussed above.

6.2.5.3 Professional associations

At the individual level, the data indicated that professional associations are a valuable source of knowledge which is general to the profession but not specific to Ericsson or to the telecommunications industry. Many respondents in both Sweden

and Australia in engineering, training and human resources belong to their relevant professional association because of its knowledge sharing and professional-standard setting roles. Most commented that they are not active members in the sense of attending meetings and conferences due to work commitments, but that they read their newsletters to keep up with trends in the profession. Many also commented that they read their association's journal. The selection of the association's journal from the many journal's published in each discipline was based largely on convenience. This was particularly the case in Sweden, where the professional associations' journals are published in the Swedish language. Therefore, not only do they provide a source of knowledge without the need to seek out specific journals and articles, but they also are easy to read. However, some interviewees have a more active involvement and see themselves as important contributors to the knowledge promulgated by their association. One Swedish training professional, for example, belongs to the Graduate Association for Technical Education and to the International Consortia on Business Education and finds their knowledge sharing to be valuable. He is committed to these groups and works to promote their learning outcomes by speaking at international conferences, contributing to newsletters and working with universities and government agencies to raise the profile of the associations.

6.2.5.4 Industry association.

The Australia Telecommunications Industry Association (ATIA) is focused on representing the interests of the industry to the Government rather than providing a forum for knowledge exchange and development. The lack of such a forum was attributed to the highly competitive nature of the industry.

In Sweden, there is no telecommunications industry association *per se* because previously Telia and Ericsson were the industry. Ericsson is an important member of the Association of Swedish Industry. Large Swedish companies use this as an opportunity to discuss issues of interest to industry at large. These tend to be related to political and current affairs rather than being product and process oriented.

However, Ericsson also is represented on other industry forums that provide opportunities for learning by investigating particular issues.

In summary, the data demonstrates that learning-related relationships with parties external to Ericsson are of central importance to Ericsson's operations, including innovation. Relationships with major customers are central to Ericsson's operations and enable Ericsson to learn about the end-user market and its demand for targeted products that are both cheap and timely. Relationships with other external parties are largely in support of Ericsson satisfying its major customers' demands, either directly (companies with compatible technology), indirectly (consultants) or with a long term view (universities). Learning-related relationships with competitors are weak, partly because the competitive nature of the industry precludes cooperation, and partly because each company's technical knowledge is not highly valued by their competitors. While learning-related relationships with the Government are not important, the Government is recognised as an important influence on the learning outcomes for Ericsson. Clusters are not generally important, except that representation at standards forums is said to provide highly valued knowledge. At the individual level, the various industry associations are said to be a valuable source of easily accessible knowledge.

6.3 Learning-related relationships internal to Ericsson

The data identified formal and informal relationships internal to Ericsson that are important for learning. The three types of formal relationships for the exchange and generation of knowledge within Ericsson are:

- hierarchical relationships between the corporate level and the local companies, and between management or supervisor and subordinate
- collegial relationships between team members, within professional groups and between local companies globally
- relationships with functional units within Ericsson

6.3.1 Hierarchical relationships internal to Ericsson

Ericsson's company structure is said to comprise fairly autonomous business units and local companies directed and united by the parent company, LM Ericsson, in line with the Ericsson Strategic Plan. The Ericsson Strategic Plan is developed by LM Ericsson in consultation with the corporate level of the business units. The company was described by a human resource expert as 'autonomous teams, coordinated and supported from Sweden.' Others describe the relationships as more hierarchical.

The data indicate that previously the corporate level was the source of knowledge, and that knowledge was primarily technical. Now, that there has been a decentralisation of responsibility for learning and product development to focus on the local market. The direction and nature of the flow of knowledge are consequently changing. Knowledge about the market and its demands now flows from the local company to the corporate level to determine future products and services. This change is said to be slow for four reasons. Firstly, there is a lack of acceptance at the corporate level of the changes caused by competitive markets. This was attributed by Australian and Swedish engineers who had worked in local companies in other countries to the lack of competitors in Sweden and to the company structure that protects Swedish operations from budget constraints. The lack of acceptance was said not to be due to a lack of knowledge, but rather to an attitude, that discounted that knowledge. Secondly, the historic dominance of LM Ericsson and the corporate level led to the development of a culture of not respecting the opinions and findings from the local companies. This is aggravated by an apparent Swedish trait of believing in the superiority of Swedish knowledge. This is reinforced by small but powerful images, for example, the continued dominance of Swedish articles in the company's flagship technical publication, *The Review*. Thirdly, those in positions of power are said to favour the old approach that gave them their careers. This holding on to power and avoiding change is said to restrict the flow of strategic information down to the local company level. Fourthly, while money continues to be made on the old technology the impetus for change is lessened.

The data indicate that hierarchical relationships continue to influence learning by local companies through the allocation of research projects and that this in turn influences the collegial relationship between local design centers. It is acknowledged that exposure to a broad range of projects creates the opportunity to learn the broad knowledge required for the flexibility and innovation demanded by the market. However, there is said to be a trade-off between broad exposure and 'efficient' management of R&D projects through specialisation. In this trade-off, the allocation of research projects by the corporate level of the Public Telephony business unit favours efficiency. Given that the corporate level plans to reduce the number of local design centres, there is competitive pressure among those centres to out-perform each other. While the corporate level described this as efficiency-enhancing competition, at the local level it was described as rivalry that results in less horizontal sharing of knowledge and a longer time being taken to reach the quality of solution required. An Australian engineer commented:

'It is expected that everyone who has a reason to know something will be told. It doesn't matter what level, what country, what team, what project. That is the culture. But in fact when competition for survival comes in between the development centres, it is possible that some of these rules are bent.'

An example of the effect that hierarchical relationships have on the learning-related behaviour of local design centres is provided by the situation mentioned earlier in which Ericsson Australia was not chosen to participate in an intelligent network research project, even though it was recognised at the corporate level to have good market knowledge, the appropriate design skills and a local customer (Telstra) demanding intelligent networks. Non-selection for the project was on the grounds of the efficiency benefit of specialisation and Ericsson Australia's poor reputation for cooperation on projects. A Swedish engineer in a management role said:

'Ericsson Australia, that is a tough question. They are fairly good at knowing their local customer, and that is important. But, their ability to fulfil the needs of the local customer depends on their ability to cooperate globally with major development projects. They are

getting better at cooperating on product development now, they were a bit isolated in the past. That is how they operated.'

This independence is not denied by the Australian designers who are proud of what they interpret as their creativity being a 'thorn in the side' of other design centres. 'Cooperation' is taken by the Australian designers to imply less market-focussed innovation and a return to technology-focused design controlled by the corporate level. One outcome of the expensive joint venture with Melbourne University (ASAC), undertaken in order to meet Telstra's demands for intelligent networks, is that Ericsson Australia, via ASAC, has a new collegial relationship with Ericsson's high profile Technical Services Application Centre (TSAC), located in Sweden. This effectively foils the hierarchical power of the corporate level at the expense of the establishment of ASAC. This example illustrates the ambiguity of change. On the one hand the lack of decentralised power suggests a continuance of the old ways, on the other hand the need for managerial efficiency suggests an attempt to reduce the costs of design in accordance with the new focus on financial matters.

While some of the data indicate that the hierarchical relationships unnecessarily restrict learning, it was also suggested that this reflects their different responsibilities. With reference to the corporate level it was said:

'They are not easy to convince. Especially if the concept is not their idea of a good concept for market goods. They look at it in a strategic way. A new concept development needs a lot of thinking at different levels of the company. We think more about the market, design engineers think more about the technical opportunity and higher up think more strategy. They think about the whole company. There is some mismatch there'(emphasis by interviewee).

The data on hierarchical relationships between managers or supervisors and subordinates suggest that they are important for knowledge that is specific to the company. Rapid technological change does not appear to have weakened the relationships based on the link between seniority and knowledge. This seems to be partly because technological change is incremental and linked to the existing

system, and partly because the majority of information sought is not held *per se* by the manager, rather it is held by individuals all over the firm. The manager typically is better connected and so is able to assist in accessing knowledge. The focus on the market is associated with the replacement of hierarchical relationships with collegial team relationships, as described below.

In summary, the move to the new market focus involves decentralisation of learning and responsibility. However, that loss of power to the hierarchical company structure is resisted by the traditional source of power and knowledge. This resistance is supported by the contradiction created by the new focus on both financial responsibility and market focussed learning. Rivalry between locations boosts management efficiency rather than innovation. Within units, the value of well-connected managers for accessing knowledge has not been diminished by the rate of technological change. This is because their knowledge is about the individuals who have the solutions rather than about the solutions.

6.3.2 Collegial relationships

The new focus on the market and the associated need for speed, flexibility and decentralisation of learning and product development has led to self-directed teams replacing line responsibility, particularly in Australia. The loss of the position of line manager is compensated for by members taking responsibility to learn and to inform each other. The data indicate that collegial relationships between team members improve productivity by reinforcing the responsibility of each to learn, to innovate and to support the team members. An Australian competence manager stated:

‘A team really is a group of people that are united in working towards and accepting common objectives. They are empowered, and empowerment is the key word, they are empowered to look after their own business arrangements - how they run their self contained business in that team for any project that they work on. Whereas with a line management organisation you are literally told what to do. There is no self-administration, no innovation. Or very little. Whereas with the team you are self-sufficient.’

However, the self-reliant nature of teams restricts the amount of knowledge that flows into them and between them.

The benefits of teamwork are said to apply in situations that retain line responsibility if a team 'feeling' is engendered. One example of such team building relates to the new emphasis on patents. A patents officer in Sweden reported trying to have the inventors see themselves as a team with him as a member, and to have them perceive patenting as their responsibility as much as inventing. This was particularly important, but difficult, because while engineers are portrayed as generally slow to accept team relationships, inventors are said to be especially used to working in isolation.

Collegial relationships among members of a professional group are reported to be fostered by Ericsson. Managers of design, training, and human resources from around the globe are brought together (separately) in small groups for professional renewal, concept development and to get to know each other. The on-going value of these gatherings is said to be the sense of a professional network for knowledge sharing. A human resource professional said:

'I think that one of the things that happens, you know when you get these groups, once they establish a network of 35 people or so, if they find that they are not getting all they need in their local company then they have a network of their own to tap into. So I think that it makes them more empowered to work with certain issues. It also gives them an opportunity to learn from what is happening in other (local) companies.'

While there is a strong occupational group among human resource professionals at lower levels in the company, this does not seem to be the case among lower level engineers. Relationships between engineers are based on having worked together rather than a sense of being in the same profession. Close collegial relationships are said to have developed between those who have been appointed to the new role of competence manager. The basis is said to be each other's acknowledged ignorance and search for understanding and methods of application.

Collegial relationships between the local companies globally are maintained by the links between the managers and top professionals. Furthermore, teams on the same design projects in different locations appear to have excellent relationships for exchanging knowledge. The generally poor relationships at other levels and between design centres not on the same project were attributed to the historic focus on engineering and technology based on centralised knowledge sharing from Sweden. The data suggest that this is exacerbated by the threat of design center closure and the resulting jealousy and reluctance to share knowledge.

6.3.3 Functional relationships

The data on relationships with functional units relate to information officers, and the training and marketing sections. Firstly, information officers located in Sweden respond to requests from staff in local companies for help with sources of knowledge both inside and outside Ericsson. They are considered to be increasingly important as the changes to the market and technology make it necessary to relate to new parties inside and outside Ericsson. These are said to be an excellent source of knowledge. Secondly, the training section has been seen historically as providing technical training in existing technology, particularly the technology of new product releases. Sweden provided both the equipment and the training modules that aimed to reproduce that technology. The relationship is now moving towards one of facilitating market related learning required by the local company, business unit or individual, as described in the competence model in Chapter 4. The responsibility for identifying the learning required to meet the market's need is the responsibility of the local company. The responsibility to undertake that learning is vested in the individual, with support from the team or line management, and functional support from the training section. Thirdly, the data indicate that functional relationships with the marketing section have begun to permeate the organisation. The marketing section has the knowledge about the market on which the designers need to focus and on which all are to base their competence plans. Engineers in the local companies have direct and regular contact with people in the marketing section.

The knowledge shared in these relationships is limited due to the engineers' inexperience in discussing concepts at a non-technical level and the marketing professionals' inexperience in discussing technical issues. Furthermore, there is reported resistance by some engineers to accept the need for marketing and its influence on design. The data suggest that LM Ericsson and corporate level staff have less direct relationships with marketing.

A factor which is said to reduce the ability of those employed in these functional roles to help others learn and to bring about change, is that these sections are typically headed by engineers. This placing of engineers in key non-engineering roles supports the supremacy of technology and generally delays the change to the new focus.

6.3.4 Informal relationships

The data on informal internal relationships relate to what the respondents refer to as networks. Networks are universally considered to be the most important source of knowledge for the success of the individual in Ericsson and for Ericsson's ability to share and use knowledge. The centrality of informal relationships does not imply that the formal networks are redundant. The formal relationships provide opportunities to meet those who will become part of the informal network, as well as providing knowledge, *per se*. Connection to a network enables individuals to know where knowledge is held, and provides them with the status to have others cooperate with their request. An Australian engineer commented:

'When you become one of the key people in your area then the key people in other areas will be happy enough for you to bug them because they know that at the same time that they can bug you and you have things that they need in terms of information. If you are a little fish who isn't known, it is very hard to get a response from the big fish who know every one. So establishing the network of friends and the people all through the network across the whole area is vital. I am naturally that sort of person any way. I came in here under a corporate graduate scheme where they moved me around all of the units. So I have worked in all of the divisions, you begin to know a lot of people and that is just perfect because when something comes up and you are not sure where to go or how to work, you're sure to know

someone who can probably give you advice and you jump on the phone. So it is critical, it is vital.'

It was widely reported that recruits find it very difficult to operate until they establish a network. With graduate recruits, a program of orientation including the provision of a mentor is aimed at facilitating the establishment of a network as well as introducing them to Ericsson's process and product technology. Although it is the responsibility of higher level recruits to make such contacts, recent recruits to senior positions commented that Ericsson staff are forthcoming with helpful information and acceptance in their network. The experience of a recently-recruited Swedish training professional, who is attempting to establish a network in the Public Telephony business unit to support the use of scientific methods of learning and teaching in technical training, has been less successful. To establish a network it is said to be necessary to have a critical mass of pedagogues who operate at a high standard. To operate at a high standard it is necessary to have the role accepted by a network. Establishing that network takes longer than pedagogues stay in the job because there are no promotion prospects. He commented:

'You need three or four years to get to be well connected and to be competent in the area of knowing people and that is a large part of the competence for doing my job. So we need to have a career here. We have to get people with a network or keep them long enough to build that network. We can't keep teachers here. They leave after three years and take their competence, we lose it all. We lose the competence and we lose the network.'

6.4 Conclusion

The purpose of this chapter was to summarise the data on learning-related relationships in order to answer the research question: What is the nature of the relationships that influence learning in industry?

The data indicate that a range of relationships is important to learning in Ericsson. Those relationships were grouped above as either internal to Ericsson, or with a party external to Ericsson. Briefly, the data show that the important learning-related

relationships with external parties are those with customers, companies with compatible knowledge, experts (including universities and consultants) and at the personal level, professional associations. The data showed that learning-related relationships with competitors are not important to learning in Ericsson because of the competitive nature of the telecommunications industry, and the peculiar nature of its proprietary systems. Relationships with the Government (as regulator) and the industry association were not generally important for learning in Ericsson. Clusters, in both the physical sense and in the sense of seeking a common solution, were generally not important other than with parties classified elsewhere as having important relationships (eg customers and universities). An exception was the standardisation forums, which were a valuable source of information. While all the internal learning-related relationships were found to be important for learning in Ericsson, informal networks were said to be the most important relationships for learning about matters internal to Ericsson.

Another dimension is that some relationships are important for directing Ericsson's operations while others support Ericsson in those operations. Relationships with customers were shown to be the most important for directing Ericsson's operations, particularly innovation. With the introduction of competition the focus has changed from developing technology to suit the immediate customers' interests, to developing innovation that will provide goods demanded by the end-use customers. The other relationships, both internal and external, were found to be in support of meeting those customers' needs. The most important relationships for facilitating Ericsson's operations were shown to be informal networks. Formal relationships provided opportunities to form networks and are auxiliary sources of knowledge. Hierarchical internal relationships, that once directed operations including innovation, are now seen to support those in direct contact with the market to satisfy that market.

It is concluded that the most important relationships that influence learning in Ericsson are those with customers, companies with compatible knowledge, experts,

and informal internal networks. There are some similar elements in these relationships.

- They are with known, specific parties. That is, they are not anonymous, and they rely on reputations.
- They are long term. While some, such as strategic alliances with companies with compatible knowledge are legally limited to the duration of an agreement, they are entered into with long term prospects and with long term connections between the companies internationally.
- They are very close and based on open disclosure.
- They are largely informal even though they are supported by formal legal frameworks.
- They are based on trust, that is goodwill, competence and contract trust, and are exclusive of those that they don't trust.
- They are largely personal, with individuals relating personally to other individuals rather than to a position.
- They are strategic as each party attempts to position themselves better to exploit the relationship, but also to promote the success of the relationships.
- They are sufficiently flexible to incorporate ongoing changes.
- They have been subject to recent changes that have introduced uncertainty to the relationships. There is a paradox that the need is for closer, more strategic and long term relationships, but that uncertainty about future changes makes such relationships more risky.
- They are intentionally established and maintained by the individuals and company.

The nature of the relationship with the customer is distinctive because of the mutual recognition that each relies on the success of the other. The development of risk and reward sharing agreements, in Australia, tie them together as virtually permanent partnership striving to understand the end-user market and jointly competing for that market. This tie is stronger than the relationships with the others but is reflected in relationships with experts and companies with compatible knowledge. Both of

these rely on relationships with Ericsson for success in parts of their business, but not necessarily for survival.

