

CHAPTER 3

THE NATURE OF KNOWLEDGE

We are drowning in information, but starved for knowledge.

(J Naisbitt)

3.1 INTRODUCTION

The purpose of this chapter is to analyse the contribution of knowledge to an improved urban environment conducive to economic growth and development. The presence and enhancement of knowledge (technology) also explains the potential for economic growth. Technology was seen by Solow (1957), *inter alia*, as exogenous and was neglected in terms of explaining economic growth. The endogenous growth model endogenised knowledge and thus R&D, while the ESA views knowledge as implicit and also focuses on people. Generating knowledge contributes to the enhancement of the capabilities of people and to the capacity of the urban economy.

Instead of assuming that growth occurs because of some exogenous improvement in technology, the economic forces underlying technological progress will be investigated in this chapter. Innovators continuously seek better and more efficient ways to improve the process of production and hence economic growth. The possibility of earning a profit may be the motivational factor for improvements in technology. In this sense, the improvements in technology and economic growth are an endogenous outcome of the economy.

It is thus necessary to explore the notion of knowledge in greater detail to determine in what ways it could enhance the capabilities of economic decision-makers or agents. It is important to generate and diffuse knowledge to empower such people. The creation of an environment conducive to the generation and proliferation of knowledge is, however, also an important aspect for local urban authorities. They themselves could benefit from such an environment to enable them to develop efficient and effective

urban policies. The acquisition of knowledge is a non-linear function and the attainment of an improved quality of life is thus more likely.

3.2 THE NATURE OF KNOWLEDGE

The different types of knowledge play important roles in explaining economic growth. The determinants in accumulating these different types of knowledge cannot be expected to be the same. The forces underlying the accumulation of knowledge in the development of science would thus not be the same as the development of knowledge in the fast-food industry. No-one can thus expect to find a unified theory of the growth of knowledge (Romer, 1996: 111). It would rather be a set of factors (or a system) that determines the accumulation of knowledge.

According to Romer (1990), all types of knowledge share one characteristic in that they are "non-rival". Simultaneous use of knowledge by more than one person is therefore possible. The marginal cost of supplying knowledge to other users, once it has been acquired, is zero, except for the distribution cost. The price of knowledge in a perfectly competitive market is thus zero and the motivation behind the acquisition of knowledge cannot be contributed to any economic gain. Knowledge should therefore be sold above its marginal cost otherwise market forces will not motivate its development (Jones, 1998: 75). Although knowledge is non-rival, it may be excludable. A good is excludable if it is possible to prevent a person from using it.

The nature of the knowledge and the institutions governing property rights will determine the excludability of such knowledge. Patent laws protect the inventor of a specific design from possible imitators. In another country under another set of laws the inventor may have less control in protecting his design. This implies that there are different degrees of excludability. Excludability is sometimes more dependent on the nature of the knowledge than on the legal system. Patent rights may not protect a secret recipe but some people might still be excluded from the "knowledge" of the recipe. If knowledge is fully non-excludable, no private economic gain will flow from its

development. If knowledge is excludable, this knowledge can be made available at positive prices with profits for the research and development efforts. The generation of knowledge without its diffusion is not worth much. It is thus important to determine in what way knowledge could contribute to economic growth and development.

3.3 KNOWLEDGE AS THE ENGINE OF GROWTH

The mere fact that knowledge is non-linear means that the technological frontier is continuously being pushed outward. A similarity between Solow's and Romer's model exists in that both describe a production function and a set of equations describing how inputs evolve over time. However, there is one major difference in the model of Romer where capital stock (K) and labour (L_Y), combine to produce output Y , using the stock of ideas (A) (knowledge) (Jones, 1998: 90):

$$Y = K^\alpha (AL_Y)^{1-\alpha} \quad (3.1)$$

where α is a parameter between 0 and 1. This implies that for a given level of technology A , the production function in equation (3.1) exhibits constant returns to scale in K and L_Y . However, when A is assumed to form part of the input into production, there are increasing returns to scale. The presence of increasing returns to scale results fundamentally from the fact that ideas or knowledge are non-rival in consumption (Jones, 1998: 90). $A(t)$ is the stock of knowledge or the number of ideas that have been invented over a period of time up to time t . Then $\bullet A$ (derivative), is the number of new ideas produced at any given point in time. $\bullet A$ is thus the growth rate in new ideas and is equal to the number of people attempting to create new ideas (L_A), multiplied by the rate at which they create these ideas ($-\delta$):

$$\bullet A = -\delta L_A \quad (3.2)$$

Labour is used either to produce new ideas or to produce output, so two constraints result from this:

