Are Innovation Studies on Industrialized Economies Relevant to Technology Policy in Developing Countries?

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UNU/INTECH Working Paper No. 3
June 1991
1. INTRODUCTION

Studies of industrial innovations in the industrialised countries, and similar studies in developing countries, tend to be done in isolation from one another. The isolation is not total of course, but it is enough to be noticeable. It raises the question whether policy researchers concerned with technology policies in the context of developing countries might not benefit from a more systematic exploration of what have been called “innovation studies” (Dosi, 1988). The purpose of this essay is to map out the “innovation studies” territory that could usefully be surveyed in the interests of research on developing country situations. It attempts to build a bridge between studies on innovation and technological change in developed countries and their counterparts in developing countries. It also attempts to connect technology studies to the broader stream of development economics.

It is in the nature of maps to be an imperfect reflection of the scale and detail of underlying reality. That, as Joan Robinson once pointed out, is the whole point of maps. It is, nevertheless, quite possible to criticise some maps for being on a scale too small to be as useful as they might be or to be arbitrary in the detail they select. Perhaps the map which is drawn in this article is vulnerable to those criticisms, for it is the outcome of a preliminary reconnaissance, not a full-blooded survey. If it is so, we must hope that nevertheless it at least shows up parts of the terrain that would be worth further exploration.

There have of course been good surveys of the issues of technology policy as they present themselves in the developing countries. A particularly valuable, quite recent one is by Martin Fransman (Fransman, 1986). Fransman covers a part of the area of this paper, but not all.

The paper is set out as follows. In the following part there is a summary and discussion of recent literature on innovation in the industrialised countries. This is focused on attempts to synthesise “innovation studies” into a coherent theory. The theoretical structures which come out of this effort, go well beyond the explanation of industrial innovation phenomena per se: they raise rather fundamental questions about traditional theories of the firm and its behaviour. The emphasis is on innovation as a mode of competition, and as a source of sustained disequilibrium in the Schumpeterian style, an approach which is in contrast to the equilibrium stories which are at the foundation of received theory.

Part III then deals with the possible relevance of this body of theory for the developing countries. It addresses two questions in particular. The first is the relevance of innovation studies to the technological learning processes in developing country industries processes whose importance has been much underestimated in a part of the literature. Second it discusses the importance of technological change in the development of export oriented industries. A final part draws conclusions.
2. INNOVATION AND TECHNOLOGICAL CHANGE

The microeconomic processes involved in the adoption of innovations, which, today, we are inclined to describe as Schumpeterian, were, it seems, clearly recognised by Classical economists. In his chapter "On Machinery" in the "Principles of Political Economy", Ricardo remarks:

"...He...who made the discovery of the machine, or who first usefully applied it, would enjoy an additional advantage, by making great profits for a time...". (Ricardo, 1830; edition 1971, Chapter XXXI, pp.378-379)

Marx expanded considerably on this notion in Book One of Capital (Marx, 1858; edition 1961, pp 312) in the theoretical discussion of the origins of "relative surplus value". If an individual capitalist ("some one capitalist, ibid. p. 316), doubles the productivity of labour, whilst the value of the means of production remains the same,

"...the individual value (of the articles produced), is ...below their social value: in other words, they have cost less labour time than the great bulk of the same article produced under the average social conditions...".(ibid. p.317).

However, ".....the real value of a commodity is ..not its individual value, but its social value; that is to say the real value is not measured by the labour time that the article in each individual case cost the producer, but by the labour time socially required for its production...(and) if therefore the capitalist who applies the new method , sells his commodity at its social value..he sells it ...above its individual value (ie. cost)...and thus realises an extra surplus value..."

In both these accounts, the adoption of the innovation which leads to the generation of extra profit or surplus value, is implicitly assumed to happen against the background of some initial equilibrium position. The subsequent story (that is after a period of extra surplus value) is essentially about a return to this equilibrium situation. Thus in his discussion of the adoption of a new type of machine, Ricardo concludes:

"...but, in proportion as the machine...(comes). into general use, the price of the commodity produced, would, from the effects of competition, sink to its costs of production, when the capitalist would get the same money profits as before, and he would only participate in the general advantage as a consumer..." (Ricardo, op. cit. p.379).