Another theme of the findings in this chapter is that the changes to the environment in which Ericsson operates impact on Ericsson's operations and learning-related relationships in a variety of ways. The outcome is that several of the salient features of Ericsson's operations are different to those that prevailed ten or fifteen years ago. These features are:

- there is a new focus on developing the products that the market demands rather than advancing the technology *per se*
- there is a new focus on the end-user as Ericsson's market rather than Telia and Telstra
- there is mutual recognition that the survival of both Ericsson and its major customers depends on how well they jointly compete for the end-user market
- there is a new focus on the financial aspects of the relationships
- there is a new focus on complementing the activities of their major customers
- there is an increase in security considerations in the relationships
- there is increasing need to form strategic alliances for knowledge development as voice technology converges with data media and computing technology
- there is a new focus on patents and contractual arrangements for the appropriation of the benefits from learning
- there has been a decentralisation of learning and product development to focus on the local market

Together, these changes impact on Ericsson's learning, innovation and learning-related relationships to such an extent as to constitute a shift from an old model of learning under the monopoly regime to a new model under the competitive regime. The old model is a characterisation of the situation that existed previously. The new model is an end point towards which the data indicate that Ericsson is moving, but may not reach. These models are not intended as cohesive analytical units, but rather they are an attempt to capture the impact that changes to Ericsson's external

environment have had on Ericsson's learning. Key attributions of the old and new models, and their implications for learning in Ericsson are set out in Table 6.1.

Therefore, it is concluded that the importance of specific learning-related relationships to learning in industry depends on the environment in which that learning is done. Most importantly, the introduction of competitive conditions has been found to impact on both the rate and direction of technological change.

Key Attribute	Old Model	New Model	Implication for learning
Reason for technological change	To advance the technology in conjunction with monopolist customers	To compete for the market demand, and to enhance relationship with major customers	Learn to acknowledge non-engineering knowledge and to communicate between designers and marketing section.
Target market	Telstra and Telia but exchange relationship not subject to market conditions. Indirect link to the mass market of end-users that had no voice in product design.	Fragmented end-user reached via joint marketing with Telstra and close relationships with Telia	Learn about that market and its current and future demands. Learn to design for market the end-user in terms of functionality, cost, and most importantly, speed
Nature of the tie to the major customer	Strong tie based on shared development of technology and establishment of infrastructure. Relationship not subject to market conditions.	Strong tie based on mutual recognition of joint survival strategies. Market conditions determine the relationship's nature and activities.	Learn about the customer, learn to keep them dependent on Ericsson and not dependent on Ericsson partners and competitors.
Activity range	Broad including wide research interests to enhance the advancement of technology	Focus on core, with core defined in terms of that which will satisfying major customer and enhance the relationships strategically.	Learn about customers' needs and develop competence to meet them. This requires both social and technical competence.
Financial considerations	Secondary importance due to connection to government funding of infrastructure	Important due to competitive pressures on price	Learn to develop cost effective methods for developing goods for the marketing.
Security	Not an issue due to lack of competitors in Sweden and a well funded environment.	Some importance due to increased competition and the need to show customers that their intelligence is secure.	Learn ways to include relationships with other parties while maintaining trust and confidence in order to enhance learning
Converging technology	Not an issue	Slow but likely to be important in the future, uncertain who will be competitors in the future, so raises the issue of security with companies with which Ericsson has strategic alliances at present	Learn about potential convergence scenarios and either gain the necessary knowledge or develop the appropriate relationships for that knowledge
Intellectual property protection	Not an issue	Very important to the appropriation of the benefits from learning	Learn about patenting and contracting process and have engineers accept responsibility for generating and protecting intellectual property
Responsibility for learning and product design	Centralised	Decentralised to capture local market knowledge	Develop efficient methods to learn and to use local market knowledge in common products

Table 6.1 Learning under the old and new models

CHAPTER 7

The Findings on Institutions That Regulate Learning

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7.1 Introduction

This is the second of three chapters on the findings of the investigation of learning in Ericsson. This chapter summarises the data on the institutions that regulate learning in Ericsson and addresses the contextualised research question: What is the nature of the institutions that influence learning in Ericsson consequent to the liberalisation of the telecommunications service market.

Institutions, as defined in Chapter 3, are humanly devised regulators of behaviour that limit the set of choices available to individuals and groups. The institutions that are of relevance to this thesis are those that regulate learning and learning-related relationships. Because creative learning includes teaching and the generation and diffusion of knowledge, the institutions that regulate any of these are of interest here.

The plan of this chapter is that the data on the institutions that regulate Ericsson's acquisition of the right knowledge are summarised in section 7.2. Those relevant to the exploitation of knowledge are summarised in section 7.3. Section 7.4

summarises the data on institutions for the security of Ericsson's knowledge. Section 7.5 presents a conclusion that addresses the research question.

7.2 Institutions for acquiring the right knowledge

While Ericsson was generally said to have had a long tradition of learning and of being technologically advanced, the data indicate that it is undergoing a change from a focus on learning more in order to advance the technology to a focus on learning the right knowledge to serve the market. Several respondents commented that there had been a change from 'learning to do things better, to learning to do better things'. Whereas 'better' was previously defined in terms of technological advancement, it is now defined in terms of the market demand. These changes represent a change in emphasis because satisfying the market demand for products still implies the need for the development of technology. A Swedish engineer commented:

'We must have very attractive products but our ability to do what the customer wants and uses is limited by our need for having and using leading edge technology.'

This section summarises the material on the institutions that regulate the acquisition of the right knowledge by firstly considering the institutions for the acquisition of knowledge and then the institutions that determine what knowledge is considered to be the **right** knowledge.

7.2.1 Institutions for acquiring knowledge

'I'd like to add that Ericsson is an individual culture. Tremendous priority to people networking and tremendous priority to resources into deeply developing personal intellectual property. All of this can not be overstated' (said by a business analyst).

Overall, the data indicate that Ericsson has a strong learning culture that workers should learn and should share their knowledge. The description of Ericsson as an 'old Swedish company' is apt in the sense that it adheres to selective Swedish

cultural norms. Staff from local companies are brought to Sweden to be socialised in that Swedish way of doing things, as well as to develop a network and to learn about Ericsson's process and product technology. The select cultural norms relevant to learning relate to:

- individual responsibility for joint output,
- the free flow of knowledge, and
- reliance on networks.

Firstly, the company learning culture is supported by the reported Swedish traditional norm of centralised power and decentralised responsibility that manifests as individuals taking responsibility for outcomes irrespective of their position in the hierarchy or process. A Swedish academic commented:

'Yes it is in the culture, that is their training. They are very proud of their skills and they do their best and they try to figure out how their part of the machine can be used, what part of quality can be added to it so that it will be a good machine. They improve it. If the engineer makes a lousy drawing, the machine will usually be better than the drawing.'

This is said to be due to the historic egalitarian society in which each was responsible for their contribution and was recognised as such. While the responsibility was individual, the outcome was communal. Modern Swedish industry is based on informal interaction within companies and between companies, with each party taking responsibility for the outcome as well as for their contribution. There are thus norms of both goodwill trust and competence trust within Swedish industry.

The individual perception of their responsibility is said to make it unacceptable in Sweden to judge another's performance. Performance assessment in Australia, on the other hand, is considered to be a valuable tool for understanding the potential for improvement. A Swedish systems manager said:

'It is very different. We are just talking about one example, planning and development discussions. I have been struggling ever since I can remember to include performance

appraisal in these. Whereas in Australia you wouldn't even call them planning and development discussions, you would call them performance appraisals. When you do your performance appraisal you also talk about development aspects but it is very different focus, it must be something cultural.'

Not being judged is said to be associated with the Swedish norm of reaching a consensus, which is said to bar alternative ideas. An engineer in Sweden commented:

'People don't want alternative ideas because they don't want to change. They work hard on their ideas and they want them to prevail. Another idea means that they were wrong - that is not possible in Sweden. This explains why Swedish companies find it so hard to change.'

The changes associated with the Ericsson's new market focus were spoken of as problems in Sweden that were causing discomfort because such changes question the status quo and destroy consensus. In Australia, on the other hand, the changes were seen as creating opportunities and problems to be confronted. Swedes are said not to be used to confronting differences of opinion.

The focus on independent responsibility for learning starts with the recruitment of staff who are interested in learning, and then encourages them to maintain that interest. Respondents typically spoke of their professional development in terms of their life interest rather than as a job. The dynamism of the company and the opportunities to keep learning are recognised as incentives to stay with Ericsson. A Swedish training professional said:

'Well actually this is my interest. These tools are my interest and I know a lot. In a way that is a happy and lucky match of my job and my interest. But that is why it is my job.'

Hence, Ericsson's new competence model (see chapter 4) is an extension of the old Swedish culture. The tradition of personal responsibility, that was previously applied to the advancement of technology that was directed from head office, is now applied to learning about the market and to supporting the company to meet

market demand. However, the associated need for consensus retards the introduction of new ideas associated with the shift to that new focus.

The second learning norm is that there is said to be a Swedish tradition of a free flow of knowledge. This is associated with the practice of Government funding research at universities, which then have the obligation to make that information freely available. Professionals in different companies in different industries meet at various forums for knowledge sharing and routinely form committees to investigate common issues. Ericsson meets regularly with other large Swedish companies for benchmarking and other knowledge sharing. A Swedish human resource professional commented:

‘In Sweden we tend to compare with other big companies rather than with companies in our situation with similar customers or with similar problems and possibilities, which is a great weakness. So we are still, for all practical things almost, we still perceive ourselves as a major Swedish industrial company. So we would compare with Volvo, SKF and those.’

The tradition of sharing with other companies in Sweden is said to have led to Ericsson’s practice of having close learning-related relationships with customers in both Australia and Sweden. This is said to be an advantage to Ericsson in the new competitive regime in which survival of companies is said to depend on the strength and quality of their relationships.

Within Ericsson, the culture of sharing knowledge is supported by an obligation to provide information freely to colleagues. This obligation was attributed to the large systems with which Ericsson works. No individual knows those systems totally, and so everyone has to seek knowledge from others. Without a network to identify those whose competence can be trusted, working with Ericsson’s big systems would be impossible. An Australian engineer commented:

‘The culture is that all information has to be shared in the company. If anyone is found to be not sharing information, to be hiding it for their own purposes that is, they are shot down in flames. It is expected that everyone who has a reason to know something will be told.’

The third learning norm is that the free flow of information is facilitated within Swedish society, within Swedish industry and within Ericsson by the practice of networking. The importance of informal network relationships for learning in Ericsson was discussed in Chapter 6. While networks are relationships, reliance on them and the expectations of behaviour established by that reliance are institutions that regulate who learns and what is learned, as well as how learning is done. An engineering consultant who had worked full-time in Ericsson and Ellemtel for several years said in reference to his own practice when recruiting staff to work in Ericsson:

‘First need is university background. At the post graduate but no PhD. Never a PhD. They become loners and self starters - not team spirit. This is more important in Ericsson. I can't emphasise enough their ability to establish a network.’

While the free flow of information within networks was said to be the greatest source of knowledge by all interviewees, the data indicates that networks exclude individuals on the basis of language, status of local company and alternative ideas. Therefore, the reliance on networks restricts learning in terms of what is learned and who learns it. A public relations professional stated:

‘I think that it is also part of the Swedish culture as well that things happen by consensus and so if this person is not going to be part of the consensus then we should no longer make him part of the group. I have seen that happen.’

Non-Swedish speakers reported strong barriers to learning from Swedes in informal networking situations. Some reported that Swedes switch from the company's official language (English) to Swedish in a deliberate ploy to exclude non-Swedes from a network. Others attributed the lack of forthcoming communication to a more formal persona adopted when speaking English. Swedes are portrayed as having a norm of not socialising, which is said to reduce the effectiveness of networks. The lack of social interaction between colleagues is said to mean that there is no forum in which ‘wildly’ alternative ideas can be discussed creatively and

imaginatively. The sociability of Australians, on the other hand was suggested to be a better source of knowledge than that available under the obligation to tell if asked. Therefore, the data provides evidence that relying on networks in a Swedish institutional context restricts, to some extent, who learns, what is learned and retards learning and reduces innovation. These restrictions are less evident in the Australian modified institutional context.

While the data indicate that networks are used to exclude alternative ideas, there is also evidence that they can enable individuals to value alternative ideas by providing links to the opinion of parties trusted in terms of goodwill and competence. Some individuals are said to use their network to assess the value of alternative ideas in a conservative way, to weed out ideas that are not compatible with the status quo. Others, who are more open to change, are said to use them more creatively to identify those alternative ideas that will be of most value. Without a network to help assess the many alternative ideas, innovation may be retarded. Therefore, the impact of networks on innovation depends on the individual's attitude to change.

Moreover, the commitment to freedom to network in Ericsson was said to provide opportunities for those who hold alternative views to discover others with similar views and to establish a dialogue. This freedom is valued by Ericsson and supported by internal seminars and other communication links including electronic bulletin boards. All those who had adopted responsibility to bring about change said that it is necessary to develop a network with a 'critical mass' in order to have new ideas listened to. Therefore, networks are institutions for both maintaining the status quo and for challenging it. A Swedish inventor who sees himself as an agent of change commented:

'I have avoided to disturb the organisation around me, but I have discussions. If they are not interested I find another. If you use conflict then I think it is not very good. But if you keep a dialogue, and move around and find where you can make it work then in this organisation you can go out to a good time and find the way to do it. But it takes a lot of energy.'

In summary, Ericsson's use of the traditional Swedish norms of individual responsibility for joint outcomes, free flow of information and reliance on networks results in a culture that at once restricts the acquisition of knowledge while providing an environment in which to explore and to value new ideas. Thus paradoxically, the reliance on networks is both the tool for maintaining the status quo and the tool for challenging it. Further, the norm of individual responsibility empowers local companies to learn about local markets, and encourages others to respect that knowledge. However, decentralised responsibility for learning without either consensus or hierarchical direction means local companies lack a well-connected network to have that knowledge valued. Evidence suggests that that norm of free flow of information has been an ideal that has not been fully borne out in practice. These paradoxes reflect the complexity of the institutions that regulate learning in Ericsson rather than confusion in the data.

7.2.2 Institutions for determining the right knowledge

While Ericsson's tradition has been to learn, there has been a change in what is considered to be the right knowledge to acquire. The recent changes in Ericsson's focus have brought a change in the institutions that determine what is 'right' to learn. The data on the institutions that determine what is the right knowledge to acquire relate to three issues: the focus on the market, the technological path, and the company structure.

Firstly, although market-based knowledge is widely recognised as essential to Ericsson's future, Ericsson is said to have been caught without methods to value that knowledge and without a culture to respect it. While local companies in Australia and Sweden are said to have excellent learning-related relationships with customers, and to use those relationships to develop products for particular customers, there are no institutions to collate that knowledge to develop common products. This is attributed to the disdain of people in the corporate level for knowledge from the local companies. A Swedish engineer commented:

'There is a problem with the short term views of the central organisation. Local ideas are knocked on the head and suffer from a general lack of commitment. This is a problem with a strong central organisation. There is a lot of wasted effort in local companies if Ericsson sees them as solutions to problems that they didn't know they had.'

There is also a disdain of marketing knowledge among engineers. A group of inventors was said to have been established and directly attached to the parent company to avoid this disdain and the associated inertia of the corporate level of the business unit. The staff's commitment to designing for the market extends to developing institutionalised practices to include and value non-engineering knowledge. A manager of that group said:

'In the beginning yes, partly because the engineers were not used to listening, they were used to extending the technology. But now that they know that it is important and they have had some practice - that is everybody - it is easier. The behavioural scientists talk to the engineers and the result is a concept specification, they discuss it a lot, not the details but the functionality. The result is a design outlined. This is then discussed by technicians to see if it can be realised.'

The current push for competence management is seen as establishing institutions that encourage learning about local markets, sharing of knowledge and valuing non-engineering knowledge.

The second issue in determining what knowledge is right, relates to the technological path established by the large systems and the incremental nature of technological change. Telecommunications technology, particularly in fixed public telephony, is dominated by large systems. The data indicate that the development of large systems was associated with the old bilateral monopoly regime and coincided with a political push to establish infrastructure. In the new competitive regime, customers demand small flexible systems that can be provided at short notice. This speed and flexibility is incompatible with the large system approach. However, the evidence suggests that Ericsson continues to focus on large systems. Two quite

different examples of big systems that are still pursued are AXE, which is a proprietary technological system, and ISO 9000, which is a quality control standard that is used by companies around the world. AXE was said to have been a logical outcome of the infrastructure-building era, and to have been developed at the end of that era. AXE is said to establish a product technology path, which due to AXE's flexibility, is suited to the transition to the new market focus. On the other hand, ISO 9000 accreditation is said to establish a process technological path that is slow and inflexible. Although ISO 9000 is said to signal to the market that Ericsson's quality is guaranteed at all levels, it is criticised as monolithic and out of step with the new market focus. An engineer with Telia commented:

'Ericsson has officially said that they should be dealt with in a very industrial manner. Big processes, ISO 9000 and so on for quality. But it means that everything must be done in line with ISO approval. But that is not an industrial process at all. If you are writing a programme and you just have to accept that it is kind of like writing a book. And books have success if they are what people want and people can get it. Ericsson doesn't realise that, they want every programme to be a magnum opus. They just don't get it. They don't realise that they are not rewriting the bible that will last for thousands of years. Yes, it is something for the next train trip. That is precise, they should be very responsive and they should be small. Like history it can be just what you want.

[Do you feel that Ericsson is aware of this, is that what you are saying?]

They are more aware than we are, but they have some kind of momentum for working in technology.'

The focus on the system means that individuals must be designed in accordance with the system rather than independently. This limits the range of the products that can be developed and limits the power of the individual to contribute their knowledge and to innovate. A senior Australian manager commented:

'It is not an operation where people sit in a room dreaming up product. If there is any innovation, it comes from a project that has been designated. And if an engineer is tinkering at it then that is the opportunity but not an opportunity to spend all day dreaming.

They are allocated a task, the project is so big and expensive that they do those particular tasks.'

The data indicate that there is usually a choice of technical solutions to any problem. The choice of a particular solution commits Ericsson to a technological path that restricts which solutions will be applicable subsequently. A Swedish engineer commented:

'If you had started now, with the technology that we have now, then perhaps you should have done this quite another way. But you don't because you built it up as an evolution, that is they have introduced new technology a little at a time. Then you apply new technology to the switch, to the computer. But you don't change the whole thing.'

The technology of the path not chosen withers and the associated knowledge is forgotten. This was said to be the case when analog voice technology was replaced by the superior digital voice technology. It was reported that in the old regulated environment of most developed nations' telecommunications service providers were not permitted to own television licenses. They were thereby uninterested in cable television technology which is analog, and so made the choice of digital technology in that institutional context. The removal of the regulation changed the institutional context, made telecommunication providers interested in analog technology, and Ericsson decided to restore its analog knowledge. Ericsson is restoring this forgotten branch by buying companies and entering strategic alliances. Thus the interplay of the technical system, commercial commitments, investment strategies and regulations influence what is learned, what is ignored and what is forgotten.