$$L_A + L_Y = L$$

The rate at which researchers discover new ideas may simply be a constant. One should, however, take into account the stock of ideas that have previously been discovered. If discoveries from the past raise the productivity of current researchers, then $-\delta$ would be an increasing function of A . It might also be that the most obvious ideas are discovered first and subsequent ideas are increasingly difficult to discover. In such a case, $-\delta$ would be a decreasing function of A . This implies the rate at which new ideas are produced as:

$$-\delta = \delta A^\phi \quad (3.3)$$

where δ and ϕ are constants. If $\phi > 0$, this indicates that the productivity of research increases with the stock of ideas that have already been discovered, and $\phi < 0$, that productivity declines. With $\phi = 0$, the productivity of research is independent of the stock of knowledge.

The number of people searching for new ideas may also determine the average productivity of research. The duplication of efforts is more likely when more people are engaged in research. Here one can suppose that it is L_A^λ , rather than L_A , that enters the production function for new ideas, with λ , some parameter between 0 and 1. If equations (3.2) and (3.3) are combined with this, the following general production function for ideas can be derived:

$$\bullet A = \delta L_A^\lambda A^\phi \quad (3.4)$$

Although a single person engaged in research in the economy would contribute fewer new ideas relative to the economy as a whole, it clearly changes with an aggregate

research effort. If $\lambda < 1$, it may reflect an externality associated with duplication, because some of the ideas of the individual researcher may not be new to the economy as a whole. If $\phi > 0$, it would reflect a positive knowledge spillover in research, thus enhancing the use of discovered knowledge. An important consequence here is that people are the key input into the creative process of generating new ideas (Jones, 1998: 94). A larger population, given that they engage in research and development, generates more ideas and because the ideas are non-rival, everyone in the economy benefits. In order to generate growth, the number of ideas must increase over time.

This suggests that progress in economics is not merely a mechanical application but involves a creative act as well. Discoveries differ from other inputs and can be used by many people simultaneously, whereas other inputs cannot. In this sense, ordinary goods are rival goods but information is non-rival in consumption. Although the information from economically important discoveries is non-rival in consumption, it does not meet the other criteria of a public good. These discoveries are partially excludable, at least for some time. People, as firms, have some control over their information from discoveries. Hence information cannot be treated in the same manner as pure public goods. Information can be sold and therefore the owner can earn monopoly profits because regarding information no opportunity cost is involved (Romer, 1994: 12).

If someone is prospecting for gold, the discovery will seem to be exogenous in the sense that forces outside the control of the prospector will determine success or failure. The aggregate rate of discovery, however, is endogenous. If many more people start prospecting for gold, eventually more valuable discoveries may be made. This will be true even if the discoveries are accidental side effects. The aggregate rate of discovery is still determined by things that people do. Thus if more effort is put into R&D in developing urban economies, this could contribute to economic growth and development even if it is just an accidental side effect. The search for new knowledge should, however, never be considered the responsibility of someone else or a time- and money-consuming exercise not worth engaging in. Innovation involves the decisive effort to search for new knowledge and the application of such new-found knowledge.

3.4 ECONOMIC AND TECHNOLOGICAL INNOVATION

An invention is no more than an idea for a new product or process of production. Practicality and economic feasibility are not the main ingredients of an idea. Inventions are merely part of the stock of knowledge from which the developers of new technology may draw. Most inventions never get beyond the conceptual stage. Some inventions may be the result of a "flash of insight", whereas the majority normally involves the commitment of resources to the purposeful research for potentially new ideas. In order to prevent the absorption of resources only, an invention should be turned into an innovation. Innovation involves the purposeful search for new knowledge and the application of this knowledge in production (Rosegger, 1996: 21). Innovation also sometimes refers to doing things differently from one's competitors in order to gain an advantage over them. It is thus important that the new idea pass all tests of technological and economic feasibility as well as market acceptance. The size of an innovator's economic return depends entirely on the demand for the idea. In order to ensure that innovators continuously seek new ideas, intellectual property rights should be protected (Rosegger, 1996: 21).

According to Brue (1994: 494) innovation is defined as:

changes in the methods of supplying goods such as introducing new goods or new methods of production, opening new markets, conquering new sources of supply of primary materials or semi-manufactured goods, or carrying out a new organisation of industry, such as creating a monopoly or breaking one up.

Innovation is therefore much more than mere invention. Invention can only be classified as innovation if the invention is applied to the industrial processes. The key to economic change is the introduction of innovations with the central innovator being the entrepreneur. The entrepreneur is the person who tries out new ideas and who introduces innovations. They are always pioneers in introducing new products, new

processes, new forms of business organisations or penetrating new markets. This person is normally one with exceptional abilities, who seizes opportunities that other people are oblivious to, or who creates opportunities through his own daring and imagination. Without innovation, economic life would reach static equilibrium and a stationary state in which the accumulation of wealth would cease (Stonier & Hague, 1964: 534).