Similarly, Marx observes:

"...On the other hand... this extra surplus value vanishes, so soon as the new method of production has become general, and has consequently caused the difference between the individual value of the cheapened commodity and its social value to vanish... The law of the determination of value by labour-time, a law which brings under its sway the individual capitalist who applies the new method of production...this same law acting as a coercive law of competition, forces his competitors to adopt the new method. The general rate of surplus value, is therefore ultimately affected by the whole process, only when the increase in the productiveness of labour has seized upon those branches of production, that are connected with..the necessary means of subsistence..."

In short, technological change results in a general increase in surplus value, which for the present we may identify with profits, only when it increases productivity in the production of wage goods (or in production of the means of production). The basis for
this conclusion is that the innovations in general ultimately leave the "rate of surplus value" unaffected - because of the re-assertion of equilibrium; but innovations in the wage goods sector reduce the costs of labour time in all other sectors.

In its early form, Schumpeter’s own analysis of innovation as a microeconomic process, especially in its early form, owes much to Marx (Schumpeter, 1912; edition 1961, Chapter IV on "Entrepeneurial Profit"). In particular, in his early writing, which was much concerned to explain, even to justify the additional profit generated for the innovating firm as a return to entrepeneurship, he places considerable emphasis on the tendency of the industry to return to an equilibrium. "The second act of the drama" of innovation (op.cit. p.131) comes when imitators enter production driving prices down and leading to a "complete reorganisation of the industry". Consequently after an innovation ";that process of reorganisation occurs which must result in the annihilation of the surplus over costs" (p.133). The idea that a re-organisation takes place in the re-establishment of an equilibrium might suggest that Schumpeter had in mind a more considerable process of adjustment than that described by Ricardo or Marx, but still the return to equilibrium is the keynote.

Subsequently, however, Schumpeter’s thinking moved toward the notion of continual change as a result of a succession of innovations, leading to ";continual reorganisation of the economic system..." (op cit. p.156), in which the re-establishment of equilibrium is pre-empted by further rounds of innovation. In his 1934 Preface to the English Edition of Theorie der wirtschaftlichen Entwicklung, he remarks:

"The conclusion suggested itself that this body of theory might usefully be contrasted with the theory of equilibrium which explicitly or implicitly always has been and still is the centre of traditional theory" (op. cit. p.xi).

Later in "Capitalism, Socialism and Democracy, he wrote:

"....(the capitalist economy)....is incessantly being revolutionised from within....existing structures and all the conditions of doing business are always in the process of change....Every situation is being upset before it has time to work itself out..." (Schumpeter, 1966; our italics)

It seems fair, then, to distinguish two distinct but closely related respects in which Schumpeter takes issue with the conventional Marshallian microeconomic theory of the firm. First, there is a fundamentally different view of the nature of competition. In Marshall, the technology of production is given and available to all firms; the technology defines the parameters within which the firms’ minimum cost levels of production are to be determined by adjustment to competition. For Schumpeter, competitive behaviour, led by innovators, is primarily concerned with changing the parameters themselves - ie. with a search for new technologies, which, temporarily, are available to the innovative firm alone and confer the advantages of monopolistic rents. It is also concerned with the imitative process which then ensues. The search for the optimum level of output and minimum costs of production is largely overshadowed by the process of competition between technologies.

The second major difference between the Schumpeterian and traditional views of the firm resides in Schumpeter’s view that competition based on the search for new technologies generates a stream of innovations which preempts the attainment of micro-economic equilibrium altogether.

Christopher Freeman puts these points in the following terms:
In Schumpeter’s framework it is disequilibrium, dynamic competition............. between entrepre-
neurs, primarily in terms of industrial innovation, which forms the basis of economic development”
(Freeman, 1982, pp. 209-210).

Intuitively, the Schumpeterian model of competition gives a plausible interpretation of
competition in a range of important sectors - especially, of course, science-based sectors
like electronic capital goods, chemicals, pharmaceutical, biotechnology and the like. It
may seem less convincing in what development economists often call the "traditional"
sectors, though as will be argued later, even here innovative competition occurs - mainly
in the form of adoption of innovative plant and equipment originating in the capital goods
sector. Later we shall discuss intersectoral differences in the sources of innovation and
relate these to the apparently differing incidence of innovative competition between
industrial sectors.