The incremental nature of technological change poses a contradiction for management. It was argued that to some extent it is necessary to be working in a **specific** area in order to appreciate new ideas. However, it was also argued that the basic technology does not change a lot, and therefore, basic knowledge in the **general** area is enough to enable learning about new ideas. Those who accept the first argument cite the importance of relationships with experts and involvement on

design projects to increase learning and prepare for future technologies. The joint venture with the University of Melbourne, ASAC, for example, is said to have been established to provide Ericsson Australia with the opportunity to develop intelligent network competence (see sections 6.2). The counter argument that general knowledge is enough to launch into new technologies was also popular among interviewees. Recruitment of civil engineers with general qualifications, representation at standards forums by technical generalists and the widespread use of scanning to make sense of new technology were all presented in support of the second argument. The second argument gives credence to the 'efficient' allocation of projects to local design centres, as discussed in section 6.3. A Swedish engineer commented:

'Technical training and experience is over-rated. There is plenty of time and opportunity to update in the face of technological changes that are incremental. If you have a good process and the intelligence, etc, you can pick up the technology. We have a lot of technologies, and I emphasise plural, and they have been around for a very long time in one form. Consider AXE from the 1970s; still used. Yes, it is very different but basically the same. It really isn't the case that if you miss one project you absolutely miss the technology. If you are good, your group can get the technology.'

In other cases, the company structure, which was said to have been designed around the company's products, is an important institution in determining which knowledge is right, and is said to have blocked innovation that does not fit into existing business units. Mobile telephony, for example, was initially officially ignored by Ericsson not only because it considered it to be a toy, but also because it was considered to be a competitor for AXE. Its production would therefore be against the philosophy that all parts of the company should support each other. The decision to ignore mobile telephony was reversed when Nokia showed interest. Ericsson's technology was subsequently modified to accommodate mobile telephony.

7.3 Institutions for exploiting knowledge

The second of the high level issues to which the institutions relate is the exploitation of knowledge. The data on the company's behaviour to exploit knowledge indicate that it is regulated by the following institutions:

- technological standards,
- closed systems,
- institutions to protect intellectual property, and
- methods for applying the knowledge within Ericsson.

7.3.1 Technical standards

Ericsson has a long-standing commitment to support and participate in the international technical standards bodies. Representatives on the standards bodies are supposed to cooperate to have the *best* technical solution accepted as the standard irrespective of company interests. These standards, though voluntary, effectively create the technological path for the industry because they are demanded by the market. Companies with proprietary solutions, which cannot be modified to the standard, lose the market to those with standard solutions. If a proprietary solution is chosen as the standard, the owner of that patent gains by licensing its use to other telecommunications equipment companies. Therefore, Ericsson's success depends on the outcome of the standards process. In practice the *best* solution is considered in light of the company's technology. A Ericsson representative to the International Telecommunications Union (ITU) said:

'What we are trying to do is influence the standards so that we can make it, but not only that but also in the direction that we think is the most profitable for our customers.'

While Ericsson participates in the standard forums to have the standards suit its products, it also uses information from the standards forum in the development of its products. Ericsson's representatives to the technical standards forums work in close cooperation with design engineers to ensure that not only do Ericsson's arguments at the forums integrate with their product development, but also that the

knowledge from the forums is used in the products the company develops. A representative to various standards forums said:

‘As we said, by being active in each of the technologies the opportunity is to develop the skills and competence in your organisation prior to the actual execution of the project. That gives you the edge, you have the skills, the competence, people in your organisation have been exposed to the concepts which may be greater than your competition. Now lead time can be reduced by having those skills, competence and exposure prior to the product development.’

The evidence suggests that while some respondents believe that the standards process is under threat because it is too slow, too expensive and too oriented to the mass market to suit the new competitive conditions, Ericsson remains committed to the institution and contributes disproportionately highly to its functioning. This was said by interviewees from inside and outside Ericsson to be due to Ericsson’s altruistic commitment to the institution of connectability. In line with their ongoing commitment, Ericsson has developed methods to marry the needs of the market with the standardisation process in order to exploit that knowledge. Not only must the development process be quick, but the patent application must be lodged before the technology becomes public knowledge through discussion at the standard forum. Ericsson has adopted a fast-track approach whereby there is overlap in the time for discussions with customers, concept development, patenting and standards. The object is to develop the product demanded as quickly as possible while protecting it by patent and ensuring that it either becomes the standard or is at least close enough to minimise the rework.

Uncertainty about the outcome of the standardisation process leads Ericsson to undertake parallel projects in the early stages. When the direction of the standard becomes clearer, some projects are disbanded. In this way, the standards determine what is the right knowledge to acquire. A senior engineer commented:

‘How we play the game is that we say that there are no closed doors. All technological and company doors can be open. The only question is ‘is it worth it’? Should we step into this

field? We run several projects at once. It is expensive and calls for a lot of investment. We do not know which standard will take off so we are prepared. We have as many options as we can open, even then we consider going for alternative standards.'

7.3.2 Closed system

The second institution that regulates the exploitation of knowledge is the 'closed system'. Telecommunications systems are closed in the sense that they use different operating platforms which make it impossible to mix and match telecommunications components, as is possible with computer components. Technical standards ensure that systems are connectable. Technical peculiarities in Ericsson's systems and products effectively lock customers into continuing with Ericsson equipment because equipment from another telecommunications company cannot be used without replacing the entire system. The tactic is to identify those products that will capture customers and lock them in. Those identified products are developed with system peculiarities while other products are standardised for the open market. A public relations professional said:

'What Ericsson wants is power, but a special type of power. The power to be thought of as important in the industry. We have always had that power, but now things are changing. The strategy is that over the next ten years we should develop the technology and create strategic alliances with the customers. We want the relationships so that the customers have to come to us to get what they want. So we must develop some certain technology that is essentially ours. The rest of it will go through standardisation. That will be more efficient, just some specific technology will be to tie the customers to us.'

The corollary of targeting innovation to achieve customer lock-in is that Ericsson avoids using components from other sources. This 'not invented here syndrome' is said to be a form of tax on the company's ability to introduce innovation. It effectively locks the company into a technology path chosen partly for its peculiarity rather than its superiority. The data suggest that these paths were treated in the past as practically irreversible. Now, though still rare, they are said to be increasing subject to reversal as Ericsson focuses on its core functions and rationalising its operations. In the case of a computer language used in the Radio

Business Unit, for example, a reversal was achieved. When the cost of continuing with Ericsson's own language could no longer be justified, a strategic alliance was formed to develop a commercial language that can be sold to offset the costs. The use of strategic alliances is less subject to complicated implications for relationships with customers when Ericsson decides to discontinue with a function (language in this case), than when it is considering entering it (data technology in the case discussed in Section 6.2)

7.3.3 Intellectual property protection

The third set of institutions for the exploitation of knowledge are those that protect Ericsson's intellectual property from use by other parties. The data reported on patents and contract law both of which are legal institutions that regulate the use of intellectual property. The data indicate that such institutions have come into greater prominence with the change to a competitive market regime. These laws were said to be less relevant under conditions of bilateral monopoly when 'gentlemen's' agreements sufficed. As discussed in Chapter 6, there is now a stronger commercial and litigious focus. Patents and contractual agreements are said to allow the learning-related behaviour established under bilateral monopoly to continue in the competitive regime. That is, these institutions do not limit learning, rather, they facilitate learning that might not happen under conditions of unprotected competition.

Patents are said to provide a 'time window' for the development and commercial exploitation of a product by removing the threat of competitors outpacing Ericsson in the race to get products to market. Ericsson seeks to develop patents for both its own use and for exchange and license. The use of patents is thus partly a tactic to block rivals' product development or to exploit their need for particular knowledge, and partly to protect Ericsson's own product development. A Swedish inventor said:

'There is almost an hysterical chase for patents. Every one is doing it and this is a change for Ericsson. Motorola is famous for having a huge portfolio to protect their technology.'

When we want a technology that someone else has we have to buy it, or if we have a valuable patent in our portfolio we can trade. So that is a large part of Ericsson's strategy - to develop a portfolio.'

The Swedish tradition of freely available knowledge is reflected in the historic lack of a 'patent culture'. This is said to attract academics from the USA who want to research without applying for patents and dealing with patent attorneys. Conversely, Swedish researchers who want to patent and have commercial success are said to move to the USA. The data suggests that the current increase in attention to property rights issues has led to the adoption of practices from the USA that are incompatible with the Swedish national culture. As described in Section 6.2, the lack of Swedish experience in patenting and contracting for the protection of intellectual property has resulted in some research projects with universities being abandoned because the agreement could not be concluded.

Previously, relationships with customers were said to be based on the institutions of trust, that is, contractual as well as good will and competence trust. Relationships with new companies, which are portrayed as aggressive and litigious, are based on the legal threat of contract law. A Swedish patent officer commented on the need for flexible institutional arrangements:

'Please understand that I think that the relationships will be more diversified. There will still be the gentlemen's agreement between some of them, but you must be prepared for other relationships when you must develop a way of dealing with others that is more suited to coping with the individual relations. I think so that you can talk to some aggressive companies in aggressive terms and with less aggressive companies in less aggressive terms.'

At the personal level, patenting requires that engineers focus on the appropriation aspects of the knowledge that they are developing. Such an interest in commercial aspects is said to be at odds with the typical inventor who is portrayed as wanting to develop elegant and brilliant technology rather than to serve the market.

7.3.4 Application methods

The fourth set of institutions for the exploitation of knowledge were related to the methods for the application of existing knowledge. While respondents claim that Ericsson is as good as any in the world for internal distribution of knowledge through intranet, bulletin boards, etc., it appears that institutions for the application of that knowledge to timely targeted products for the market are not yet in place. In some cases, that flow of knowledge is faulty due to the historic dominance of the Swedish operation and the rivalry between local design centres. In other cases the continuation of the old focus on technological advancement restricts the development of institutions for the broader application of technology.

Ericsson continues to focus on technology, but with a new focus on market-driven technology. This focus on the technology is said by some to be misplaced because Ericsson has enough technology. What Ericsson apparently needs are institutions to apply knowledge so that more products can be produced from a single technology. The reuse of technology and knowledge was said to be a rationalisation of the design process in accordance with the new commercial focus. There is a paradox that the focus on the market means that Ericsson will design whatever the customer wants, but customising is incompatible with the need for cheaper design to meet end-user demand. The solution is said to be to develop new products on the old already standardised technology. The reuse of old technology is said to be cheaper and quicker but less appealing to engineers who prefer independent development of solutions. The lack of norms for the reuse of knowledge was a major concern to several of the respondents. Nevertheless, inventors are beginning to focus on extending the application of existing knowledge. An inventor said:

‘Well it certainly is different to the old way. We used to concentrate on how we can develop new technology, now we ask is there any existing technology that can be put together in new combinations in order to meet this need?’

7.4 Institutions for securing knowledge

The third of the high level issues to which institutions relate is that of securing knowledge from being learned by others. The data on the way that security issues regulate learning in Ericsson mainly relate to security with external parties. Internal security was said not to be a major regulator of learning because parties in Ericsson are almost universally trusted. However, sensitive material, particularly regarding price, was typically given to few people to reduce the risk of inadvertent disclosure. The data on institutions for securing knowledge from external parties indicated that there is no protection against security loss due to careless conversation. However, small breaches of security are not considered to be a problem, because the systems are so large that isolated snippets mean nothing. Further, the pace of technological change means that any damage due to a security breach would be localised and temporary. Therefore, Ericsson relies largely on the integrity of its staff to determine what knowledge to share with whom, rather than imposing institutional constraints on that sharing.

The data on securing knowledge from particular external parties related to competitors, suppliers of knowledge (experts and companies with compatible technology) and customers, as follows.

7.4.1 Security with competitors

The importance of security issues with competitors is said to be reduced by various institutions including the industry's norms of honourable behaviour, industry-wide commitment to reputation for honesty and goodwill trust, and technical reasons such as the system's peculiarities that software is not normally subject to reverse engineering. Together these regulate how Ericsson learns and how it protects its knowledge from its competitors.

Ericsson is said to value its position in Swedish society, which is said to rely on their world-wide reputation for moral behaviour. Ericsson's commitment to moral behaviour and being appreciated for that by others was repeatedly mentioned as

limiting its learning behaviour. However, this was said not to restrict learning outcomes because ethical conduits exist for the knowledge that Ericsson seeks. Moreover, an honourable reputation enables Ericsson to develop learning-related relationships that enhance learning.

New parties in the industry, including new service providers, are said to operate under different institutions for the collection and exploitation of knowledge. This is said, for example, to have led to Ericsson's practice of not publicising their successful patent applications, which is said to be common practice among their competitors. The reason given is that Ericsson fears that its successful inventors will be head-hunted. Head-hunting has not been an industry norm among established companies. While the practices of the new service provider companies are said to include head-hunting, they are also said not to include R&D. Therefore, the risk of inventors being head-hunted by either new competitors or old is said to be small. However, there is said to be some companies that operate by establishing large patent portfolios developed especially for sale to the telecommunications equipment companies. There may be some risk of them head-hunting successful inventors. This situation did not arise in the monopolistic era because there was not a focus on patents and no such operators.

Personal institutions, including norms and habits as well as the requirements of particular jobs, determine how much contact individuals have with competitors. While some jobs require a lot of contact through standards forums or on certain projects, others do not. Those who have contact with competitors use their personal norms to determine how much information they disclose. Experienced representatives to the standards bodies indicated that they use their personal discretion in 'cat and mouse games' of intelligence and counter intelligence to learn what they can while revealing what they have to.

Some of those whose jobs do not require interaction with competitors choose to interact and to develop their own institutions for security. These interactions are typically at the concept level and involve open communication. This is said not to

breach security because security is not an issue at the concept level. Those who use these interactions for ideas insisted that they don't steal ideas, rather they have their own ideas stimulated by exposure to new ideas. A Swedish inventor commented:

'Of course you make use of ideas that appeal to you when you discuss with people. I don't know if I would say *steal* an idea as it is formulated by another person but of course it adds a new piece to the picture. I have some kind of model myself so I can fit it into the model and find out perhaps another way of using the idea. Or to transfer it to another application'.

Others believe that security requires that no contact be made with the competitors. In the extreme, old friends who went to work for competitors were completely dropped. A Swedish engineer commented:

'Well I think that it is a bit dangerous having contacts with other companies like that. Maybe I am not correct there, but I wouldn't have thought that it would be encouraged to have contact on the weekend with someone working in Siemens. It depends, if you are working on a standard in ITU with a Siemens guy then you would have contact'.

Such extreme institutions for security were not mentioned by Australian respondents, who have had more experience in dealing with competitors than have the Swedes.

7.4.2 Security with suppliers of knowledge

Learning-related relationships with external parties that supply knowledge (universities, consultants and companies with compatible knowledge) were explained in Chapter 6 to be increasingly important and increasingly common. While, the use of the associated knowledge is protected by patents and contracts, it is not generally secured because in close relationships, trust and a free flow of information rather than security are necessary. A norm of commitment to long-term, mutually-dependent and supportive relationships, a reputation for such relationships, and extensive relationships with Ericsson around the world are said to be the best forms of protection against opportunism. Those who have close contact with the market including consultants and strategic partners report no cases of

breaches and no cases of in advertent disclosure of information to the detriment of Ericsson. An Australian engineer commented:

'I know that there are opportunities but that is how it is. Also it is a basic understanding that a company of the size of HP or Ericsson Australia, a breach would mean a black mark. And this would be known by everyone in the industry globally. It is in their interest not to do that as well. That is why it is preferable to deal with large companies like HP and not some small consultants although they also say that they realise the importance of it.'

7.4.3 Security with customers

The data indicates that while competition makes relationships with customers more important, it reduces the level of confidence in those relationships and raises security issues. The mutual recognition of their shared fate is said to be security enough to regulate the behaviour of both Ericsson and its major customers. A senior manager for Telstra said:

'There has to be, and this is something that we are all having to learn in this new environment, the openness that has been traditional in the industry has to be moderated by the need to respect the commercial interests, and you will find many people who are engineers will spend far too much time being open and honest and it is hard for people to actually draw back and not give information.'

Not only does Ericsson ensure that its partners won't divulge valuable information, it commits resources to ensure that the market has confidence that Ericsson will not breach confidence. These institutions manifest in the physical isolation of those working with Vodaphone from those working with Telstra in Australia. The establishment of 'Chinese walls' between the two is said to be a display of Ericsson's commitment to each customer as much as a method to prevent leaks. Moreover, it was argued that an ethical reputation with third parties, including competitors and suppliers of knowledge, enhances relationships with customers that seek to establish a relationship with an honourable company that they can trust in terms of contract trust and goodwill trust as well as competence trust.

7.5 Conclusion

The purpose of this chapter was to summarise the data on the institutions that regulate learning in Ericsson, in order to answer the research question: What is the nature of the institutions that influence learning in industry?

The data identified a wide range of institutions that regulate learning in Ericsson. These can be grouped according to whether they operate at the national level, the industry level, the company level, the personal level or the professional level. Another group of institutions relates to the influence of the technological path on learning. The institutions in each of these groups are:

- At the national level are laws and regulations, and cultural norms including individual responsibility, consensus, sociability and the free flow of knowledge.
- At the industry level were technical standards and behavioural norms of competitiveness and the protection of honourable reputation.
- At the company level were institutions related to the following issues:
 - * Policies and practices for acquiring knowledge, referring not only to Ericsson's acquisition of knowledge, but also to ensuring that it is the right knowledge.
 - * Policies and practices for the exploitation of knowledge, including its appropriation and application.
 - * Policies and practices to secure Ericsson's knowledge from being learned by others.
- At the professional level were norms and professional standards for engineers, human resource experts and trainers.
- At the personal level were norms of trust, personal integrity, personal development and commitment to Ericsson.
- Technological paths, both process and product, also regulate the learning in Ericsson through the institutions of closed systems and big systems, and because knowledge is cumulative.

The data further indicate that these levels are interdependent. While institutions at all levels regulate learning directly, they also generally impact on the company level institutions that then regulate learning. Furthermore, professional level institutions and national level institutions impact on personal level institutions, and the technological path institutions also impact on industry level institutions. The interdependence of these levels of institutions are indicated in Figure 7.1.