This is in line with Schumpeter (1934) who felt that the key process in economic change was the introduction of innovations and the central innovator the entrepreneur. According to Schumpeter (1943: 83):

The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumer's goods, the new methods of production or transportation, the new market, the new forms of industrial organization that capitalist enterprise creates.

He regarded economic fluctuations as an integral part of economic growth and emphasised the role of the innovator in fostering such growth. Endogenous forces which bring about economic evolution and qualitative change were stressed. A society thus has to do more than just adapt to changing market conditions. Development is therefore viewed as changes in economic life not enforced from without, but which arise as a result of society's own initiative, from within. Schumpeter, (1934: 64) proceeds by saying:

Every concrete process of development finally rests upon preceding development. Every process of development creates the prerequisites for the following.

The creation of a market niche leads to the swarming of new innovations by imitators, with opportunities coming in clusters. Although these clusters are unevenly distributed, it is still possible to locate their epicentre. The changes brought forward by the

opportunities are not relatively smooth, but proceed in fits and starts (Clark & Juma, 1988: 213). To Schumpeter, two essential features are important for economic growth and development: Firstly, the introduction of new products is essential to the process of growth; an essential characteristic is that this implies alterations in combining production factors. This entails radical changes in production methods, management and organisation, and the exploitation of new markets or sources of raw materials. The introduction of radical new products and the continuous improvement of existing ones, give an extra dimension to economic growth. Secondly, reaping the economic benefits derived from economic development is an important factor. Schumpeter maintains that only if the innovator could sell his/her product to the masses, would he/she be able to reap the rewards of large-scale and highly-mechanised production. Schumpeter continued that (1949: 67):

The capitalist achievement does not typically consist in providing more silk stockings for queens but in bringing them within the reach of factory girls in return for steadily decreasing amounts of effort.

Economic growth meant not only an increase in the quantity of output, but also a revolution in its quality and composition. Schumpeter maintained a firm belief in economic fluctuations. He viewed each long wave of economic upswing as a miniature industrial revolution, followed by the absorption of its effects by the economy during its long-wave downswing. Each period of upswing brought new production methods, new forms of economic organisation, new products and new markets. All forms of innovation were present during this period. Once the period of upswing ended, there was a halt in expansion as the economy adjusted itself to the new situation and consolidated the ground it had gained (Stonier & Hague, 1964: 549).

Schumpeter (1943: 133) describes this process of upswing and downswing as one of creative destruction. Certain parts of the economic structure are destroyed from within as new structures are being created to fill these gaps. This process is continuous and here the importance of the innovator is emphasised. The innovator is a forceful pioneer,

who extends the boundaries and the process of creative destruction by exploiting commercially new products and processes. The innovator - the entrepreneur par excellence - is exploiting inventions, most of which were invented by others. He/she is not merely trying to satisfy the demand for existing products more effectively, nor is he/she satisfying old needs with new goods - he/she is driven by the concern to initiate economic change, create entirely new demands and "educate" consumers if need be. Consumers are brought to the point where they want new things. The activities of the innovator are thus not only to facilitate economic growth and progress, but to transform the whole nature and role of competition (Stonier & Hague, 1964: 550).

The progress and success of the capitalist system would, however, eventually come to a halt. According to Schumpeter the economic and social foundations of capitalism would crumble because of (a) the obsolescence of the entrepreneurial function, (b) the destruction of the political strata, and (c) the destruction of the institutional framework of the capitalist environment (Brue, 1994: 495). This is because the "progress" in the capitalist system will either cease or become completely automatic and therefore break to pieces under the pressure of its own success (Schumpeter, 1943: 133). Without innovation, the economy will be forced into a near steady state.

Contrary to Schumpeter's notion of creative destruction, creative accumulation can also be associated with innovative activities (Malerba & Orsenigo, 1997: 264). Certain indicators play a major role in capturing the degree of creative destruction or the degree of creative accumulation associated with innovative activities. The concentration of innovative activities (clusters) combined with the size of a firm are two important indicators. Stability is also a key factor affecting international technological specialisation, emphasising that creative accumulation is a fundamental property of technological change. Firms that are continuously active in the innovative environment accumulate knowledge and expertise and are able to perform successfully within given technology. A correlation thus exists between technological performance and a stable group of innovators who are engaged in continuous efforts of innovation (R&D) over time. As far as policy is concerned, the primary focus of government should be on

creating, supporting and strengthening a core group of innovators continuously and consistently.