As well as intersectoral differences, there have been historical differences, that is changes
within sectors over time, in the incidence of innovative competition. It is interesting to
speculate whether Schumpeterian modes of competition are perhaps more characteristic
of the modern (ie. twentieth century) industrial economy, than they were, say, during and
after the Industrial Revolution. It may be that the emergence of Schumpeterian thinking
reflects - with a considerable lag of course - historic changes in the nature of competition
itself. Perhaps Marshall has been overtaken by events rather than shown to have got it
wrong.

Recent theoretical approaches to innovation have been based importantly on empirical
observation of firm’s behaviour and have been informed by the Schumpeterian concept
of how competition takes place in the industrial sector. In particular, they draw on
Schumpeter’s notion that, at the level of the firm, competition is about creating a stream
of disequilibrium situations, in which there are quasi-monopolistic rents. The idea that
firms are continually in search of innovations in this way has been shown in a seminal
study by Nelson and Winters (1982) to generate plausible explanation of economic
growth processes. There has of course been a considerable development of these basic
notions. At the risk of doing an injustice to the conceptual richness of the discussion of
innovation, we will select three especially important and related developments. These
are: first, the idea that technological change is localised; second, the notion that innova-
tion at the level of the firm is the outcome of a cumulative process; and, third the different
incidence of factors determining the appropriability of new technologies. After discuss-
ing these three elements, which are primarily about conditions within innovative firms,
we will go on to look at two characteristics of the environment within which the firms
operate. These are the technological and institutional contexts.

First, localisation: the idea that technological change may be localised was put forward
in a theoretical article by Atkinson and Stiglitz (1969) in which they contended that
technological change may be better represented by a localised "bulge" in the neo-classical
industry production function, rather than by an uniform shift of the whole frontier. The
location of the bulge depends essentially on the point at which firms were producing
initially - in short upon their prior technological choices. At the same time as Atkinson
and Stiglitz, Nathan Rosenberg (1969) put forward an economic historian’s empirically
founded notion of localisation. These ideas were subsequently used by David (1975),
who proposed an explanation of localisation based on "learning" processes in production:
Because technological ‘learning’ depends on the accumulation of actual production experience, short sighted choices about what to produce and especially about how to produce it using presently known methods, also in effect govern what subsequently comes to be learned.” (David, 1975, op. cit. p. 4).

It is helpful, at this stage, to keep in mind that learning cum localisation phenomena take place at the level of the firm. It is quite possible therefore, that individual firms within an industrial sector have different "vectors" of technological change - that is to say, firms have different patterns of localisation within the particular technological fields relevant to the industry’s production activities. There are many cases of the coexistence of different patterns of localisation. An example is the simultaneous emergence of Apple Macintosh computer system and the IBM PC system; another is the co-existence in various major chemical firms in the 1970’s of several different methods of "catalytic cracking". Sometimes one or other of the competing variants on the basic technology will prove to be a dead-end, but this does not always happen. Implications of these differences between firms in their vectors of technological change, especially implications for market structures, are discussed later.

Second, there is the question of cumulativeness. David’s account of the origins of localised technological change leads naturally to the concept of cumulation in the innovative process. Innovation processes are cumulative in the sense that David sketches out: technologies of production used today influence learning processes and the nature of accumulated experience. These, in turn, influence the uses to which innovative inputs (like R and D at the level of the firm) are put, and so also the nature of tomorrow’s production technologies. And so on.

The simplest examples of cumulative innovative processes at the level of the firm are the processes of "learning by doing" (Arrow, 1962), and the other, more empirically founded and realistic variants of that processes described in the literature. These processes have the characteristic that the productivity changes they generate depend upon accumulated experience of actual production. They are aptly described as irreversible, dynamic economies of scale.

The cumulative processes which are in question in theories of innovation may include learning by doing in its traditional form, but they also refer to other learning processes which may not be so simply related to the experience of production per se: technological learning, for example, or learning about effective resource allocation for innovation.