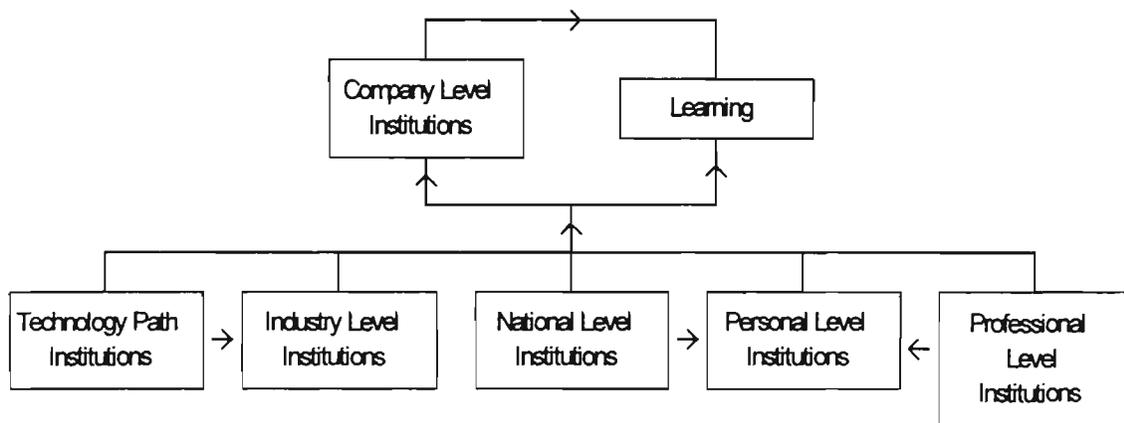


Figure 7.1 *Schema of the levels of institution, showing interdependence*

It is therefore concluded that institutions that operate at various levels impact on Ericsson's operations and separately and together influence Ericsson's learning.

Another finding is that institutions can be described according to several dimensions. Institutions may be:

- formal, in that they are officially recognised and overtly stated (eg telecommunications laws) or informal, in that they are not officially recognised, and may not be overtly stated (eg individual agreements between colleagues);
- hard, in that they create a protocol that must not be broken and it will be known if they are broken (eg the obligation to share knowledge, in principal) or soft, in that they are flexibly adhered to (eg commitment to diffuse knowledge through network);
- macro, in that they apply to a wide context (eg national culture) or micro, in that they apply to the individual or local level (eg practices within teams);
- currently relevant, in that they regulate behaviour in a way that leads to learning that is appropriate today (eg decentralise responsibility) or outdated, in that they

are counter productive for the learning that is required today (eg engineering norm of discounting non-engineering knowledge);

- for display, in that they exhibit a commitment to a regulation of behaviour even though that regulation may not be due to that institution (eg practice of separating staff working on Vodaphone and Telstra projects) or practical, in that they cause the perceived regulation of behaviour (eg design practices);

Despite the fact that each of these institutions was found to regulate learning in Ericsson, their influence on individual and business unit behaviour is variable because they are subject to interpretation and personalisation. For example, individuals differ in how actively they seek to inform others of their knowledge. Furthermore, institutions interact on one another. Some institutions are compatible in that they can be adhered to simultaneously, for example professional integrity and personal integrity. Other institutions are incompatible and a choice must be made as to which to adhere to, for example, the policy to target niche markets and the policy to reduce product tailoring. Institutions are also subject to perception and interpretation. As such individual behaviour differs in response to the perceived regulatory implications of a common message. Therefore, the institutions are not a cohesive set of regulators leading to a uniform and unambiguous set of behaviours.

In terms of the changes to Ericsson's operations and learning that were found in Chapter 6 to constitute a change in model, the data indicate that the institutions regulated learning under the old model have different impacts under the new model. Some of the institutions that under the old model enhanced learning, for instance, were found to retard learning under the new model. Other institutions that led to the right learning under the old model, led to the wrong knowledge under the new model. This suggests that as Ericsson moves from the old to the new model, institutions need to be flexible and modified, or abandoned and replaced with more appropriate ones. The impact on learning of the institutions under the old model and under the new model is summarised in Table 7.1.

Institution and level	Effect on learning Old model	Change to institution	Effect on learning New model
<u>National level</u>			
Law and regulations			
Patents	Not relevant	No change	Directed toward strategic time windows, some projects cancelled
TV licence restriction	Digital replaced analog	Service providers now eligible for TV licence	Analog reinstated
Carrier licence	Focus on advancing technology for monopolist	Competition introduced	Focus on developing products for end-user market, focus on cost and speed to market, focus on tying major customers to Ericsson.
Culture			
Consensus	Promote united vision	No change	Stifles alternatives
Sharing knowledge	Promote diffusion	Unofficially less sharing due to rivalry within Ericsson	Promote diffusion, now access to increasing amounts of knowledge due to electronic media
Decentralised responsibility	Sweden directed and supplied knowledge to local companies	Decentralised responsibility for direction	Local companies as source of market knowledge, but no institution to have this respected at corporate level
Networks	Diffusion of knowledge	No change	Diffusion, can exclude those with alternative opinions, but enables critical mass of alternative opinions holders to amass
<u>Industry level</u>			
Behaviour norms			
Competitive	Independent solutions	New players are more rivalrous	Independent solutions but with some cooperation at behest of major customer, increase in use of patents
Reputation	Restrict method but not content	New players not yet clear if they have same institutions	Restrict method but not content
Technological standards	Central to product technology path	No change	Central to product technology path , now demanded by customers
<u>Company level</u>			
Acquiring knowledge	Learning is promoted within company	No change	Learning is promoted within company
Right knowledge	Focus on advancing technology	New focus	Focus on end-user requires learning what is right for each niche in each period.
Exploiting knowledge	Not a focus of learning	Institutions inadequately developed	New focus on learning how to reuse knowledge, how to patent, how to market and how to lock customers in.
Securing knowledge	Not an issue for learning	Increasingly important and increasingly litigious	Learning to increase security without damaging communication in relationships
<u>Professional level</u>			
Competence managers			
Developing profession	Not relevant	New profession	Learning about new role, content and relationships
Engineers			
Advancing technology	Focus on advancing technology	Under threat	Learning new role in the company that now recognises the value of non-engineering knowledge.
HR managers			
Developing profession	Learning focused on professional service	No change	Learning focused on professional service in times of change
Training			
Developing profession	Learning focused on reproducing knowledge	New focus	Increasing commitment to pedagogic principles and provision of targeted knowledge, increasing commitment to soft issues
<u>Personal level</u>			
Goodwill trust	Learning what others expect	No change	Learning what others require
Integrity	Learning what and how self requires	No change	Learning what and how self requires
Loyalty to company	Learning so as to advance the company's interest	No change	Interest of company no longer clear due to lack of unified vision, some are committed to old way of company and some to change
<u>Technological path</u>			
Closed system	Peculiarities developed due to independence	No change	Peculiarities maintained to locks customers in, but the 'not invented here' complex is too costly, so it is selectively applied
Big system	Compatibility with process and product system was central	Outdated	Retards learning and leads to inappropriate focus on system not service.
Cumulative nature of technology	Single path followed	No change	Multiple paths needed in order to prepare for convergence or other radical technological change.

Figure 7.1 Institutions and learning under the new and old models

CHAPTER 8

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8.1 Introduction

This is the third of the three chapters that present the findings of the investigation of learning in Ericsson. This chapter summarises the data on the learning that is undertaken in Ericsson and addresses three contextualised research questions:

- How is learning done in Ericsson in the face of liberalisation?
- Why is learning undertaken in Ericsson in the face of liberalisation?
- What is learned in Ericsson in the face of liberalisation?

As in the previous chapter, 'learning' is treated broadly here as a creative and social process that covers teaching, the generation and diffusion of knowledge and the acquisition of knowledge. A wide range of activities are included as learning, some of which are immediately identifiable as learning, while others are less easily recognised. For example, the respondents reported their activity in terms of developing a method or implementing a policy rather than as learning *per se*, but those activities have learning embedded in them.

When the respondents explained what they learned they also tended to explain how and why they learned it. In the interest of economy, the following summary of the data is structured around what was learned. The data on how and why learning was undertaken are presented in that context. The plan of this chapter is that the data on learning about relationships, institutions and the market are summarised in sections 8.2, 8.3 and 8.4, respectively. The data on learning about the nature and process of change are summarised in section 8.5. The data on learning about knowledge and about the pedagogic methods of teaching and learning are summarised in section 8.6. The data on learning about technology are summarised in section 8.7. A conclusion is provided in section 8.8.

8.2. Learning about relationships

The importance of relationships for learning in Ericsson was found in Chapter 6 not to be a new phenomenon. Under the old model, relationships with the monopoly service providers were fundamental to Ericsson's prosperity and advancement of technology. Further, internal network relationships were crucial to Ericsson's operations. What is new is the recognition of the importance of learning about those relationships. The data suggests that there are three phases in learning about relationships: learning about the importance of relationships, learning how to develop relationships, and learning whom to include in a relationship.

8.2.1 Learning about the importance of relationships.

While interviewees in Sweden reported having tried for up to fifteen years to have the importance of relationships recognised by Ericsson, they also report that recognition has only happened in the last five years and has yet to permeate the company. Relative to other parts of Ericsson, Ericsson Australia recognised the importance of relationships early when consultants, who were brought in to identify methods for boosting productivity, indicated the need to learn about relationships as the key to improved speed and quality of design. An Australian engineer said:

‘When we started we didn’t realise that it was all about people, we thought that it was about, it was more ... emphasis placed on the process that people would use and how they, we would do it. When the real crux of the issue was how you got along with the person you were working with. How you got along with the other teams. That was the real issue, just being able to do that and get that synergy and to make those giant steps forward. They were all about people sharing their knowledge instead of individuals sitting down in the corner and coding their little bit of software.’

This learning related to developing relationships internal to the group and between the group and its external customer (Telstra). Closer relationships with Telstra enabled the development of an iterative design process that involved the customer at every stage and is said to result in better designs in terms of timeliness and satisfaction of customer needs. The success of this during a period of uncertainty due to rationalisation in Telstra led to Ericsson Australia delivering courses on the importance of relationships to all its staff.

The importance of learning-related relationships, both internal and external, is now formally recognised as a topic for learning by Ericsson globally. Information on the importance of relationships is provided through newsletters, bulletin boards, seminars and workshops. Australians are invited to teach about their experience throughout the company. Moreover, the company-wide competence model, which is a major tool for refocusing the company in line with the shift to the new model, exhorts the staff to develop the necessary competence for a market focus. A key

competence is said to be to establish a new set of relationships around learning about the market.

However, at the individual level there are different degrees of acceptance of the importance of relationships. Engineers are said to be especially in need of learning about the importance of relationships. They have had no training or previous interest in relationships other than networks of fellow engineers in design. Respondents commented that although they can provide information to engineers about the necessity to improve relationships with non-engineers, there is reluctance to accept this and to change attitudes

‘I know what I want my managers to learn and what I want them to do with what they know. But, how to change their attitudes, that is the thing.’

Various individuals and groups who are committed to improving relationships work throughout the company to inform others about the importance of relationships. Some of these are employed in that capacity, but as they have no line responsibilities they can only use the power of reason to try to change attitudes. Others, such as the Australian group, the ‘groundbreakers’, have adopted the mission of improving engineer’s awareness of the value of relationships in addition to their normal responsibilities. Nevertheless, the evidence suggests that some staff have not yet received the message that the company encourages relationships. One Australian engineering recruit commented that she would like to organise a barbecue to help keep in touch with others in her intake of recruits, but said that although Ericsson has barbecue facilities, she didn’t know how such an event would be accepted by the company. She also commented that she kept in touch with friends from university who were working in competitor companies, and was unsure if that would be accepted. An Australian marketing professional argued that there were no benefits to Ericsson from interacting with other companies at the annual Australian Telecommunication User Group (ATUG) conference because no sales were made there. These comments were surprising given Ericsson Australia’s emphasis on relationships.

8.2.2 Learning how to develop relationships

Ericsson commits resources to courses on how to develop relationships. Ericsson Australia gave courses on relationship building to its entire staff. These courses, which were run by the Human Resources Department, are reinforced by courses run by technical and factory training sections. The inclusion of training on developing relationships in technical training courses introduces a focus on communication, trust and commitment that are new dimensions to engineers and factory workers. In the Melbourne factory, relationship training was necessary in order to have the hands accept the change to team work with its greater responsibility for output. Training on developing relationships is said to help engineers identify the customer's needs. An Australian engineer in PBX commented:

‘These soft courses are based on the adage, *don't just fix the fault: fix the customer*. We had none of this in our university or tech courses, but we need it now. If you get to know the customer, you can get to know what the problem really is. Then design a solution that deals with the real problem not just the problem identified by the customer.’

In cases where training in relationship building is not provided, such as at the Ericsson Management Institute, the company provides practical situations that favour the development of relationship building skills.

Knowing how to develop relationships is an attractive quality in recruits. While in Sweden there does not appear to be an assessment of relationship building ability of applicants for jobs, in Australia purpose-designed packages are used to assess relationship-building ability. The lack of attention paid to recruits' relationship skills in Sweden is an interesting omission given the historic and central importance of networking to learning in Ericsson. Until the recent 'discovery' of relationships in Australia, that omission also applied to Australia.

8.2.3 Learning whom to include in a relationship

The data indicate the importance of learning who possesses the sought-after knowledge, who is cooperative, who is trustworthy and who has power. The decision to include someone in a relationship is said to be largely subconscious and based on experience of their work and character, and on the opinion of others already in a network of respected colleagues. A Swedish competence manager described learning about people and networks as an iterative process of learning by doing:

‘You meet people and you try them, they try you. Maybe you can help each other, maybe you can’t. So you learn about each person by trial and error. That is what I mean by learning by doing. Plus, you learn how to network by trial and error. You try to set up this sort of network and use it for something and you see it could be better. You see that you could add more value by doing something different. You work on it and you think about it. Not all the time, but it is there. You have to be in a company and in a situation for maybe ten years to know about networks and to have your own.’

While learning whom to include in a network has always been important to success in Ericsson, it has not previously drawn official attention and resources. However, they have traditionally committed resources to connecting people, or facilitating them to connect. At the local level, recruits are socialised and mentored. At the global level, projects in foreign locations are routinely headed by well-connected Swedish personnel who bring with them not only experience of projects, but also knowledge about contacts in Sweden. Ericsson staff travel to meet colleagues, supervisors and subordinates in order to learn about contacts with whom to develop relationships. Business units support foreign operations through information officers who provide contacts as discussed in Section 6.3. Training courses provide opportunities for people to meet those with common interests.

Now, Ericsson provides courses that teach how to identify people with power, those who are facilitators and those who are hindrances. Several respondents in various roles in the company commented that they saw their role as largely and increasingly about connecting people. This role is increasingly more important as change means

that new relationships have to be developed to suit the new conditions. A manager with Telia said:

'When I changed from being a consultant and I started with Telecom Research, that was a major step for me, and I kept up contacts and I worked on that. Then we changed focus there, so I built up my network there. That is deliberate. I have planned to go out to meet people, to talk to them and really build up the network. Sometimes it is best to refresh the network. It is good to change focus rather than keep on going. I don't see that losing the old network has been a problem. A network has always to be refreshed. The old network has changed context. It is easier now I am good at keeping on. I suppose that I don't keep up with too many of the old. It is my network for now and the future that I must attend to. You have to do that.'

8.3 Learning about institutions

The data on learning about institutions focused primarily on the formal institutions of the technical standards process, patents and company policy, and the less formal institution of expected methods of performing.

8.3.1 Learning about company policy

Learning about the company's policy and expected methods includes learning about the current ones, and developing new ones. The company is said to be good at teaching about existing policy, methods and processes. However, this was said to be increasingly irrelevant because the decentralisation of responsibility effectively devolves their development throughout the company. That is, individuals, teams and local companies have the responsibility to develop methods and processes to regulate behaviour while offering flexibility. The company-wide competence model is an example of the new approach, where the direction from the parent company (LM Ericsson) is that responsibility should be taken at the individual level to develop methods. The competence model requires that methods be developed to learn about the market, and that methods be developed to apply that knowledge in order to design appropriate solutions and to get products to market quickly. The development and implementation of such institutions is an important management

role, which given decentralised responsibility, devolves to the individual and to the local company.

Many respondents were concerned with the lack of knowledge about how to establish the appropriate institutions to support the new foci of the company. The company apparently commits resources to teaching top level management, and others with executive potential, how to develop institutions to achieve desired behaviour. Given the devolution of responsibility, this appears to be more suited to the old model, than to the new. The data indicate that a lot of effort is placed on learning about management broadly, including human resource management, competence management, and professional and personal development, at all levels in the company. The focus of this management training has been on relationship building in order to enhance individual learning, rather than on the establishment of institutions that will regulate and support that behaviour.

It was argued that the company needs to become a learning company by developing policies and methods to put individual knowledge into the system. Several interviewees commented that they, at the lower-middle level of the company, need to learn how to communicate with the executive at the corporate level to teach them, while the executives need to learn how to value their input. Becoming a learning company was also said to involve learning from mistakes and confronting and resolving, rather than evading, problems. A Swedish senior engineer said:

‘I think that learning by doing is enough if you use the results... A lot of people would say that we have been talking about the same problems for the last 15 years. That is pretty true. So we don't seem to really fix the things and get rid of them. It is a cycle of sorts of recognising a problem trying to do something about it and then the initiative dying out and several years later the problem sort of coming up again.’

8.3.2. Learning about the technical standards process

The data on learning about the technical standards process involved learning about the strategies and relationships of the parties to standardisation, and the potential for

changes to the standardisation process to impact on Ericsson. Under the old model, it was indicated that only the representatives needed to understand the process, others had to learn about the outcomes and use them in subsequent design. Now, the need for speed to market requires methods to integrate the standardisation process and the design process need in order to fast-track product development, standardisation and patenting. Moreover, the change to the competitive environment has changed the way that parties to standardisation forums are aligned in negotiations. It is important for Ericsson to understand that alignment and how it impacts on the politics and the outcome. Also there are new members at the forum who's position and tactics have to be understood. A representative at various standardisation forums commented:

'To do the standardisation role properly you need technical strengths but you also need a political awareness. It is a strategic thing you also need to know what is happening out in the market place. Sometimes I think that it is recognised in this company, and sometimes I think that it is not. Technical knowledge will never be enough. You have to know how to package it, when to stop, when to push. It is not really a formal process - just getting the mindset of the people.'

Ericsson, it was said, must learn about the pressures on the standards process for change pressures and how they will impact on their operations, and how to minimise problems and exploit the opportunities. The pressures arise because of the need for faster standardisation, freeriding by private companies that will undermine the incentive to contribute to the expense of standardisation, and alternative (competing) standards that may proliferate thus reducing the power of each standard.