According to Dosi (1988: 222), innovation concerns:

the search for, and the discovery, experimentation, development, imitation and adoption of new products, new production processes and new organisational set-ups.

A few features concerning innovation should be kept in mind when dealing with the process of innovative activities (Dosi 1988: 222). It is obvious that what is searched for cannot be known with any certainty before the activity of search and experimentation is completed. Therefore the technological and commercial outcomes of the innovative efforts can hardly be known *ex ante*. This feature of uncertainty is the first factor concerning innovative activities that should be kept in mind. An increasing reliance on new technological opportunities stems from major advances in scientific knowledge, which can be viewed as a second feature concerning innovative activities. The third major feature of innovative activities is the increasing complexity of research and innovative activities that tend to favour formal organisations such as firms' R&D laboratories, government research institutions, universities, etc. as opposed to individual innovators. The fourth feature is that firms can primarily learn how to use, improve and produce by the very process of doing them. This can happen through the informal activities of solving production problems, meeting specific requirements of consumers, etc. Fifthly, the process of innovation and technological change is a cumulative activity.

According to Malerba & Orsenigo (1997: 241) Schumpeter proposed two major patterns of innovation activities. The first pattern of innovative activity is characterised by the technological ease of entry into an industry and by the major role played by new firms in the process of innovation. A new entrepreneur enters the industry with new ideas, products or processes and launches new enterprises that challenge established ones. This continuously disrupts the existing methods of production, organisation and



distribution and also eliminates the quasi-rents associated with previous innovations. This pattern of innovation could also be called the "widening" of innovation. A widening pattern of innovative activity refers to an innovative base that is continuously enlarged through the arrival of new innovators and the erosion of the traditional competitive advantages of established firms.

The second pattern of innovation is characterised by the prevalence of large established firms with certain restrictions to entry for new innovators. These large firms are able to create R&D laboratories and with their accumulated stock of knowledge, competence in large R&D projects, production and financial resources, are able to keep out new entrepreneurs and small firms. This pattern of innovation could be viewed as "deepening" of innovation. A deepening pattern of innovation refers to the dominance of a few firms that are continuously innovative through the accumulation of innovative capabilities over time (Malerba & Orsenigo, 1997: 242).

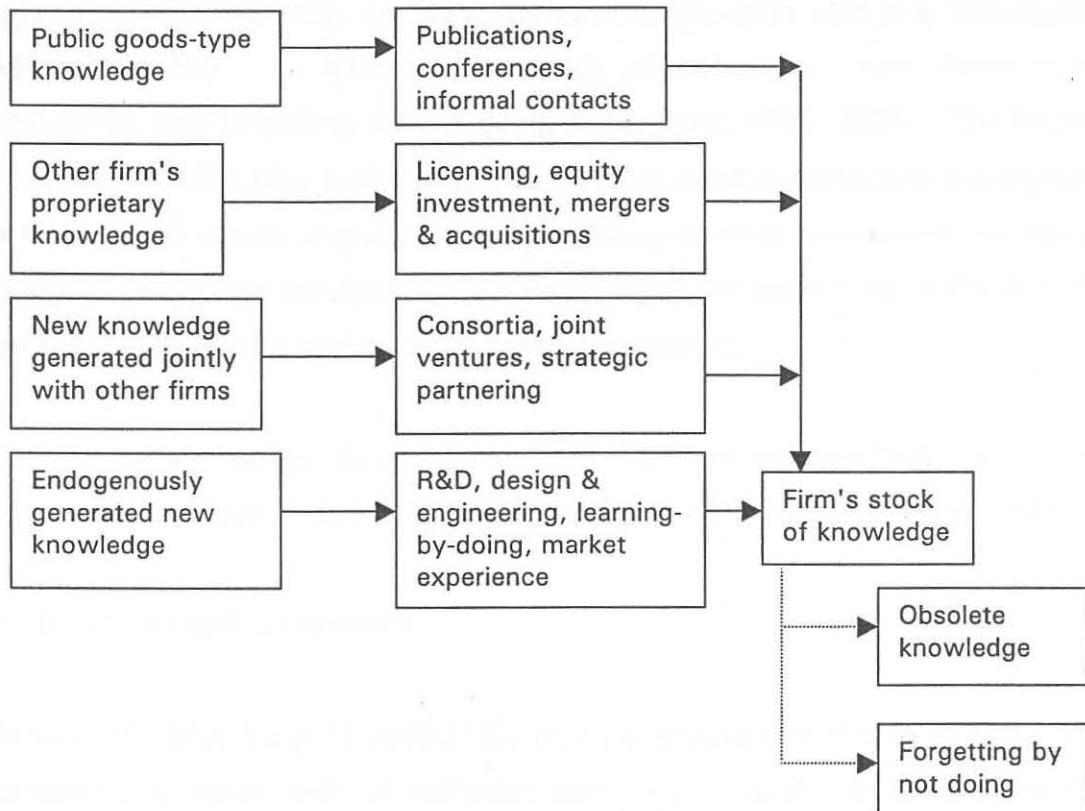
Developing urban economies should be able to combine their production factors in such a way as to alter production methods and exploit new sources of inputs and markets. Economic growth and development should therefore be viewed as changes in the economy without these being forced via external elements, but rather from within, using its own initiative. The endogenous forces within the urban economy should be exploited to create an environment conducive to inventions and innovation. This could stimulate new ideas, providing economic opportunities to the entrepreneur. An urban developing economy should thus acquire knowledge by purposefully stimulating research to enable optimal endogenous growth.