By a straightforward extension of the discussion of "localisation", the process of cumulation of "problem solving capabilities" (Dosi, 1988, see note 8 above), is likely to take firm specific forms. The theory of innovation as it has developed in the recent past thus endows individual firms with histories, which have a more than antiquarian interest: a firm’s history determines what it is good at technologically, and that in turn has a direct influence on the rate and direction of innovation it pursues, and on the differences in performance between it and other firms in the same industry. Learning processes of various kinds and the pattern of intrafirm accumulation of technological capability connect the firm’s past with its present. The contrast between this and the ahistorical "firm" of neo-classical microeconomics whose whole existence is supposedly adequately described by a set of cost curves identical to those of all other firms in the industry, is rather stark.
The third characteristic of innovation is that the knowledge incorporated in new technologies can, in varying degrees, be appropriated by the innovating enterprise. Appropriation of technological knowledge is essential to the innovative process, since it is appropriation which allows a temporary preemption of imitation and hence monopolistic rents (also temporary). It is the anticipation of these rents which induces enterprises to innovate in the first place. Appropriation is achieved in a number of ways. In some sectors (drugs, for example, or fine chemicals) patents are especially important; in others, secrecy is enough. The lead times which imitators face can be important, as may learning curve effects in the innovator firm. Appropriability may also depend upon the extent of tacit knowledge associated with the innovation (for a discussion of tacitness, see Dosi, 1988 op.cit.). As implied above, appropriability differs between sectors.

The rate and direction of technological innovation may well be explicable up to a point by the localisation and the cumulative nature of the innovative process or by opportunities for appropriation. But these intra-firm factors are, as we indicate earlier, only a part of the story. A more complete explanation depends in addition on "technological trajectories" (the constraints imposed by the logic of technological development itself) and on institutional factors (which are usually nation specific). The institutional side is receiving much attention at present. Its parameters are set out with particular clarity by Nelson (1988a and 1988b).

Intersectoral differences in innovation, and the flows of knowledge related to innovations between sectors are important, especially in relation to developing countries (see below). That sectors differ both in the frequency and extent of innovation and in sources of innovation has long been recognised. Initially, in the literature of the 1960’s and 1970’s, "traditional" and supposedly non-innovative sectors were distinguished from more "science-based" innovative ones. More recently ways of grouping industrial sector in relation to the nature and sources of innovative activity, have consciously or otherwise, returned to a pattern very similar to that implicit in Marx’s historical account of relations between "science" and production (Marx, 1858, op. cit. Book I, Chapters 13 to 15). Marx essentially differentiates the capital goods (machine making) sectors as primary points of contact between science and production. In the same spirit Robson et al (1988) distinguish "user sectors" and "producer sectors", where the latter are chiefly the science based sectors and the more traditional capital goods sectors. Pavitt (1984) and later Dosi, Pavitt and Soete (1990 op. cit. pp. 92-98), distinguish supplier dominated sectors, which in the main receive innovations embodied in producer goods and are essentially innovation user sectors (they include traditional sectors of manufacturing); production and scale intensive sectors (largely machinery making sectors, consumer durables, automobiles, steel, etc.) which are predominantly innovation producers; and the science-based sectors which are producers and a source of innovation for many other sectors (these include electrical and electronic sectors and chemicals). These sectoral distinctions will be useful in later discussion on the developing countries.

Before going on to a discussion of the relevance of these theoretical approaches to developing countries, we shall discuss two important implications: first, for market structure; and second, for international trade and competitiveness.

Innovation is seen as based on the cumulation of firm-specific technological skills, leading to localised technological changes. It is therefore pre-eminently a differentiating process, in which firms attempt to establish market controls by developing new products
and new processes. This of course is in contradiction to the conditions of ‘perfect competition’ and to the firm behaviours which are conventionally presumed to follow from those conditions. It suggests market structures closer at first glance to those of the Robinsonian model of imperfect competition. There are however, important differences: first, the Robinsonian model is mainly associated with the explanation of trivial product differentiation, whereas the product differentiation associated with innovative activities is in general non-trivial and essentially depends for success on real technical advances. Second, imperfect competition models, Robinsonian or otherwise, are usually concerned with underlying trends to equilibrium - albeit different equilibria to those of perfect competition. Innovative competition, in Schumpeter’s vision, is a process in which there is a continuing search for and attainment of new disequilibria in markets, from which rents flow. From this standpoint,

Given this distinction, it would seem that innovation theory as it has evolved recently can be more convincingly related to concepts of market structure and competition which do not rely on tendencies to equilibrium. One obvious example is Kalecki’s concept of the "degree of monopoly" (Kalecki, 1971, Chapter 5, "Costs and Prices", based on an earlier essay published in 1943). Alternatively, Sylos-Labini’s analysis of oligopolistic market structures as a meta-stable configuration of competing firms might also provide a more convincing framework for describing and predicting innovative competition (Sylos-Labini, 1967). A strength of the innovation theories discussed here, is that they provide an explanation of market imperfection which derives from the competitive process itself - market imperfection is, as it were explained by an endogenous process (Nelson and Winter, 1982).