8.3.3 Learning about patents

Learning about patents was said to be particularly important because the industry's and Swedish traditions of not patenting were said to have left Ericsson poorly equipped to deal with the 'almost hysterical chase for patents'. The lack of experience in Sweden necessitates learning from other Ericsson companies,

especially those based in the USA, as well as from patent lawyers. Moreover, it is necessary for engineers to learn new attitudes and develop institutions that integrate patenting with the design process. This means that engineers must learn to view their work as 'not obvious to anyone normally skilled in the art', which was indicated as a criterion for patenting in Sweden. It was also important to learn how to negotiate property rights to facilitate joint research agreements.

8.4 Learning about the market

The data on learning about the market relates to learning about customers, competitors and companies with compatible technology.

8.4.1 Learning about customers.

Learning about the customers is important to the market focus, and implies learning who the customers are, what they want, what they will pay and other conditions of their demand. Historically, Ericsson's reason to learn was to satisfy the monopoly customer, and for the 'fun' of technology. Now, the reason to learn is to satisfy the fragmented end-user market, and so keep the major customer satisfied. Ericsson knew the monopoly service providers through years of working together on the development of technology. Now, that 'market demand' relates to the end user, Ericsson must learn about its customers' customers. Ericsson has several ways of learning about the end users, including a joint marketing agreement with Telstra. Together they undertake market research and analysis. Market analysis in Sweden is undertaken in clinical tests of targeted populations in Ericsson's Human Behaviour Laboratory. This is supported by market surveys and scenario analysis of consumer behaviour in hypothetical situations.

Ericsson is also now learning about the new service providers, which includes the new rationalised Telia and Telstra as well as new entrants to the industry. Ericsson learns about Telstra through a variety of sources including three staff members who work half-time inside Telstra. Moreover, the relationships between Ericsson and

Telstra staff built up over the years are said to be the best source of updates on Telstra. Learning about Telia is said to be problematic because it underwent complete rationalisation, which saw a complete restructuring and replacement of many people.

The data on learning about new service providers related also to the conglomerates of service providers from various nations, for example Uniworld joins Telia with telephone companies from the Netherlands, Switzerland and Spain and with AT&T from the USA. Together, these represent Ericsson's largest market. A problem appears to have arisen because the overall company direction is said to be based on knowledge learned through relationships at the highest level between Ericsson executives and those of its major public telephony customers. The parties have changed and their situation has changed. A senior engineer in Sweden said:

'The other thing to remember about Alcatel, is that Alcatel is a merger of several companies. So while France Telecom has had a close relationship with the French part of that, they probably have less association with the Belgium or German part. The politics of the new situation are terribly complicated.'

8.4.2 Learning about competitors.

The data on learning about competitors related to learning who they are, their products and supply conditions such as time to market. Most respondents reported that they knew enough about the competitors notwithstanding the weak learning-related relationships that are heavily regulated by individual and company level institutions.

Ericsson's Competitor Intelligence Unit learns about Ericsson's competitors through intelligence and surveillance. The intelligence unit is decentralised globally. Local companies collect data on competitors' activities that are relevant to their market. This is collated and analysed in Sweden. Through bought information, local market data and rumour, the analysis team pulls together a picture of each company's financial position, project activity, technological path, strategic

relationships, personnel and market position. The most difficult thing to learn about is said to be pricing data. A major contributor to this intelligence comes from the standardisation process where experienced representatives are able to learn about a company's position from the stance it takes and the arguments it puts forward. The stability of the global telecommunications equipment industry with its dominance by a handful of global companies means that each company is well known to the others. When a major customer releases a list of contenders for a project, each party is known to the others. The only surprises are if a company has held back at the standardisation forum in an attempt to win an anticipated tender by offering a technological edge.

8.4.3 Learning about companies with compatible technology

Issues associated with companies with compatible technology were discussed in Chapter 6. The reason for interacting with them at all, and for learning about them and their technology in particular, is that they have technology that is demanded by Ericsson's major customers, but which Ericsson does not have the time to develop itself. Such situations have arisen because of the convergence of previously distinct technologies. The data suggest that there are two possible scenarios related to the convergence of previously distinct technologies. In one scenario 'convergence' implies that a single technology is developed that will provide, for example, both data and voice communication. A 'single technology' implies convergence of three characteristics of the technology to form a common network, a common functionality and a single product. If voice technology converges with other technologies to form a single technology, the companies with that technology will become Ericsson's direct competitors. To compete, Ericsson would need to develop a technology for both data and voice communication, as well as learn about the institutions of the new market, and its key players. At present, this convergence has not taken place and so Ericsson continues to scan broadly to learn about the key players that may become important and how they may behave if that scenario came about. This involves collating and analysing published data as well as scanning for material relevant to reputation. In the second scenario, which is said to be the case

now, convergence implies that two distinct technologies integrate to form products that use the still-distinct technologies. That is, there is convergence in either one or two of the three elements, but not the third. If this scenario prevails Ericsson needs to continue to learn about the companies with which it enters strategic alliances to serve the market, and the institutions that regulate them. At present, these alliances are supported by institutions of trust and long term commitment to partnering each other, which permit virtually full disclosure of knowledge. The evidence suggests that Ericsson is uncertain as to whether convergence of technologies implies the first or the second scenario. Therefore, they are committing resources to research a single technology for both voice and data, for example, while developing relationships with companies with data technology to deal with the immediate market demand.

8.5 Learning about change

The data indicate that the stability of the telecommunications industry under bilateral monopoly conditions led to Ericsson being accustomed to operate and innovate under conditions of relative certainty. Now that change is said to be happening on all fronts - relationships, institutions, the market and technology - Ericsson is said to be experiencing uncertainty. That uncertainty is relieved by learning about change. This includes learning about what change is, what is changing, and the implications of change for Ericsson, and learning to implement change in the company.

Although some interviewees reported having tried for up to fifteen years to teach Ericsson that changes in the external environment made changes to the company's operations necessary, it appears that Ericsson learned the need for change recently when brilliantly engineered products did not find a market. Now, knowledge about the need to change to a market focus, to reuse technology, and to accept non-engineering knowledge was said to have permeated Ericsson through bulletin boards, workshops and newsletters. However, there is resistance to the next step of accepting that knowledge. That is, although there is now a lot of knowledge about

the need to know, there has not been the associated change in attitudes. There appear to be three factors that reduce the capacity of the knowledge to bring about changes in attitude and behaviour. The first, is that it provides 'soft' information on the change process while engineers in particular are said to require concrete information about outcomes. Secondly, there are strong forces against accepting change. The infrastructure, careers of successful decision makers, dominant networks of engineers that exclude those who propose alternatives, and the company culture that continues to attribute strength to size, and status to technological advancement, all mediate in favour of conservatism. Together these forces contribute to a common vision of what the company was and, to some extent, still is. On the other hand, the uncertainty of the implications of those changes for Ericsson means that there is no common vision of what the company will be after the changes. Moreover, money is still being made on the old products while the new are fraught with risks. A Swedish competence manager commented:

'There is a lot of hype. Everyone wants to, especially now that there is competition about our customers, they are very eager to find new ways of being competitive so they jump on things also and of course they want something that doesn't cost very much. But, we have to invest a lot in it to develop it. If they change their minds, which they can do the next day, we have wasted away a lot and this makes it difficult for us to react.'

The third factor that reduces the capacity of knowledge to bring about change is that many of the prime-movers for change are Ericsson staff whose mission is made more difficult by two factors. The first is that their message is not as well received as that of consultants. This is partly because they do not have the freedom to investigate and a forum to present their ideas, which consultants have, and partly because they are less able to act as a catalyst because they become socialised in Ericsson. The second is that they lack connection to senior management. Greater support from senior management, it was suggested, would help change the attitudes of those who currently resist change. While senior management is said to know about the need to change, some managers fail to support it. Some interviewees attributed this to their on-going confidence in the old model that gave them their success. Others attributed this to their generally conservative management

approach that avoids rather than addresses issues. Respondents reported not knowing how to teach senior management that the issues of the shift from the old to the new model were not going to disappear. A Swedish project engineer said:

‘What we are trying to push on now is that what we are doing is a long term initiative and that it is not going to go away. This is something that Ericsson has been very bad at before, there is a lot of initiative started up and after 6 months you never hear of it again. And a lot of the management, they have been trained or they have learned the behaviour of “if you do nothing for six months it will probably go away anyway”. We are trying now to show them that this is not going to go away. Pretty soon they are going to be left behind and we have tried to work on a sort of voluntary basis, but we try to keep a fair bit of tension and pressure on the management so that they feel that they have to react.’

The rapid growth of the Radio Business Unit was said to be a force for change from within Ericsson. Radio’s shorter history avoided the monopoly era with its lack of flexibility, length of time to market and lack of consumer awareness. Radio’s focus is on the market, its flexibility and acceptance of change were said by some to reflect that its roots are in the new model. They added that as Radio continues to dominate Ericsson in terms of prestige, employment and profit, its institutions of seeking change would spread. Others doubted this and suggested that Ericsson’s resistance to change was at the core of the company. Their perception was that Radio is run by basically the same people as the rest of Ericsson and that once the rapid growth in Radio had petered out, they will be seen to be as conservative.

8.6 Learning about knowledge

The importance of learning and knowledge for Ericsson’s operations was reflected in the data about learning about the knowledge held by others and the data on learning about the pedagogic of learning and teaching.

8.6.1 Learning about the knowledge held by others

The data on learning about the knowledge held within Ericsson includes learning about the knowledge held by individuals and that held by sections of the company.

Three reasons were given for needing to know the knowledge level of individuals in Ericsson. The first was to assess the gap between recruits' knowledge and that necessary to perform tasks. The basic knowledge level of engineering recruits is well known because of Ericsson's involvement on university boards. This is especially the case in Sweden where the universities and their courses are extremely well known. Ericsson has less history of involvement in other disciplines, and less knowledge of those recruits knowledge level. New recruits are given blanket courses in all relevant material and broadly exposed to experience within the company by a system of rotation. It appears that they are selected for employment because of their perceived intelligence, interest in learning, and other personality traits rather than their specific knowledge.

The second reason to need to know individuals' knowledge is for competence management. Learning about the extent and level of individuals' knowledge level is an important component of competence management, and various attempts have been made to identify and measure it. It was reported that no attempt anywhere in the company nor outside the company was known to have succeeded in developing a framework that could record competence thoroughly. Competence mapping, for instance, records the individual's knowledge as manifested in task performance, but does not capture their knowledge that has not been targeted to those tasks. Moreover, attempts to identify tasks have become bogged-down in the details of historically-important major tasks, leaving many current important tasks unaddressed. One attempt that used self-assessment failed due to the workers' inability to assess themselves objectively. Other attempts have become bogged down in attempting to detail individual knowledge. More recent attempts have aimed for objectivity in the belief that it would better enable the company to assess the competence of people irrespective of personal shyness and cultural differences in tendency to brag. The concept of objectivity is also said to appeal to engineers who relate well to numbers. Although the importance of social competence is stressed by Ericsson in accordance with the new model, the evidence suggests that competence managers of engineers have not yet attempted to map their social

competence. It was said that it is expected that this will be more difficult to reduce to numbers.

Many methods are used to collect and store knowledge about individuals' knowledge. Ericsson compiles databases that detail individuals' work experience, and academic records provide information about the technologies to which they have been exposed. The databases do not record details of individuals' other interests, social knowledge and abilities. The databases, therefore, provide knowledge of what individuals have done rather than what they can do in the future. Supervisors generally know the workers, their history, sociability and interests outside work. This largely-tacit knowledge has been used in the past to identify workers who hold knowledge that was newly of interest to Ericsson. However, the loss of supervisors in team structures means that Ericsson has lost a source of such knowledge. This has been recognised as a potentially serious loss due to the uncertainty of the future direction of technology. Supervisors have therefore been replaced by competence managers who are trying to put together and record that knowledge that was previously largely tacit, and to make it the basis of competence management.

The third reason to learn about individuals' knowledge level is to determine whom to include in a network. Informal learning about others' knowledge is done through experience of working with them, through conversations with them, and indirectly through knowledge of their activity in projects and through discussions with those in a network. Because the level of professional knowledge among Ericsson staff was reported to be high, the emphasis of learning about their knowledge is on what they know, who they know, the strategic value of that knowledge, and their preparedness to share it, rather than on how well they know it. Australian engineers reported using an international network of individuals who had worked in Australia to learn about the knowledge held and the social attributes of potential appointees.

Ericsson conducts an annual survey of staff opinions, *Compass*, that provides information that help managers at the local level to learn about their staff including their knowledge. The object is to provide a relative position of the local company in terms of the overall company in order to stimulate discussion that will lead to further learning in accordance with Ericsson's commitment to ISO 9000 (quality control).

Learning about the knowledge level held in sections of the company is important to overall management because it helps in project assignment, and sourcing staff to move in order to diffuse knowledge. However, it is said that the company finds it difficult to track the diffusion of knowledge. A Swedish engineer said:

'Ericsson believes that knowledge leads to growth of the firm. We want to know about the diffusion of our knowledge but because of the hierarchical functional format of the company it is difficult to track the knowledge.'

This hierarchical structure was said to have led to poor communication between some sections of Ericsson that makes it difficult to identify what knowledge is held by other parts of the company. This means that some learning is repeated, and some 'wheels reinvented'. The outcome is that Ericsson is prevented from becoming a learning company in the sense that knowledge is taken from the individual or group and used for the benefit of the company overall. A consultant engaged to advise on becoming a learning company suspects that the company does not intend to heed his advice. It was said that at present learning leads to more learning, while ideally it should lead to learning how to learn more.

8.6.2 Learning about learning

The data suggest that Ericsson has had an interest in scientific methods of learning and teaching for some time and that this is increasing in line with the need to learn more and to learn faster. It is said that neither academics nor the professional associations, the Global Alliance for Transnational Higher Education (GATE) and

the International Council for Business Education, have any knowledge on ways to improve methods for learning and teaching in industry. Therefore, Ericsson has undertaken investigations into improving methods for teaching and learning about technical material. This process involves developing modules of the essential knowledge component of technical material, which requires intensive discussions with design engineers who possess the knowledge that is to be taught. The use of these modules is said to have reduced the duration of some training programmes by up to seventy five percent. This process is hampered by the engineers' typical inability to communicate about technology in lay terms that the pedagogic analyst can understand. One such analyst with teaching qualifications in science and a life-interest in developing tools for teaching and learning in science, reported that without this background his role would be impossible because he would not be accepted into the engineers' networks.

More generally, technical training in Ericsson has been rationalised to make use of knowledge about better, quicker, cheaper and targeted learning methods. The philosophy is to provide highly effective training in specific areas for specific purposes rather than to provide general technical training to all engineers. Training modules are now produced by professional trainers who also train the trainers in the various local companies and business units. Courses are scheduled to coincide with work experience to reinforce the learning. Courses increasingly recognise the value of previous learning and experience in learning incremental knowledge, and so target the gap between the held and the desired knowledge.

8.7 Learning about technology

Ericsson's product is technology, and the data indicate that learning about product technology is important to the company's operations and to the individual's contribution. The interviewees referred to both 'soft' and 'hard' technology. Hard technology refers to product technology. Soft technology refers to the processes and styles of management including human resource management, competence management, and marketing. Formal training in Ericsson is said to be 70% hard and

30% soft technology. Informal 'action' learning is said to combine technical and soft issues inseparably because professional behaviour is a meld of the two. Soft and hard technologies are integrated in project management. A project manager in Sweden commented:

'To be a manager here is to manage competence more than to manage technology. If the workers have the right competence, then the technology follows.'

The new competence model formally acknowledges this integration of competence management and technical management.

8.7.1 Learning about Ericsson's current technology

Engineering recruits are given intensive training in the technology of Ericsson's existing products and processes. While many recruits have been exposed to Ericsson product technology in their university courses, the intensive course concentrates on the peculiarities of Ericsson's system and processes. Longer-serving staff members are given targeted training especially when a new version of a product or service is released, or when the staff member takes on new responsibilities. In either case, it is routine for either Australian employees to travel to an Ericsson company overseas, which is more advanced in the technology, or for experienced workers to visit Australia to teach. In a current case, when Australia joined a project, the project leader was recruited from the UK project team. The Australian team of 10 was then sent to the UK for several weeks to learn the technology by working with their UK counterparts. The emphasis of that learning is equally on process and product technology. A great advantage of travelling to learn the technology is said to be that it provides the opportunity to establish networks for sharing knowledge. Movement of staff within Ericsson was said to be an important method to diffuse technical knowledge, partly because it enhanced networks and partly because it relays tacit knowledge about processes.

Other steps taken by Ericsson to keep their staff up to date with Ericsson's technology include *the Review*, internal publications, electronic bulletin boards and

a well developed internal web. Moreover, Ericsson subscribes to journals and reports from standards bodies. These are circulated and stored in libraries. Information officer have the responsibility to connect individuals and to identify where information is available. It was generally stated that any technical information wanted is available formal channels, however for more in-depth understanding it is necessary to access it through a personal network.

Although it was generally recognised that Ericsson is very good at making technological knowledge available, the size of the company and the complexity of the technology was said to prevent individuals from learning the technology, *per se*, rather they learn of the existence of the technology and its general functionality and application. It was argued that the common basic threads of the technology enable them to know enough without undertaking specific training. Moreover, training sessions are used as a means to learn who is interested in a technology and who has advanced knowledge in order to extend the network, as much as they are used to get the technical information. The company's aim for technological advancement through competence means that knowing about the market can't be separated from knowing the technology, nor can technology be separated from the relationships that make it important

8.7.2 Learning about future product technology

The change in emphasis from learning in order to advance the technology, to learning in order to develop products to satisfy market demands, means changes for learning about future technology. Although it was said to be 'definitely not science fiction', Ericsson has a history of innovation and working in new areas. By definition, there is a lack of written technical material directly related to the inventions that are underway. Inventors rely on networks inside Ericsson and in research institutions (both academic and industrial) to stimulate ideas. Personal contact was stressed as the most important source of 'really new' knowledge. To stimulate concept development in Ericsson, senior engineers are brought together at residential workshops that lead to expert groups to report on specific topics. There

is argument that this practice prevents novel solutions, and that cross-disciplinary groups would be more innovative

While the new focus on exploiting existing technology has reduced the emphasis on developing new technology, the prospect of the convergence of voice with previously distinct technologies of computing, data communication and media, and other radical technological change, means that Ericsson must learn about alternative technologies in order to work on solutions in anticipation of market demand. Although Ericsson usually focuses on the application of technology and development of products rather than on basic research, issues of convergence have led to an increasing emphasis on research projects both in-house and in conjunction with universities. Ericsson also monitors the developments of others in various fields, which involves networking, discussing concepts, and seeking broad stimulation of ideas because the area is new to all involved. Broad scanning and reflecting on possibilities are said to be essential because of the uncertainty as to where the right knowledge will come from, and the risk of being locked into an unsuccessful technology.