3.5 SOURCES AND MEANS OF KNOWLEDGE

A number of theories attempt to explain when and why inventions occur. Some are of the opinion that inventions are the result of random genius and are therefore unpredictable, sporadic and inexplicable (Rosegger, 1996: 127). Another view is that inventions are the result of social evolution and thus occur when the "time is ripe" for a

new invention. Some also feel that inventions are due to the pressure of social or technological needs where actual or potential demand is probably the most important determinant (Rosegger, 1996: 127).

Figure 3.1: Sources and means of knowledge acquisition



Source: Rosegger. 1996.

From an economic point of view the most agreeable explanation is the notion that inventions are the result of purposeful search and research (Rosegger, 1996: 129). The potential success of a firm's searchers for new ideas and the transformation of these into innovation, depend greatly on the firm's ability to acquire the necessary knowledge. Figure 3.1 illustrates the sources of knowledge and also shows the means whereby knowledge is created and transferred.

The first type of knowledge takes the form of large amounts of information that are public goods by nature, and are accessible at a relatively low cost. The second major source is the proprietary knowledge of other firms, which may be obtained through contractual agreements (such as licensing) or by actually acquiring the person in whom the knowledge is vested. Another method of acquiring knowledge is to engage in joint R&D efforts with other firms. Finally, the stock of knowledge can be enhanced by endogenous activities such as R&D, design, engineering and the accumulation of market experience. In addition, the stock of knowledge may diminish through obsolescence and forgetting by not doing (Rosegger, 1996: 183). The former type refers to the fact that new technology may devalue existing skills and experience. The latter refers to situations where a firm specialises and relies on external sources without maintaining a requisite level of internal knowledge. In such a case the firm may no longer be able to absorb and apply acquired information.

Some of the main forces receiving the most attention in governing the allocation of resources to the development of knowledge will now be discussed (Romer, 1996: 113).

3.5.1 Basic scientific research

Basic scientific knowledge is traditionally made available free of charge. This research is normally undertaken without economic gain as a motivational force. Governments and wealthy individuals support this research and individuals are motivated in this pursuit by the desire for fame or by love for their field of study. This type of knowledge is made available at zero cost and is seen as a positive externality due to its contribution to production.

3.5.2 Private incentives

Many innovations such as the development of new products or small improvements in existing goods are motivated almost entirely by the possibility of private economic gain. The knowledge created by this type of research should at least have some form of

excludability, affording the inventor some economic bargaining power. The price attached to this new idea is limited by its usefulness in production or the potential returns that others can gain by acquiring it. Under conditions of imperfect competition, the equilibrium condition would not be optimal. Inefficient divisions of resources between research and development and conventional goods production may occur.

Three externalities of research and development have been identified (Romer, 1996: 114). The consumer surplus effect is the first externality where innovators obtain some surplus since they cannot engage in perfect price discrimination. This will be classified as a positive externality of research and development. The business-stealing effect is the second externality, where the introduction of superior technology makes existing technology less attractive and therefore harms the owners of those technologies. This externality is negative in nature. The research and development effect is the final externality where innovators do not control the use of their knowledge in the production of new or additional knowledge. Innovators only receive a return on their knowledge in the production of goods but not in knowledge production. The development of new knowledge is a positive externality for other researchers.

The net effect of these three externalities is dubious. In some cases the business-stealing externality may outweigh the other two. The incentives to capture the profits earned by other innovators may cause the allocation of too many resources to research and development. Normally the overall externality of research and development is believed to be positive. Additional externalities are also possible. If only partial excludability is possible there is an additional reason for the private return to research and development being below social return. On the other hand, excessive incentives for some kinds of research and development are possible if an innovator is awarded exclusive rights to a new innovation. In this case the private returns would exceed social returns.