The implications of these Schumpeterian approaches to innovation for international trade have been explored by Dosi, Pavitt and Soete (1990). The theme, which is in direct confrontation with conventional trade theory, is sketched in the introduction to the Dosi et al Study (ibid.p.11):

"...In so far as technology gaps and their changes are a fundamental force in shaping international competitiveness, their impact on domestic income, by inducing and/or allowing relatively high rates of growth via the foreign trade multiplier, will be significant.......it is the relationship between technology, trade and growth which is at the centre of the analysis, rather than the question about the short-term gains from trade stemming from the open economy allocation of resources, so crucial in the conventional view....".

Later (ibid. Chapter 6), there is a detailed econometric study of the OECD countries, covering forty industrial sub-sectors, of the relationship between competitiveness, (measured by each countries exports in each of the 40 product groups, as a proportion of total OECD exports in that industry) and an index of technological innovation (share of each country’s US registered patents in each of the industry groups in total OECD share of US registered patents in that industry group). The regressions show that the technology variable is strongly associated with competitiveness in most of the science based sectors, and that the association is non-significant in the so-called traditional sectors. These results support the idea that absolute trade advantages may be built upon superiority in innovations.

From the point of view of the discussion which follows, these results need to be handled with some care. In particular they must not be taken to show that innovation and the increases in factor productivities to which it gives rise, are unimportant in determining competitiveness in the traditional sectors. In these sectors innovation does not show up
in patenting, precisely because they are "supplier dominated" sectors as far as innovation goes: they receive their innovation from producer goods suppliers who do the R and D and hold the patents on the equipment used in these traditional sectors. Nevertheless, the competitive position of these sectors will depend importantly on the application of innovations developed in the supplier sectors. The traditional sectors may well be innovative despite the lack of patenting, but innovative in the sense of using new technology rather than producing it. This has special importance at the present time in view of the increasing application of microelectronics innovations in such sectors.
3. IMPLICATIONS FOR DEVELOPING COUNTRIES

In principle the theoretical framework which has been developed from empirical studies of innovation and of the behaviour of innovative firms, could give useful guidelines for policy studies in developing countries from at least two points of view.

First, innovation theories contain insights into how and why technical capabilities are developed in the industrial sectors of the advanced countries. In effect they give some new dimensions of meaning to the concept of "accumulation of local technological capabilities", which has come to play an important part in technology policy in developing countries. Second, innovation studies have much to tell us about the structure of international industrial markets. This kind of information is important in defining strategies for industrial export development.

This part of the paper is consequently in two sections: the first examines innovation studies and the accumulation of technological capabilities; the second focuses on trade and technological change.

3.1 Innovation Studies and the Accumulation of Technological Capabilities

An obvious problem in trying to relate innovation studies in the industrialised countries to technology policy issues in developing countries is that there is comparatively little technological innovation taking place there, especially if innovation is strictly defined to mean the first commercial introduction of a product or process in the international economy.

It is, however, a rather limited view of innovation theories that they are, or should only be concerned with the initial introduction of products or processes. Clearly, the imitative phase is important too - and in a sense, needs to be looked upon as integral to any explanation of innovative behaviour. There are two reasons for this. In the first place, the behaviour of innovative firms is importantly influenced by expectations about the likely speed of imitation. Innovators might also seek to pre-empt imitation by strengthening their appropriation of the new technology. So that, a convincing theory of the innovative firm, and particularly one which purports to explain intersectoral differences in innovative behaviour, must have a grasp of the objective conditions determining imitation. Second, a theory of innovation must surely reach beyond explanations of the behaviour of individual firms, to consider the implications of innovation for industrial sectors, especially for market structures. Here too, the story will be incomplete without a reasoned consideration of imitation and of other processes that might be involved in the diffusion of innovations. At the level of industrial sectors, a theory of innovation must include a theory of imitation if it is to be complete, though the relative scarcity of empirical work on imitation might lead one to believe otherwise.
It is probably a sensible assumption that the skills which are commonly associated with innovative capability are to a large degree relevant to imitative activity - or, perhaps more precisely, that the skills needed for imitation are essentially a sub-set of those needed for innovation. To see this, return to the discussion of the main characteristics of innovative firms. The studies we have reviewed emphasise the localised, and cumulative processes whereby firms build technological knowledge which ultimately becomes the source of new technologies. These capabilities, it is argued, are built around the methods of production in use (i.e. around "...previous choices of technique..." as Paul David (1975) puts it). But whilst this accumulation of partly explicit and partly tacit knowledge is argued to be a necessary condition for success in innovation, it does not follow that it’s existence in a firm, is sufficient to ensure that firms will innovate. And, more important, nor does it follow that firms pursue this accumulative (and costly) process solely for innovative success. For some firms at most times, and for all firms at some times, this capability may as important for the purposes of effective imitation of technological leaders as for originating innovations.