While scanning was typically described as unsystematic and relying on easily accessible information, it was argued that by using many sources the most important things are heard about. Learning was generally described as a life interest of the interviewees, however, most commented that the pressure of work and the need to be an expert in a specific area limited their ability to scan. This was supported by respondents from university and research institutes who commented that the Ericsson environment stifles learning about alternative product technologies.

8.7.3 Learning about future process technology

Process technology including methods for performing tasks, and for managing that performance, become institutionalised when those processes become prescribed or expected methods. The data do not clearly distinguish between learning about new processes that will be institutionalised and those that will not. This is perhaps

presented in Section 8.3 on learning about institutions is also applicable to learning about processes that do not become institutionalised.

8.8 Conclusion

This chapter summarised the data on the learning that is undertaken in order to address the research questions:

- How is learning done in Ericsson in the face of liberalisation?
- Why is learning undertaken in Ericsson in the face of liberalisation?
- What is learned in Ericsson in the face of liberalisation?

The findings relevant to these questions were, briefly:

- What was learned? The data identified six topics about which Ericsson learns: relationships, institutions, the market, knowledge, technology and the nature of change.
- How was it learned? The data on how learning was undertaken indicated eight methods of learning: interaction, instruction, search, reflection, experience, recruitment, reading and observing. Of these, only recruitment does not imply that an individual learns. Rather, it implies that Ericsson acquires knowledge by bringing that knowledge in house, or moving staff within Ericsson so that their knowledge is acquired by another section. It also applies to the acquisition of companies with wanted skills. Moreover, learning methods were found to be either direct or indirect. Direct methods are when learning about an issue is achieved by approaching that issue directly rather than through an intermediary. An example of indirect learning is that Ericsson learns about their competitors via the standards forums. Learning was also found to be either professional in that it is the outcome of a process for which the staff is qualified (professionally or otherwise), or is non-professional in that it is the outcome of a process for which the staff is not qualified.
- Why was learning done? The data on the identified six reasons for learning. These were to reduce uncertainty about future technology, to reduce uncertainty about market conditions, to enhance relationships by satisfying market needs, to

or otherwise), or is non-professional in that it is the outcome of a process for which the staff is not qualified.

- Why was learning done? The data on the identified six reasons for learning. These were to reduce uncertainty about future technology, to reduce uncertainty about market conditions, to enhance relationships by satisfying market needs, to establish or respond to a technological path, because it is company policy to learn, and because of personal interest in learning.

These three practical issues are interdependent in the sense that in telling what was learned the interviewees tended also to explain how they learned and why. The material is summarised in Table 8.1.

In terms of the shift from the old to the new model, which was discussed in Chapters 6 and 7, it was found that a lot of learning in Ericsson is about that shift or is a direct result of that shift. While some of the topics of learning are not new, the focus of that learning has changed. For example, the demands of the market have always been learned about, but that previously meant the interests of the monopoly service providers. Now it means the demands of the fragmented end-user market. Other topics, for example relationships, concern issues that have been important to Ericsson, but have not previously been a focus of deliberate and formal learning. Still other topics, such as the nature of change, are completely new to Ericsson's circumstances, while others, such as learning about future technology, have been demoted in emphasis. Issues relevant to why learning is done and how learning is done, have had similar changes with the model shift. These changes are summarised in Table 8.2.

What was learned	How it was learned and taught	Why it was learned
Relationships - Importance of relationships	Instruction from consultants, Australians teaching overseas, seminars and workshops, and interaction with those who believe in their importance	Originally to boost productivity through cooperation between colleagues, but mostly to understand the interests of the major customers, and to tie them to Ericsson through social dependence. The reasons it was necessary to learn about this was that engineers, in particular, had little exposure and interest in soft issues.
How to develop relationships	Training, experience, and the recruitment of those with relationship building skills	It was learned because of the importance of relationships, see above, and the lack of experience in the deliberate establishment of those relationships.
Whom to include	Iterative process of learning by doing and reflection, involving experience, interaction and observation of individuals in order to share their knowledge and propensity to share. Training now available.	Need to determine who can and will provide the knowledge required. This has always been the case but now, the change in circumstances increasingly implies the need to learn systematically and quickly so as to establish the appropriate relationships.
Institutions - Company policy	Learning about existing company policy is by courses, network interaction, observation and through documentation. Not clear to interviewees how to establish company institutions for the new focus.	Overall company management, to regulate behaviour in line with new foci, to become a learning company
Technical standards	From representative who learns from experience, and forum publications	New model requires speed to market, achieved by integrating patent/design/standardisation. Knowledge reduces uncertainty.
Patents	Courses from patents office, patent attorneys, USA experience.	Company policy to be successful in technology, new patents race, company policy to get 'time windows'.
The market - Customers	Experience over time, personal contact in local market involving interaction and learning by doing, and staff working inside Telstra. To learn about their end-use customers market analysis, clinical analysis, scenarios, some of which are undertaken with the major customers.	Knowing the major customers and the end-users is essential to Ericsson. Although the major customers have generally been well-known for years, they have recently undergone change and rationalisation and this is why they have to be learned about, as well as new market entrants. The end-users have to be learned about almost from scratch because they have not previously been the focus of learning of either Ericsson or its major customers
Competitors	Central collation of knowledge from local companies, standards forums, and bought information, as well as industry gossip.	To reduce the uncertainty about the capacity of the competitors' to meet Ericsson's major customer's and the end users' demands, to anticipate their tenders for major contracts, and as an indication of the overall direction of the technology and industry.
Compatible technology companies	Learning about their competence and goodwill by experience in partnering on projects locally and globally, and their reputation.	Ericsson learns about those companies in order ensure the best technology is combined with its own, with minimal risk to the relationship with major customers, and minimum risk to its reputation.
Change	Experience and interaction with those who have experience or seek to teach about change is the main way to learn about the nature of change. Also, electronic bulletin boards and workshops.	Externally imposed change is new to the industry and to many who work in it. This lack of experience makes it necessary to learn in order to understand the nature of change to decrease the uncertainty and to enable choices to be made of what to learn in light of the new conditions.
Knowledge - Held by others	Official databases on individual's work experience and qualifications, supervisors and colleagues learn by interaction overtime about tacit and non-work related knowledge. Competence managers seek to formalise that knowledge. Bulletin boards call for knowledge that is new to Ericsson. The knowledge held by sections is known to the company through their experience on projects and from the annual survey <i>Compass</i> . Learning by sections about other sections not involved in projects is poor.	Knowing about the knowledge held by staff is important for management including overall planning, training needs and suitability for jobs and projects. Knowledge held by staff, which they have not gained through work experience, is increasingly important because the change in foci of the company needs alternative knowledge, both social and technical. Similarly, individuals in new roles need access to knowledge on other individual's knowledge. Knowledge about the knowledge level in sections of the company is important for project management, it is also a requirement for the ISO9000 quality assurance accreditation, which is considered to be a marketing advantage. Sections need to know more about the knowledge held by other sections in order to avoid repetition.
Pedagogy	Learned by experience due to lack of academic knowledge, applied through analysis of information from interaction and experience.	Better learning in terms of speed, cost and market focus are recognised as essential to meeting the markets demands. The pedagogic analysts learn about methods and tools of learning as their life interest.
Technology - Current	Ericsson's current technology is mostly learned through training, experience and interaction. Other methods include reading newsletters and journals, and generally scanning for issues. Strategic alliances provide the interaction to learn about technology of other firms. Those firms are bought, if possible, if technology is required long term.	The company's business is basically selling product technology which relies on process technology, and so they are learned throughout the company. Technology is therefore learned because it is company policy. Individuals learn about technology because it is their life interest. Learning about the technology of other companies is important due to convergence, and the associated need to reduce uncertainty.
Future	Learning about future technology involves R&D into new technology, and into ways to apply old technology to new goods. Both of these involve interacting with others in various fields, scanning for concepts, and reflecting on a wide range of stimulants, as well as undertaking laboratory and design work.	The future of the company depends on how well it can develop products for the market by developing new technology and applying old technology to new products. Learning to develop new products from old technology is important because it is potentially faster and cheaper to use already standardised technology. Learning about future technology reduces the uncertainty in the company. It also is a life interest of those involved.

Table 8.1 Summary of the practical issues of learning

Aspect of Learning	Old Model	New Model
What was learned		
Relationships	Relationships were important but not recognised, they were learned about as a side effect of experience and interaction rather than through a formal process.	Relationships are formally recognised as central to Ericsson's success, and are the new focus of the company's deliberate learning activity.
Institutions – Company policy	Developed centrally and professionally, as well as by custom and practice. It was diffused by training and documentation, as well as through observation.	Policy development is partly decentralised but not yet subject to established institutions, and professional development. Diffusion of the decentralised component is not well established.
Standards	Representatives' learning was deliberate and professional. Others learned from publications.	Development of standard, patent and product are integrated through interaction between engineers in different sections, and with marketing. Learning remains deliberate and professional.
Patents	There was no systematic focus on patenting, although some products were patented.	Patents are central to the inventor's role and responsibility for patenting is spreading to designers generally. Learning about patents is deliberate and professional.
Market - Customers	Learning about the customer was a side-effect of advancing technology together. It was neither deliberate nor professional.	Learning about the fragmented end-user customers requires both a professional and deliberate process of search and analysis, as well as learning by experience.
Competitors	Learning about competitors was deliberate and indirect through reputation and standards forums. Learning was by both professional groups as well as more generally throughout the company.	No change, except that there are new competitors to learn about.
Companies with compatible technology	Learning about companies with compatible technology was not very important because technological change was slow enough for Ericsson to supply all the required technology	Learning about companies with compatible technology has become increasingly important due to convergence. Companies are learned about directly, and deliberately through partnership experience, and indirectly through reputation.
Change	Change was not seen as relevant as a focus of learning because the key players (Ericsson, Telia and Telstra) could control that limit it to technological advancement.	Learning about change is deliberate, but largely through indirect methods due to its nebulous nature. Learning by experience of change and interaction with those with that experience is important.
Knowledge – Other individuals'	Learning about others' knowledge was a side-effect of the line manager role	Learning about others' knowledge is deliberate, and an element of competence manager role. It is part of the professional approach
Other sections'	Learning about other's knowledge was an issue for central management, and deliberately investigated	Learning about other's knowledge is increasingly an issue for local companies
Pedagogy	Scientific methods of learning and teaching were not an important issue	Learning about better methods for learning and teaching is increasingly important. It is professional and deliberate
Technology - Current	Learning about current technology was centrally organised through deliberate, generalised and professional training, but networks were the main source	Learning about current technology is centralised, and occurs through specialised training, that is professional and deliberate. Networks are still the most important source of learning.
Future	Future technology was the major issue for the company. learning about it was centrally organised, deliberate and professional.	Future technology is less important, and learning about it is partly decentralised, professional, deliberate and strategic
How learning was done		
Interaction	Formal interaction for knowledge from central authority. However informal interaction was the most important method of learning. Knowledge flow from locals to central, and between locals was poor.	Informal interaction is still most important, with interaction within teams increasingly important. Formal interaction with knowledge going from local to central, and between central is increasingly common, but is not well established between locals companies that are not connected by an informal network.
Instruction	Instruction largely technical, general, internally sourced, and not pedagogic.	Instruction is specific and pedagogic, soft as well as technical, and externally as well as internally sourced
Search	R&D was highly respected as the method of searching for technological breakthroughs.	There is less emphasis on technical R&D with a new focus on social and market research. R&D is important for converging technologies. Scanning is increasingly important for new professional knowledge, and for knowledge about the activities of other parts of the company.
Experience	The slow pace of change, and loyalty of customers suited learning by experience. Narrow technical experience was enough.	There is now a need to capture and exploit what is learned from experience, to become a 'learning company'. Broad technical experience is needed, and social experience is valued greatly.
Recruitment	General engineering qualifications were sought, and engineers were promoted out of their profession to all high positions. The movement of staff was important for diffusion of knowledge, both technical and social.	Social skills are learning skills are sought in recruits. Engineers are still promoted outside their profession although this is increasingly inappropriate. Movement of staff within the company is important, and increasingly so between customers and companies with compatible tech. the alternative, which is to buy the company, is another form of recruitment.
Observing	Observation was important for tacit process technology and socialisation, but less so for product technology due to the non-mechanical nature of the technology.	No change
Reading	Reading was important for technical and professional material	No change, but now there is so much material that no one is able to keep up
Reflecting	The process of reflection was not recognised as a learning method	Reflection appears to be important for new technology concept development and for social issues, but it is not formally recognised nor allowed for.
Why learning was done		
Uncertainty about technology and the market	Not very important because the parties were well known and technology followed a predictable path. So, only needed to know those parties and that path.	Extremely important due to the convergence of technology and the increasing potential for technology to follow various paths with alternative standards. Increasingly important to lock customers into Ericsson's technology.
Enhancing relationships	Although important for advancing the technology, it was not recognised as such and was not deliberate.	Central to Ericsson's learning and operations in general. Enhancement of the relationship with customers is behind everything that Ericsson does and plans.
To establish or to respond to a technological path	Very important as Ericsson and its major customers' primary focus for learning was to advance the technology.	Central to Ericsson and behind standardisation efforts, system peculiarities, and R&D effort. Convergence drives Ericsson to learn about alternative industries, their key players and institutions as well as their technology.
Company policy	Company policy drove learning and directed the content	Company policy is partly decentralised by still drives learning and directs the content.
Personal development and interest	Personal drive to learn was supported and stimulated by Ericsson.	While Ericsson continues to stimulate and encourage the personal learning interest, that interest may be incompatible with the new company focus.

Table 8.2 Practical issues of learning under the old and new models.

CHAPTER 9

Conclusion

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9.1 Introduction

This chapter presents the conclusions arising from both the theoretical and empirical components of this thesis. Firstly the conclusions from the theoretical component are presented in section 9.2. The conclusions from the empirical component are discussed in section 9.3. The theoretical implications of those conclusions are discussed in section 9.4. This is followed by conclusions to the thesis in section 9.5.

9.2 Conclusions arising from the theoretical component

1. Neoclassical growth theory seeks to model endogenous steady state growth in conditions of rigorous competition.

Economic interest in learning in industry has been raised by the success of the new growth theorists in modelling sustained endogenous growth driven by the learning associated with innovation. That success is the result of a long process of developing neoclassical growth theory to exploit the Solow-Swan finding that, in certain circumstances, technological change can drive per capita, steady state growth. Those circumstances were that rigorous competition prevailed with marginal cost pricing, constant or decreasing returns and perfect knowledge. The technological change that drove the growth in the Solow-Swan model was

exogenous. An exogenous engine was needed because decreasing returns to the accumulated factor (physical capital) reduced the incentive for accumulation, and so endogenous growth petered out. Dissatisfaction with models in which growth was driven by unexplained technological change inspired subsequent developments of the neoclassical growth theory, which explore ways to endogenise growth while maintaining the fundamental neoclassical assumptions that formed the basis of the Solow-Swan model. Thus the essence of the neoclassical growth modelling enterprise is to demonstrate sustained steady state growth within a rigorously competitive framework. Moreover, it aims to do so in a way that the engine of growth is explained within the model. A secondary consideration is that the scenario that the model represents should be realistic in terms of the details of actual economies.

2. The development of neoclassical growth theory from the Solow-Swan model with growth driven by exogenous technology to models with sustained endogenous growth driven by learning in industry required six significant steps.

One stream of the development of neoclassical growth theory explored ways to demonstrate sustained growth in models with both accumulated and non-accumulated inputs in such a way as to maintaining constant returns to the accumulated input without introducing increasing (internal) returns to scale, which are incompatible with the perfectly competitive regime. One arm of that stream sought to endogenise technological change through links to learning and innovation in industry. That arm is referred to in this thesis as the new growth theories. The discussion of the new growth theories in this thesis is based on the eight models reviewed (*vis* Arrow, 1962a; Romer 1986 and 1990; Stokey, 1988; Lucas, 1988; Grossman and Helpman, 1991 two models; and Young, 1994).

Recent contributions to the new growth theories have succeeded in modelling sustained endogenous growth driven by learning in industry while essentially maintaining the rigorous neoclassical framework. There were six significant steps in that advancement of the neoclassical growth theory. Those steps were:

1. The recognition that growth is an inter-temporal, constrained optimisation

problem, and the development of tools to model such problems in which choices made in one period impact on subsequent periods (Cass, 1965; Koopmans, 1965).

2. The recognition of the links between economic activity, learning and technological change (Arrow, 1962a).
3. The recognition that knowledge spills over to form external benefits that generate increasing returns that are external to the firm, and hence are compatible with the maintenance of the rigorously competitive framework (Arrow, 1962a).
4. The recognition that learning is the intended outcome of costly investment dedicated to that learning, and is undertaken in response to market signals. That is, learning is intentional and endogenous (Romer, 1986).

Although Romer's (1986) work was widely heralded as having succeeded in modelling endogenous sustained growth in a competitive regime with both accumulated and non-accumulated factors, it was later recognised that the introduction of costly research with exclusive benefits to the firm undertaking the research was incompatible with perfect competition. With marginal cost pricing, each input receives a return equal to the value of its marginal contribution to production. The value of the output is equal to the sum of the returns to the inputs, and so there is no rent. If all costs are variable costs, as neoclassical economics generally assumes, then the full cost of production is met by the value of the output. If there are fixed costs, due to R&D for example, the value of the output is less than the full cost of production, including fixed R&D costs. Therefore, the cost of innovation cannot be recouped under perfectly competitive conditions. However, in an ex-post situation the associated knowledge provides benefits, which if appropriated, constitute a competitive advantage to the firm that invested in the learning. That competitive advantage generates monopoly power, which is incompatible with the decentralised production of the neoclassical framework. Therefore, for the new growth theories to remain within the constraints of the neoclassical enterprise, they required a device by which costly deliberate learning could be reconciled with competition. This was achieved as follows.