3.5.3 Talented individuals

Baumol (1990) and Murphy, Shleifer and Vishny (1991) have shown that improvements in knowledge are often ascribed to the work of highly talented individuals. These individuals also have opportunities other than pursuing innovations. Therefore, economic incentives for highly talented individuals are very important in stimulating the accumulation of knowledge. According to Baumol (Romer, 1996: 115) these individuals were traditionally attracted by other high-profile jobs such as politics or military positions. These activities often lead to negligible or even negative social returns and are seen as a form of rent-seeking. These individuals attempt to capture existing wealth and opportunities rather than create new opportunities and wealth. A strong link between the efficient use of the skills of these talented people and the level of economic progress in a country is also clear.

Three factors that would influence talented individuals to pursue activities that are socially productive, were identified. Firstly, the size of the relevant market determines the potential returns for an individual and this represents an incentive for research and development. The second factor, is the degree of diminishing returns. Activities that limit the innovators' time do not represent the same potential returns as activities whose returns are limited only by the size of the market. The final factor is the ability to retain the returns (money) from one's activities. Well-defined property rights tend to encourage innovations and entrepreneurship.

3.5.4 Learning by doing

This last determinant of knowledge accumulation is somewhat different to the three already mentioned. In the production process, individuals may think of creative ideas to improve the production process. The Nobel Laureate Arrow gave a dynamic interpretation to increasing returns through "Learning by Doing" (Meier, 1995: 102). This was an attempt to render technological progress endogenous to growth models by making productivity an increasing function of cumulative aggregate investment for the

industry. The accumulation of knowledge is sometimes merely a side effect of conventional economic activity and is not due to deliberate efforts by anyone.

3.6 RESEARCH AND DEVELOPMENT

In the theoretical literature on economic growth, technological progress is perceived either as a "free good", as a by-product (externality) of other economic activities or a result of intentional R&D activities by private firms. It is increasingly accepted that the third source of technological progress (intentional R&D activities by private firms) is one of the most important sources of technological progress in an economy (Fagerberg, 1994: 1170).

Although some of the greatest inventions of the past came from the work of individuals working independently, it seems as if the days of the freelance inventor are limited, due to modern inventions being almost made to order in R&D laboratories of big enterprises. A number of reasons are given to emphasise this possibility (Rosegger, 1996: 137):

- i) Scientific work sometimes necessitates the combining of engineers and scientists in one setting.
- ii) The high capital requirements of modern applied research.
- iii) The advantage of economies of scale.
- iv) Growing control over resources and markets of large enterprises.
- v) The increasing reluctance of financiers to finance inventor-entrepreneurs.

Since there is no measure of the importance of a specific invention *ex ante*, it cannot be said that the role of the individual inventor has completely disappeared. Different types of research may demand different approaches and as some may require major organised structures, others may require small-scale methods. Decisions as to who should conduct the research are not completely clear, although the opinion of an experienced researcher is illustrated by the following (Rosegger, 1996: 140):

The best person to decide what research work shall be done is the man who is doing the research. The next best is the head of the department. After that you leave the field of best persons and meet increasingly worse groups. The first of these is the research director, who is probably wrong more than half the time. Then comes a committee, which is wrong most of the time. Finally, there is a committee of company vice-presidents, which is wrong all the time.

Some sectors may rely mainly on the informal process of "learning-by-doing"; others rely heavily on formal research activities of their R&D division; in some innovation is primarily generated by big firms or sometimes small firms. Pavitt (1984) identified a group of sectors to determine why sectors differ in their rates and modes of innovation in terms of the origin and use of R&D. This group of sectors are (Dosi, 1988: 231):

i) *Supplier dominated sectors*

These sectors will include textile, clothing, leather, printing and publishing and wood products. Innovations in these sectors are mainly process innovation. Innovative opportunities arise due to new forms of capital equipment and intermediate inputs, originating from firms who are primarily involved outside these sectors. The process of innovation is thus mainly a process of diffusion of best-practice capital goods and of innovative intermediate inputs such as synthetic fibres. The base of knowledge in these sectors relates in principle to incremental improvements in the equipment elsewhere. Technological capabilities are rather low and firms are not very big, with the exception of textiles, which present economies of scale opportunities.