5. The recognition that learning can be the engine of growth because knowledge is unlike other inputs in that it is non-rival, and so can be reproduced costlessly to generate the non-convexities in the cost function that allow for the increasing returns to scale that drive growth (Romer, 1990).
6. The recognition that monopoly power from the exclusive use of non-rival knowledge in production was necessary to maintain the incentives to accumulate knowledge, and the introduction of limited monopolistic competition in one sector of a multi-sector model in order to quarantine the monopoly power in an otherwise competitive model (Romer, 1990 following Dixit and Stiglitz, 1977).

Thus, developments to the new growth theories achieved the twin objectives of modelling sustained endogenous growth, and preserving the basic neoclassical framework.

3. Although learning is central to the growth mechanisms in the new growth theories, their treatment of that learning is schematic.

In achieving the twin objectives of the neoclassical modelling enterprise, the new growth theories have heightened the profile of learning in economics, but have done so in models that are focussed on the requirements of that modelling enterprise rather than on capturing the reality of learning in industry. In terms of the practical issues of how learning is done, why learning is done, what is learned and by whom, the new growth theories indicate the following.

- Various methods of learning are relevant to industry. The new growth theories analysed in this thesis have identified learning by doing, by research, and by education, with diffusion by inspection and lack of secrecy.
- Various reasons to learn are relevant to industry. Some learning is the unintended outcome of learning in industry, other learning is the intended outcome of responses to market signals included in the model, and is therefore endogenous. Those models that have not included endogenous learning have

done so for simplicity or to model a specific point rather than to argue that learning is exogenous. The reasons to learn identified by the new growth theories are to seek monopoly profit, to survive obsolescence, and to take advantage of strategic opportunities created by learning by other companies, and, indirectly, to save costs. Therefore, the new growth theories indicate that learning is endogenous and undertaken for a variety of reasons that are both short term and strategic.

- The focus of what is learned in the new growth theories is on innovations of new processes, or of new products of greater variety and better quality. Other outcomes of that learning are new markets and new dynamics of existing markets.
- Learning is done by parties in various sectors and that knowledge spills over more broadly to other sectors.

While together the new growth theories identify a diversity in these practical issues, each model is restricted to typically one element of each. Moreover, the scenarios developed to provide an interpretation of the specification of the models identify those elements but do not expand on them sufficiently to explain the process and nature of that learning.

4. The learning that is theoretically applicable to learning in industry is social, creative, strategic and learner driven.

An investigation of selected theories from psychology and sociology on the nature and process of learning suggested that the three practical issues of how learning is done, why learning is done and what is learned are important to innovation in industry. Moreover, it indicated that social considerations are important to each of those practical issues, as follows.

- How is learning done? The learning process involves conversation and observation, both of which are social activities. The eight identified methods of learning (learning by doing, using, internal interaction, external interaction, searching and instruction and learning from science and through spillovers) involve conversation and observation in various situations and in conjunction

with various activities. The conversation and observation not only transmit existing knowledge, but also stimulate new knowledge. Relationships are an essential component of learning because they enable knowledge to be accessed and assessed.

- Why is learning done? Learning is driven by the learner in order to capture short term and strategic values. It is therefore both deliberate and endogenous. Those values are determined by relationships and the institutional structure. Learning is undertaken in part to enhance relationships that will increase the value of existing knowledge.
- What is learned? The choice of what to learn depends on the value of knowledge, which is determined by the social context in which it is applied. The choice of what to learn can only be understood in the social and institutional context that provides the reason to learn. Learning is creative and the outcome is innovation. Innovation can be a new process, a new product, a change in the social context or organisational change.

5. Relationships and institutions are central to learning in industry.

The investigation of learning theories also indicated that while learning is essentially social and relies on relationships between parties, those parties are rarely free to interact with any other party and to learn anything, whatsoever. Rather, they are influenced by institutions that regulate behaviour and interaction. Institutions can promote innovation by providing information on expected behaviour, and enhancing the communication associated with the generation and diffusion of knowledge. Moreover, trust within a relationship reduces the risk of investing in innovation. Relationships are links between parties that enable those parties to specify roles and to capture and manage the strengths associated with those roles. These links are not anonymous and instantaneous, rather they have continued over time to form stabilised interaction between selected and known parties. Learning-related relationships not only enable parties to access knowledge, and to evaluate that knowledge, they also imbue that knowledge with value. The literature indicates that relationships within the firm, exchange relationships, and relationships external parties through industry associations, professional associations and clusters are

likely to be the most important for learning in industry.

6. The relationships and institutions that influence learning form part of a larger system that determines the rate and direction of innovation.

While each of the identified relationships and institutions influences learning, they also interact to influence learning jointly, and to influence each other, and so influence learning indirectly as well. This interaction can be understood within a systemic approach. In particular, the national system of innovation approach explains that each nation has distinctive production and social contexts that jointly determine the rate and direction of innovation. To understand fully the influence of relationships and institutions on learning and innovation, it is necessary to understand them within that broader system.

7. Economic performance can be understood within the context of the national system of innovation, which links learning and innovation to growth in a radically different way to that of the new growth theorist.

The national system of innovation approach argues that learning and innovation are central to economic performance. Economic growth can be understood within the social and productive contexts peculiar to each nation. Therefore, to understand learning and innovation and their role in the growth process it is necessary to understand the context of the system in which they take place. A particular system can be understood through exemplification, rather than through generalised formal modelling. While this approach is different in both style (being descriptive exemplification rather than formalised mathematical modelling) and level of inclusion (including all relevant factors rather than including only those necessary to specify a model), the fundamental differences are due to paradigmatic issues. The system of innovation approach is couched in an evolutionary and institutional framework in which collective effects constitute a system of interactive elements that evolve from disturbances in an ongoing process of adjustment which is beyond the full understanding of any party. The new growth theories are couched in the neoclassical framework in which individuals make optimising decisions with perfect knowledge and without institutional constraints. The approaches thus

constitute entirely different enterprises, and so cannot be reconciled by introducing institutional elements to the new growth theories models, nor by mathematising the arguments of the national system of innovation approach.

8. There is a need for an empirical investigation of learning at the company level in an industrial context.

While the literature identifies the importance of learning in industry for innovation and growth, and provides arguments for the development of a theoretical understanding of the nature and process of that learning, there is a lack of systematically collected empirical evidence investigating learning at the company level in the industrial context. Therefore, a need for an empirical investigation into the learning at the company level was identified. In particular, a need was identified for an investigation into the practical issues of learning as they occur within the social context of industry. Therefore, it was determined to undertake an empirical investigation structured around the following research questions:

- What is the nature of the relationships that influence learning in industry?
- What is the nature of the institutions that influence learning in industry?
- How is learning done in industry?
- Why is learning undertaken in industry?
- What is learned in industry?

9.3 Conclusions from the case study

To investigate these issues empirically, a descriptive qualitative case study of learning in the telecommunications company Ericsson in Sweden and Australia was undertaken and the findings reported. The conclusions from that case study are discussed here.

9.3.1 Findings related to the relationships that influence learning

1. The relationships with the strongest influence on the rate and direction of learning and innovation in Ericsson in both Australia and Sweden are those with

their major customers, the telecommunications service providers.

Relationships with several parties were found to be crucial to learning and innovation in the case study. However, the importance of those relationships has only recently been officially recognised and incorporated in Ericsson's policies and supported by programmes to enhance them. Most important for the direction of learning in Ericsson is its very close learning relationships with its major customers in both Sweden (Telia) and Australia (Telstra). These relationships are recognised as crucial to Ericsson's survival, and the success of the relationship depends on how well Ericsson can serve Telia and Telstra in meeting the needs of their end-user customers. This in turn depends on the rate at which Ericsson jointly with Telia and Telstra introduce products that are tailored to the needs of the market. Therefore, the success of both parties and of the relationships depends on the rate and direction of learning and innovation in Ericsson, and the direction and rate of that innovation depends on the relationships. The choice of what to learn is determined by the value of knowledge in terms of its ability to serve the major customers and enhance those relationships. Ericsson's commitment to provide the innovations and services to meet the demands of the end-user customers of Ericsson's major customers implies an effectively permanent relationship, which recognises that the success of both parties depends on their combined ability to learn about and meet end-user customer demands. Therefore, although the relationship is structured around formal agreements that cover specific activities for a specified period, it is mutually recognised that the relationship supersedes those agreements.

2. Other relationships are subordinate to those relationships with the major customers. The most important of these are informal networks of selected individuals, which are at once a conservative element and a source of the alternative knowledge associated with change.

Other relationships that are necessary to learning in Ericsson are secondary and subordinate to the relationships with the major customers. Learning relationships internal to Ericsson and with external parties are largely undertaken in order to access the knowledge that will enable Ericsson to follow the direction established by the relationships with its major customers. Internal formal relationships

(hierarchical, collegial and functional) are focused on providing individuals and sections of the company with the knowledge needed to serve the market. However, the most important source of such knowledge is informal relationships within networks of selected individuals. These relationships have been recognised as central to learning in Ericsson and are now supported by programmes to help individuals form and develop networks, as well as opportunities to socialise. These informal networks are selective in the knowledge that they promulgate. While this discrimination on the basis of value of that knowledge is an important element in the direction of learning, it can be a conservative force that precludes alternatives and hinder Ericsson's capacity for flexible innovation in response to market interests. That is, the network's valuation of knowledge, and therefore the choice of what to learn, may not be compatible with the market's valuation that determines the company's direction. The new thrust of developing informal internal relationships in order to enhance Ericsson's market-oriented innovation may be counter productive if the conservative element prevails. However, networks also provide opportunities for those with alternative views to connect with each other in order to learn and to develop a power base with an alternative valuation of knowledge. In the case studied, views that were previously considered to be alternative were in fact consistent with the newly adopted market focus. Their valuation of knowledge was apparently compatible with that of the market, which is now driving the company. Therefore, informal networks are at once the most important source of knowledge, a force for conservatism and a force for change, as well as an influence on the value of knowledge. As such they are determinants of the selection of what to learn.

3. Relationships, often in the form of strategic alliances, with companies with compatible technology are vital for Ericsson to access the knowledge necessary to meet the demands of the major customers.

The most important relationships with external parties for the learning in support of its relationships with its major customers are those with relevant sources of knowledge, including companies with compatible technology, consultants and academic researchers. Relationships with companies with compatible technology

(especially data, computing or media) are entered into to enable Ericsson to meet its major customers' demand for technology that Ericsson has not the competence or time to develop itself. These relationships introduce a third party to the relationship with the major customers, which is considered to be a second best option for two reasons. Firstly, it demonstrates to the major customer that Ericsson does not have the required competence. Secondly, it provides an entree to that relationship to a third party that may, if the technologies converge, become a direct competitor with Ericsson. Therefore, while these relationships are close and long term, there is a latent interest to dispense with the relationship and serve the customer alone. That interest is latent for two reasons. On the one hand, the major customers demand the best products and services, and so the flexibility to work with the best company for compatible technology, to ensure customer satisfaction enhances that relationship in the short term. On the other hand, Ericsson's long term ability to partner companies with compatible technology depends on behaving in an honourable rather than an opportunistic way towards those companies. In fact, better relationships with companies with compatible technology require that Ericsson does not develop its own technology in that area. Therefore, the rate of technological change forces Ericsson into strategic alliances with companies with compatible technology, in order to access the technology that will enhance its relationship with its major customers, although those relationships present strategic risks. Once in those relationships the need to maintain an honourable reputation in order to access knowledge in the future restricts Ericsson's learning and development of technology in a way that effectively ties them to other parties. Where possible, Ericsson prefers to buy these companies and bring the knowledge and the relationship in house, because that avoids the risk and the complication of the relationship with the major customers.

4. Relationships with consultants and universities are less concerned with directly and immediately meeting the demands of the major customer.

Relationships with other sources of knowledge, that is with consultants and academic researchers, are also important to learning in the case study, though the learning involved is less concerned with directly and immediately meeting the

customers' needs. Consultants provide knowledge relevant to the operation of the company that indirectly enhances the company's capacity to satisfy its customers. Consultants stimulate learning in Ericsson because they bring a fresh perspective from their involvement with other companies. Such fresh approaches are not always available within Ericsson, or from its relationships with its major customers because they have become socialised to a possibly outdated perspective. Consultants are not brought in-house because they lose the ability to act as a catalyst for a new approach to learning. This is not just a matter of valuing knowledge differently: rather, they bring knowledge that is not known about within Ericsson, as well as that which is known but not valued within Ericsson.

Relationships with academic researchers provide knowledge that is directly related to serving the market, but in the long term rather than immediately. These relationships also provide stimulation because the academics are involved in basic research rather than its application to product development. There is tension because not only do they provide access to knowledge that is new, but their academic culture values that knowledge differently. Therefore, while they hold the key to the future knowledge that Ericsson requires to develop products in anticipation of market demand, their valuation of that knowledge, and so choice of what to learn is often different to both the market's and Ericsson's.

9.3.2 Findings related to the institutions that influence learning

1. The company has the power to harness and modify selected institutions to enhance learning.

A number of institutions were also found to be crucial determinants of learning in Ericsson. The company is not passively subjected to institutional regulation of its learning any more than it is passive in its relationships. Rather, the company has the power to harness and modify some institutions while it is subject to control by other institutions. The company, for example, selectively uses and interprets Swedish traditional norms to develop a company culture that encourages learning and the sharing of knowledge. The interpretation and reliance on these institutions

is modified to suit the circumstances. The Swedish norm of centralised authority and decentralised responsibility was previously used to encourage individuals to take responsibility for the quality of the product that they were told by Ericsson's central authority to develop, now that same norm is used to direct individuals to take responsibility for the decision about which product to develop for the market, as well as its quality. This increase in responsibility is generally in accord with the staff's personal norm of seeking personal development. In this way the institutions of the broader context are adopted to become company institutions, and modified over time to suit its changing needs. Other Swedish norms that were adopted as company institutions are those of informally sharing information and seeking consensus. Together these facilitated the diffusion of knowledge and a unified vision of the company during the stable period of monopoly service provision. However, in the current period of change, these institutions exclude alternative ideas and those who hold them from the informal networks. One of these institutions, seeking consensus, appears to be unsuited to the need for flexibility and variety in the approach to the market. The stubbornness of these institutions together may be because the informal nature of the networks that support those institutions is less subject to the sway of the central authority's decrees. Moreover, in order to abandon the commitment to consensus it is necessary to accept a change of attitude, which would suggest that the individual's and the network's previous stance was wrong but would not offer a benefit for accepting that suggestion.

2. Institutions that regulate Ericsson's dealings with external parties are less under Ericsson's control, but Ericsson seeks to maximise their influence on those institutions in order to enhance relationships.

Other institutions are less subject to control by Ericsson because they regulate Ericsson's dealings with external parties who also seek to influence those institutions. These include national laws, industry-wide commitment to honourable reputation and the technological path, all of which Ericsson has varying degrees of influence over. The industry's institution of commitment to and reliance on reputation limits what is learned in relationships with companies with compatible technology, and limits the methods of learning about competitors, while at the same

time encouraging Ericsson to learn more in order to boost its customers' competence trust in Ericsson. An honourable reputation is such an asset for business relationships in the telecommunications industry that it not only curtails short-term opportunism, but also influences strategic planning. This creates a need to be *seen* to be doing the right thing, and this impacts on Ericsson's learning. This is especially the case with the need to be seen to have no plan to encroach on service provision and so compete with the major customers. Therefore, Ericsson deliberately maintains its reputation and maintains the institution of relying on reputation.

3. The technological path is an institution that Ericsson seeks to influence in order to enhance the value of its knowledge, and so enhance its relationships with its major customers.

The technological path is another important regulator of learning in Ericsson. The industry's technical standards are functional regulators of learning, which though voluntary, are effectively compulsory due to market demand for them. Therefore, they determine the direction of innovation in the telecommunications industry by determining what will be valued by the market. Ericsson has its own institutionalised commitment to influencing those standards, as well as to incorporate those standards in its innovations. Therefore, Ericsson's learning influences the standards, as well as that learning being influenced by those standards. Ericsson's technological path is therefore partially determined by the combined influence of the other parties to the standardisation process, and their technological paths are partially determined by Ericsson's impact on the standardisation process. A major consideration in the development of Ericsson's argument at the standardisation forums is the profitability of those arguments for their major customers, that is, the demand for that technology from the end-user market. Therefore, Ericsson's major customers have two voices at the forums, their own direct voice and indirectly Ericsson's voice, which is conditioned by Ericsson's broader considerations.

4. The network nature of telecommunications technology, the prevalence of closed

systems, and Ericsson's commitment to big systems all limit the direction of learning in Ericsson. However, Ericsson exploits these, where possible, to enhance relationships with major customers.

Ericsson's technological path is further restricted by three institutions associated with technical systems. The first is that the telecommunications industry has closed systems that are peculiar to each equipment company and are connected through technological standards. This enables Ericsson to lock customers in to entire systems by making key technologies peculiar to those systems. This strategy is treated as an insurance against a major customer defecting to a competitor. This insurance has limited power to prevent defection and must be backed up by on going commitment to ensure that the technology into which the customer is locked is indeed central to their ability to meet the end-user customers' demands. The second regulator of Ericsson's technological path, the commitment to big systems, relates to process technology as much as to product technology. This is a vestige of the era when infrastructure building required big systems. It limits the individual's ability to add creative input to the design process and so restricts the innovative possibilities. Moreover, those big systems are not compatible with the quick and flexible learning required by the new end-user market focus of the industry. While the evidence is that Ericsson knows that such systems are outdated, it appears that there is inertia within Ericsson that maintains commitment to those systems. The third institution related to the technical system is that telecommunications is a network technology, and hence subsequent technology has to be compatible with existing technology. Superiority of technology and so the value of the associated knowledge can only be assessed within the context of the existing system, and not in an academic way in isolation from it. This limits the range of technologies that are assessed as being worth learning about. Therefore, the market, the technology and the history provide the context that determines what will be learned.

9.3.3 Findings related to the systemic interaction of relationships and institutions

1. Changes to national regulations, which are the institutions over which Ericsson has the least control, have resulted in extensive and fundamental changes to

Ericsson's operations and innovative behaviour. In particular, the introduction of competition has had a fundamental impact on learning within Ericsson.

National laws and regulations for the telecommunications industry are the institutions that are perhaps least under Ericsson's sway, even though in Sweden Ericsson and Telia are central figures influencing policy, and in Australia Ericsson lobbies the government on relevant issues. The change in the regulations that introduced competition among service providers has had perhaps the greatest impact on Ericsson's operations and the rate and direction of their learning and innovation. The introduction of competition has changed the focus of the relationship with its major customers from advancing technology that was of technical interest to both parties, without primary concern for the end-user market, to providing products and services that are of interest to the end-user customer. This was found to be the genesis of radical and far-reaching changes in the operations and direction of Ericsson, which in total constitute a change from an old to a new model. This effect has percolated through to change relationships with companies with compatible technology, relationships within Ericsson, the nature and process of learning and the overall operation and direction of the company. The extent of the effect that the change to the competitive regime has had on the relationships, and the process and subject of learning suggests that learning in Ericsson is systemic, because when the balance between the elements in the system is disturbed all parts of that system are subject to review. It is not simply a matter of an institution having been changed by forces isolated from the system and then impacting on that system. Rather, the changes to the competitive regime resulted from pressures within the end-user market for deregulation, a growing ethos of privatisation which was compatible with the end of the infrastructure-building era and technological change which made it possible for service providers to operate without extensive capital and infrastructure. Therefore, national and international forces within the system produced the change in regulation that subsequently are revolutionising operations within Ericsson.

2. The changes to the competitive regime have changed the institutional context to which learning and innovation in Ericsson is endogenous.

The model shift is in fact a change in the focus of endogenous learning and innovation from a system that generated learning in order to advance technology in isolation from the end-users' interests, to one that develops products and services in response to and in anticipation of market signals generated by those end-users. The rate and direction of learning and innovation generated under the old model was determined by the institutional context of the monopoly regime. The rate and direction of learning and innovation generated under the new model is determined by the institutional context of the competitive regime. Therefore, the institutional context to which the learning is endogenous is central to the rate and direction of learning and innovation.

9.3.4 Findings related to the practical issues of what is learned.

1. Informal interaction is central to learning in Ericsson because it is practical and enhances relationships. Knowledge learned from experience is accessed through informal interaction.

Informal interaction not only enables the learner to access and evaluate knowledge, it also enhances relationships within the firm and with external parties. These relationships enable the learner to access subsequent knowledge by creating a culture of sharing knowledge. While this is increasingly important because of the recent and on-going changes in the industry, the importance of knowledge gained by experience is still valued. This is because the technological path remains a determinant of the subsequent learning. Also, to an increasing extent the desired knowledge is about people who have particular knowledge and interests. Such social knowledge is accumulated over time within the company and through wider connections. Moreover, learning by experience provides the background information that enables individuals to understand and assess the value of subsequent developments. Therefore, even though technological change is rapid and diverse, learning by experience is still important, but that that knowledge is largely accrued by informal interaction.

2. The practical issues of learning in Ericsson are interrelated and influenced by

the social context

With regard to the practical issues of what is learned, how it is learned and why it is learned, the evidence suggests that these should be seen as three integrated parts of a learning experience rather than as distinct phenomena. The basic anatomy of the learning experience is that learning is intentionally undertaken in response to some reason to learn; the reason to learn indicates what should be learned to respond to that stimulus, the content of that learning and the reason to learn combine to indicate a general method of learning that is both practical and meets other needs of the learning situation. This anatomy can be understood in terms of the case study as follows. In the short term, the major reasons to learn in Ericsson include direct or indirect orders from either a customer or an authority, to satisfy a personal interest in learning. In the longer term, learning is undertaken to position the company or the individual in a strategic position to gain from relationships and institutions. In both the short and long term, the choice of what is learned by Ericsson is driven by the reason to learn and the perceived value of knowledge in responding to that reason. Together the reason to learn and the content to be learned suggest a method by which that learning is done. The choice of method may be on strategic as well as practical grounds. Because a visible display of learning is said to enhance relationships, for instance, the chosen method may be one that displays the learning process, such as personal interaction, which at once leads to learning, displays a learning effort, and provides social interaction to strengthen the relationship. On the other hand, some methods of learning are curtailed because they would harm relationships or violate an institution. Head-hunting and industrial espionage are examples of these, respectively. Therefore, to understand fully each of the practical issues of learning in Ericsson it is necessary to understand them in the light of the total learning experience and in the social context in which that learning is undertaken.

3. Much of what is learned in Ericsson is about the change to the market focus.

The content of what is learned in Ericsson is dominated by the need to satisfy the end-user market in order to satisfy the major customers. Overall, learning about the fragmented end-user market and the importance of that market for the future of

Ericsson has been the most important learning for Ericsson in recent times. This has resulted in shock waves of consequent learning about relationships, about the value of non-engineering knowledge, about techniques to reuse technology, as well as about the market itself. This is changing Ericsson's operations and image of itself from a developer of advanced technology to a server of the end-user.

4. Learning about the change to a competitive regime and associated issues has not achieved the desired change in behaviour.

Although Ericsson has committed resources to teach the staff about the importance of changes in line with the new market focus, there is a marked difference in the level of acceptance of the need to change among Ericsson staff. Those who continue to resist those changes do so despite knowledge provided by Ericsson, and that gained through experience. Moreover, those who have accepted the need to change report that they have been unable to implement those changes because institutional support for that behaviour is lacking. In the absence of new institutions, some old and outdated institutions hold sway and some behaviours are left without regulation. Ericsson has not committed resources to teach about institutions, and how to establish them, as it has with relationships. Nevertheless, Ericsson has introduced policies, such as the company-wide competence model, that require a change in behaviour. In this way Ericsson has mandated new institutions to regulate behaviour.

5. A major strategic reason to learn in Ericsson is to render the customers dependent on Ericsson as they jointly meet end-user needs.

Learning is deliberately undertaken in Ericsson, and vast resources are committed to enhancing that learning. A major strategic reason that learning is undertaken is to position Ericsson with customers so that they are locked in to Ericsson's technology and services through social and technical dependence. This is achieved by identifying and anticipating end user needs and interpreting them in a way that requires that the telecommunications service providers must deal with Ericsson in order to capture and satisfy the end-user market. The objective is to ensure that its major customers are as dependent on Ericsson as it is on them, and so create a

balance of powers. This strategy then creates reasons to have relationships with third parties, especially those that supply knowledge. The essence of those relationships is to access knowledge that will support the relationship with the major customer without tying the customer to the third party.

9.4 Implications for theory

1. The finding that the process and nature of learning are social and strategic phenomena support the theoretical explanation of learning.

These findings support the theoretical explanation of learning developed in Chapter 2 of this thesis. In particular, the findings support the argument that the process of learning can be understood within the social context because learning is by nature social and strategic. Moreover, the findings confirm that Ericsson's major relationships give value to knowledge provide the reason to learn, direct what is learned and determine how that learning is done. Moreover, the learning behaviour in Ericsson is shaped by institutions at the national level, company level, industry level and personal level, as well as by the technological context of the technological path. Therefore, to understand learning Ericsson it is not enough to understand the practical issues of the process because they cannot be fully made sense of without understanding the social context in which Ericsson learns and the and strategic response to that context.

2. The findings about the practical issues of learning in Ericsson support the diverse treatment of learning in the new growth theories, but indicate an emphasis on different reasons methods of learning, different reasons to learn and different content of learning to those indicated by the new growth theories.

The findings about the nature and process of learning in industry can be compared with the treatment of learning in the new growth theories. The findings that learning is diverse, endogenous and deliberate are in accord with the new growth theories. However, the details of the new growth theories' treatment of practical issues of learning do not coincide with the emphasis indicated by the case study. Whereas the methods of learning in the new growth theories are restricted to

learning by doing (experience), R&D and formal education, with diffusion by observation, the case study emphasised learning by informal interaction and experience, while identifying many other methods of learning. The lack of emphasis, in the case study, on learning by R&D can be explained by two factors. Firstly, the concept of research and development is very broad and includes processes of reading, interacting, trial and error (experience) and reflecting, among others. An individual who would be described at one level as learning by R&D, may describe their learning method in terms of the more detailed contributing activities, that is interacting in this case. Secondly, to those who daily are involved in the process of R&D, the novelty of emphasising the interaction component of that process may appear more important and so be discussed ahead of the more mundane components, for example writing software. Therefore, the case study has emphasised detail and the novel emphasis of the overall R&D process. The new growth theories identify learning about new products and new processes, with new markets also being generated through innovation. The case study acknowledges learning about processes and products, but emphasised learning about relationships and institutions, which are alien to the neoclassical framework of the new growth theories. The new growth theories identify profits, costs, and survival in the market as the reasons to learn. The case study findings emphasise issues of market survival, which are closely lined to specific relationships, as the reason to learn. While profit and costs were mentioned, their lack of emphasis may be explained by the fact that the subjects were at arms length from the company's financial management.

3. The finding that learning and innovation are endogenous supports both the new growth theories and the national system of innovation approach.

The finding that learning and innovation in Ericsson is endogenous validates the new growth theories in their decision to seek to develop neoclassical growth theory by modelling endogenous learning as the driving force of growth. The thesis did not investigate whether that learning does drive growth. However, if it is accepted that it does, as is argued by both the new growth theories and the national system of innovation approach, then the finding that learning is in fact endogenous supports

that enterprise. It also supports the argument of the national system of innovation approach that learning and innovation can be understood within the system in which they occur.

4. The finding that learning and innovation are endogenous to a specific social context provides strong support for the national system of innovation approach, and suggests that the relevance of the new growth theories for an understanding of learning in industry is limited.

The finding that learning and innovation are endogenous to a specific institutional context and that a change in that institution context can change both the rate and direction of learning, is strong support for the national system of innovation approach. Moreover, the finding that relationships and institutions play a central role in determining the practical issues of learning in industry is further support. However, as these findings indicate the importance of the social context, which is not consistent with the neoclassical foundations of the new growth theories, it is argued that the new growth theories have limited relevance to the understanding of learning in an industrial context.

5. The finding that both the rate and direction of learning and innovation are determined by systemic influences offers strong support for the national system of innovation approach.

The finding that a change in the regulatory environment has had far reaching impacts on Ericsson's operations, constituting a change from an old model to a new model, indicates that both the rate and direction of learning are heavily determined by systemic influences. This strengthens the support for the national system of innovation approach. The finding that Ericsson is not the passive subject of the system, but rather commits resources to harnessing and modifying that system, throws light on the impact of the system on the unit and of the unit on the system.

9.5 Conclusion

Overall, the most important finding from this thesis in terms of its strength and theoretical relevance, is that both the rate and direction of learning in industry are

heavily influenced by the system, of which relationships and institutions are important components. From a theory perspective, this finding indicates the limitations of the new growth theories, and the relevance of the national system of innovation approach, for understanding learning in industry. The strength of the finding suggests the possibility of policy implications. While this thesis is not equipped to explore those options, it is apparent that the design of policies to exploit the influence of relationships and institutions on learning and innovation would require further investigation to develop an understanding of how those relationships and institutions may be manipulated to achieve the policy objective.

Finally, this investigation has involved a case study of learning in Ericsson. The description produced and the conclusions drawn have provided an in-depth understanding of learning in Ericsson, and have indicated implications for theory. While the method employed in this investigation was selected in order to ensure credibility, confirmability and dependability, the degree to which these findings may be generalised or transferred to other situations can only be determined in the light of those circumstances.

APPENDIX

Dear

As discussed on the telephone recently, I wish to interview as part of the data collection for the PhD. that I am undertaking at the Centre for Strategic Economic Studies. I am interested in understanding several aspects of learning and the knowledge that you use in your work.

While it has been increasingly popular to attribute economic growth to learning in industry, not very much is known about that learning. Therefore I have proposed an investigation to cover the following issues of how learning is done, what is learned and why it is learned. I am also interested in the sources of knowledge and the relationships with those sources. While I am interested in what you learn and how you learn it, I am also interested in what, if anything, limits your learning.

The method by which I will collect this data from you is an interview that will be conversational in style. There are no set questions, and no right answers. I will have a list of topics that I will cover with you. That list is based on the issues mentioned above, I want you to respond as fully and frankly as you can to relay to me your experience of learning. Some of those issues may not be relevant to you and you may be able to suggest other important features of learning in your job. This flexibility is important to the work that I am doing, and it will allow you to provide your personal insights based on your own intelligence and experience. I think that you will find the interview to be interesting and pleasant.

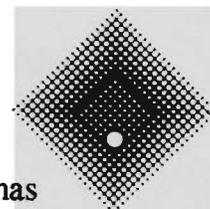
I plan to use a tape recorder to aid data collection and to ensure that your comments are accurately recorded. If you are unhappy about this and would prefer not to use the tape, I am happy to comply. Regardless of the method of recording, I can assure you of confidentiality. The thesis, with your contribution, will be forwarded to you for your approval before submitting.

If you have any concerns please contact me at this Centre or email s9410402@cougar.vut.edu.au
Or, contact my supervisor Prof. Peter Sheehan also at the Centre.

I will call you on the day before our agreed appointment to confirm that that time still suits you.

Yours sincerely

Lucy Firth
April 1996.



Dear Review Panel Member,

I am a PhD student with the Centre for Strategic Economic Studies. My thesis has investigated learning in industry with a case study of learning in Ericsson. The case study uses qualitative methods to investigate the interviewee's perception of learning. An issue with qualitative research is the need to confirm the credibility of the work. As my thesis is nearly complete, I am establishing a two-member panel to assess its credibility. I seek your support in acting as one member.

You do not need to know any research method to help me. I imagine that you did some quantitative research method study back in your university days. You may have forgotten most of it, but you may recall issues of internal validity, external validity, reliability and objectivity. In qualitative research these issues are replaced by credibility, transferability, dependability and confirmability. The following excerpt from my methodology chapter explains the concept of credibility.

'Credibility' means that the research should be trustworthy in the sense that the reader may be confident that the findings are true to the context in which the study was undertaken. Credibility is analogous to internal validity in quantitative research. Credibility in this study was enhanced by two methods. Firstly, multiple sources were used to confirm comments. Comments were checked with other interviewees who were in a similar or corresponding situation and therefore would be in a position to know. They were also checked with interviewees outside the area in order to assess their generality. Care was taken in this process because the contextual basis of the comments by the first party may not be relevant to the second party and so distort their understanding. Secondly, the summarised data, findings and interpretation were checked by a review panel. The purpose of this check was to check for factual accuracy and interpretational logic in order to assess and enhance the credibility of the research. The panel comprised of two well-experienced engineers in the telecommunications industry, one of whom is an employee of Ericsson, neither of whom took part in the research.

What I want you to do is to read through the chapters that have been sent to you and see whether you believe them. It is not a matter of whether you know the facts, it is more that you, knowing the context of the TC industry, find them believable. Moreover, that you

find the interpretation credible. You are being asked to assess its credibility not its truthfulness or factual veracity.

While you read through I want you to look for problems of factual inaccuracies, inappropriate interpretation, inappropriate emphasis, misleading statements, or other factors that you feel make the work incredible to some extent.

You should then contact me to discuss any concerns. I can be contacted on 'phone 93290468 night or day, or by email mellor@deakin.edu.au

Once your concerns have been addressed satisfactorily, you should sign part A of the attached form. If your concerns have not been satisfactorily addressed, you should sign part B of the form.

I ask that you do this as soon as possible. My submission date is 30 September 1997. Therefore, I would appreciate it if you could respond before 18 September 1997.

You have no legal responsibility for either the quality or the content of this thesis. Your responsibility is that you will use your professional and personal ethics and discretion to determine what is acceptable.

Thank you for your participation in this work. University students continue to rely on the cooperation of the public to achieve their goals. You are an essential resource and much appreciated.

Your sincerely

A solid black rectangular box redacting the signature of Lucy Firth.

Lucy Firth
10 September, 1997.

**Credibility Assessment for the Case Study of Learning in Ericsson
as submitted by
Lucy Firth**

Part A

I DAVID HUCK..... have read the empirical chapters of this work. I am qualified to comment on its credibility due to my experience as an engineer in the telecommunications industry and familiarity with the issues discussed in this work.

Knowing what I do of the telecommunications industry in general, I find the work to be credible.

Name DAVID HUCK.....
Current Position MANAGER, TELSIRA TRANSPORT
Employer SIEMENS.....
Other reasons to be qualified in this role.....

Signature... .....
Date 20.9.97.....

Part B

I..... have read the empirical chapters of this work. I am qualified to comment on its credibility due to my experience as an engineer in the telecommunications industry and familiarity with the issues discussed in this work.

Knowing what I do of the telecommunications industry in general, I do not find the work to be credible. I have addressed my concerns to Lucy Firth, but have not had them resolved to my satisfaction.

Name.....
Current Position.....
Employer.....
Other reasons to be qualified in this role.....

Signature.....
Date.....

**Credibility Assessment for the Case Study of Learning in Ericsson
as submitted by
Lucy Firth**

Part A

I WARREN HALLIDAY..... have read the empirical chapters of this work. I am qualified to comment on its credibility due to my experience as an engineer in the telecommunications industry and familiarity with the issues discussed in this work.

Knowing what I do of the telecommunications industry in general, I find the work to be credible.

Name WARREN HALLIDAY.....
Current Position MANAGER AMP&D-AMPS TAC
Employer ERICSSON AUSTRALIA.....
Other reasons to be qualified in this role 11 yrs with ERICSSON.....

Signature .....
Date 22-9-97.....

Part B

I have read the empirical chapters of this work. I am qualified to comment on its credibility due to my experience as an engineer in the telecommunications industry and familiarity with the issues discussed in this work.

Knowing what I do of the telecommunications industry in general, I do not find the work to be credible. I have addressed my concerns to Lucy Firth, but have not had them resolved to my satisfaction.

Name
Current Position
Employer
Other reasons to be qualified in this role.....

Signature.....
Date

Dear Interviewee,

You probably remember that I interviewed you last year about the learning done in Ericsson, as part of my PhD thesis. The thesis is nearly finished, and as promised, I am sending you a copy of the empirical section for your approval.

If you read it, I hope that you find no problems with it. If you find problems please contact me before 20 September 1997, to discuss them. The problems that you might find could include: inaccuracies, breach of confidence, material that is damaging to Ericsson or to some other party, or an inappropriate emphasis.

If you read it and are satisfied that your comments have been faithfully reported, there is no need to reply.

Please contact me on email mellor@deakin.edu.au

Thanks again for your cooperation.

Yours sincerely

Lucy Firth
1 September 1997.

To Whom It May Concern

Re: Study on Learning In Ericsson by Lucy Firth

This is to certify that as a researcher familiar with the principles of qualitative research I have audited the analysis of the data collected for the above study. I have found that the interviewer did not lead respondents nor contribute to any bias in responses. The data has been accurately transcribed, reliably coded, reported comprehensively, and interpreted without bias.

David Mellor
B.Sc.(Hons), Dip.Ed, Dip.Soc.Sci, M.Cl.Psych.

October 4, 1997

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