ii) *Scale intensive sectors*

In these sectors innovation relates to both processes and production. The production activities generally involve mastering complex systems and economies of scale in production and R&D, to mention but a few. Firms tend to be big, produce a relatively large portion of their own process technology, devote

a fairly large share of their own resources to innovation, and manufacture some of their own equipment. This group of sectors includes transport equipment, electric consumer durables, metal manufacturing, food products, parts of the chemical industry, glass and cement. A distinction concerning the nature of the production process can be made between assembly-based industries (cars, electrical consumer durables, etc.) and continuous process industries (cement, food products, etc.).

iii) *Specialised suppliers*

Innovative activities relate mainly to product innovations that enter other sectors as capital inputs. Firms are usually relatively small, operate close to their users and embody a specialised knowledge in designing and equipment building. This group includes mechanical- and instruments engineering. A high level of opportunities exists and is often exploited through informal gatherings of design improvements, introduction of new components, etc.

iv) *Science-based sectors*

This group of sectors includes the electronics industries and most of the chemical industries. Innovation is often directly linked to new technological frontiers due to scientific advances. Opportunities are great and mechanisms range from patents (chemicals and drugs) to learning curves (electronics). Innovative activities are formalised in R&D laboratories and this product innovation enters a wide variety of other sectors as capital or intermediate inputs. Firms sometimes tend to be big, with the exception of highly specialised producers.

In the process of innovation, R&D is very important in generating new ideas. Four characteristics that have central importance can be identified (Kay, 1988: 282). Non-specificity is relevant at the level of the product and the firm, and much of the R&D is not product specific insofar as a particular piece of work may feed into a variety of final products. Much of the R&D is also not firm specific, generating externality and property right problems. Lags and delays are a particular feature of R&D activity with a given

piece of R&D often taking many years before it becomes available for commercial ventures, if at all. Uncertainty is also a problem (meaning unmeasurable uncertainty) in contrast to predictable or measurable risks. This also refers to general business uncertainty, meaning all decisions concerning the future. This again is linked to technological uncertainty, which is the achievement of specified performance and market uncertainty, which refers to the possible achievement of a commercially viable product or process. Lastly, another major problem may be if R&D cost levels exceed the internal financing capability of the firm and there are barriers to external capital market financing of corporate projects.

It is important for firms engaging in R&D activities to keep in mind that the new technologies emanating from their research effort do not compete in the literal sense. Only firms compete as decision-making entities articulating a technology to achieve specific objectives within a certain environment. The outcome of their decisions is precisely what determines the significance of rival technologies. Such a firm possesses a certain knowledge base and design capacity to translate that base into products and processes of production. Three attributes of a firm are important in this respect (Metcalfe, 1988: 568). Firstly, efficiency as measured by the quality of a firm's products and the productivity of the methods it uses in its production activities. Efficiency depends on two interwoven aspects of the firm's knowledge base: the first one of the two is its technological knowledge of how materials and energy are combined into the desired products, and secondly, its organisational knowledge base which determines the firm's managerial skills to plan, co-ordinate, control and monitor its productive activities. The second attribute of a firm is its propensity to accumulate the ability to translate profits into the expansion of the capacity to produce. Accumulation refers to the possibility of growth opportunities, the ability to command internal and external funds, the investment requirements to expand capacity, the ability to manage growth without sacrificing efficiency, as well as the willingness to expand. A firm that does not wish to grow will have zero propensity to accumulate. Lastly, the creativity of a firm is the ability to enhance product and process technology either through improvements within existing design configurations, or by the addition of new design configurations to

the technological base. The creativity of a firm will depend on the richness of a firm's technological environment, the resources that can be directed towards R&D, the incentives to advance technology, the ability to manage the process of acquiring new knowledge and its ability to move from knowledge to artifact.

3.7 HUMAN CAPITAL INVESTMENT

A characteristic of the modern economic society is the fact that technological innovation has removed inhibiting factors like space and time. The relative demand for information, services and intellectual capital will rise. This implies that businesses will tend to become smaller in terms of people but more dynamic and bigger in terms of turnover. Their single most important asset will be the intellectual capital residing within their people. Investment in education and training plays a central role in technological progress and thus economic growth. Considering the importance of knowledge and innovation, the role of investment in the education and training of human beings cannot be overestimated. Investment in education and training of humans over the centuries has brought us to a position where the accumulated stock of capital assets that it represents is our most valuable possession (Stonier & Hague, 1964: 551). The influence of accumulated human skill and knowledge on economic growth could be seen very clearly after the rebuilding of Germany and Japan after World War II. The amazing process of rebuilding these countries in such a relatively short period was due to the accumulated knowledge and skill of the Germans and Japanese people not having been destroyed during the war. It would almost certainly have taken much longer to rebuild these countries without the accumulated knowledge of these countries, and the process of scientific and technological discovery and learning would have had to be repeated.

The process of investment in people has three critical elements (Stonier & Hague, 1964: 551). Firstly, new generations should have access to any appropriate parts of knowledge that have already been accumulated by previous generations. Although not all such knowledge will remain relevant, education and training should be flexible

enough to decide which particular pieces of knowledge are still relevant, and to adapt learning programmes accordingly. No one person can accumulate all existing knowledge and some form of specialisation is thus essential. It is also important to know where knowledge can be found, rather than to try to absorb all knowledge.

Secondly, investment in people should be directed towards helping the innovators to see how to apply existing knowledge in new ways. It is important to see how existing knowledge can be used to develop new products, to introduce new processes and production methods and to improve the efficiency of organisation in businesses and government. However, if people are taught merely to apply old ideas in new ways, the value added will be basically non-existent. People should be encouraged to develop entirely new ideas, products and processes as well. Education and training is therefore necessary to equip innovators with the best possible knowledge and to encourage them to use energy, initiative and imagination. Existing knowledge cannot, however, show where new ideas, new products and new processes are necessary and how to introduce them.

3.8 IMPLICATIONS FOR URBAN ECONOMIC DEVELOPMENT

Urban economic development implies that quality of life should be improved and it thus seems that developing economies should engage seriously in research and development. Urban areas could contribute to providing the infrastructure to stimulate R&D activities in developing economies. The creation of an environment to foster inventions or ideas is important, although these inventions and ideas are mainly part of the stock of knowledge. To become an innovation, these inventions should be applied. The entrepreneur or innovator should be given a fair chance to introduce innovations. Although entrepreneurs are daring people and seize economic opportunities, they still need a complementary urban environment to tackle the challenges posed. Urban policies and policy objectives of local urban authorities should carefully consider the creation of such a complementary urban environment. Local urban authorities in developing economies desperately need daring entrepreneurs to grasp economic

opportunities, to ensure economic growth and development. An improved quality of life may only become a reality once a growth-hampering environment is substituted by the creation of an economic environment complementing the revival of business activities.

3.9 SUMMARY

It is to the benefit of any economy to promote research and development and hence generate knowledge. If knowledge is non-rival in consumption everyone in the economy benefits from this, although the degree of excludability may differ. This excludability factor serves as a motivation for individual researchers to engage in research and development. The potential prospects of economic gain culminating from research are the driving force behind their efforts.

Another factor is the existence of property rights that improve the potential for innovators to earn the profits that encourage them to engage in the development of new ideas. Without research, no new ideas would be created, technology would remain static and there would be no chance of increasing per capita growth. The fact that a person receives personal gain from research does not imply that no social benefit is gained. The gap between private and social returns suggests that there are still incentives for research and development for individuals.

Knowledge is the engine of economic growth. Due to the nature of knowledge, increasing returns to scale in the production process are possible as compared to the model of Solow. Although the growth rate of the population is important because more researchers can generate a larger number of ideas, the availability of incentives to encourage R&D could be more productive. This could ultimately lead to a higher per capita growth rate. It can thus be seen that knowledge is the only instrument of production that is not subject to diminishing returns.

The theory of Schumpeter, explaining the process of growth, maintained that at intervals a number of innovators would apply new ideas commercially in the economy on a

relatively large scale. This would create an eruption of investment activity and lead to a boom in the economy. Innovation may be imitated, building up to a wave of innovating investment as others followed suit. This would lead to a lengthy upswing, followed by a downswing during which the economy would absorb the innovations. However, according to Schumpeter, the capitalist system would mature and investment opportunities would disappear with the entrepreneurial function becoming obsolete. This is because the "progress" in the capitalist system would either cease or become completely automatic and therefore disintegrate under the pressure of its own success. Without innovation, the economy would be forced into a steady state.

Although there are various views on how to acquire knowledge, one method on which there is most consensus intentional R&D activities by private firms. The research approach may be on a relatively small scale as well as major R&D projects by big firms or research institutions. High capital requirements as well as the advantage of economies of scale may favour large formal R&D institutions as compared to individual independent researchers. Due to the importance of R&D in generating knowledge and innovation, investment in education and training is essential for stimulating economic growth.

Since the urban environment can be seen as the economic powerhouse of a country where the major energy is generated to engage in R&D and thus acquire knowledge and foster innovation, a functional analysis of urban economics and the possibilities for urban economic growth will be explored in the next chapter. It is, however, important to note that Chapters 4 to 9 will mainly undertake an analysis of urban economics, the purpose being to gain insight into urban economic matters, prior to these chapters being integrated into the economic growth theories in Chapter 10.