As a corollary, it is possible that the capabilities which are built up through successful imitation become the basis from which innovative capability finally emerges. The notion that there is a time sequence in which skills initially applied to what might be termed "sub-innovative" technological activities, like imitation or simply incremental improvement of productive efficiency, eventually become the basis for innovation, is probably part of the historic experience of many firms. An analysis of firm strategies towards innovation by Chris Freeman (1989, pp. 169 ff.) helps to make this point. Freeman distinguishes between five types of strategy which he calls: offensive, defensive, imitative, dependent, and traditional strategies. The first two of these are primarily concerned with the early, if not always initial introduction of new technologies and differ mainly in the tactics of timing; imitative firms, in contrast, are "content to follow way behind the leaders in established technologies" (p. 179). Imitative firms, Freeman argues, need some compensating advantages to deal with this lag. These may vary from control over a captive market to decisive cost advantages. Firms following the dependent strategy are in the main small sub-contracting enterprises, whose technology is usually entirely determined (and often supplied) by customer enterprises. Finally, "traditional" strategy is essentially non-innovative: firms do not change their products in technically significant ways because markets do not require them to do so. For the present argument the particularly interesting point about Freeman’s categorisations is found in his analysis of the technical functions (or types of technical skill) with each of them. He discusses a number of these technical functions, ranging from R and D functions (3), through design, quality control and technical services and on to patenting and scientific and technical information. These are expected to be needed in some degree in all strategies, though in different intensities (Op. cit. Table 8.1, p. 171.). It is not difficult to see how firms might progress from one strategy level to another through an historic learning process in which they strengthen particular learning functions. It is also clear that skills associated with imitation can reasonably be described as a subset of innovative skills.

The usefulness of these approaches to the understanding of circumstances in developing countries is suggested by three lines of analysis; first, by extending Freeman’s discussion of innovation strategies (and linking it to Pavitt’s (1984) analysis of sectoral differences)
and relating this conceptualisation to the types of technology transfer which are used by enterprises in developing countries; second, by considering how the "innovation studies" account of localised, cumulative technology learning processes relates to the little detailed knowledge we have of learning processes in firms in developing countries; and third, by reexamining the concept of "accumulation of technological capabilities", which has become so important in technology policy in the developing countries, in the light of what we can learn from innovation studies.

First, then, we consider the question of innovation strategies in developing country firms. An obvious point of departure is that for the most part even technologically advanced firms in developing countries are committed to be imitators in the Freeman sense. This is partly because of limited technical resources, and partly because of their comparatively limited production experience. The terms on which imitation processes takes place in developing countries are essentially mediated by the ways in which technology is "transferred" from the industrialised countries. It is customary in the literature on developing countries to distinguish two main "mechanisms" of technology transfer: there are "direct" transfers, which involve transactions with machine suppliers, engineering consultants, and other agents in industrial countries; and there are "indirect" transfers, which are done by way of licence agreements with innovative firms in industrialised countries which have successfully appropriated relevant segments of the production technology. Indirect transfers may or may not involve foreign direct investments.

Whilst both groups of technology recipients are imitative, they are sharply differentiated in other ways. Direct transfer recipients are "supplier dominated" in Pavitt's categorisation. They imitate earlier adopters in supplier dominated industries in industrial countries. Recipients of indirect transfers on the other hand mainly operate in what Pavitt calls "production intensive or scale-intensive sectors", or even in science-intensive sectors, which are associated with relatively high R and D intensities in industrialised countries. Both these latter types of sector in the industrialised countries, themselves generate most of the technologies they use. In these sectors therefore new imitative entrants can generally only access the technology they need by contractual arrangements with the innovators.

This analysis suggests, interestingly, that there are a priori grounds for expecting the imitative lag and associated competitive disadvantages faced by recipients of direct technology transfers to be less onerous than the circumstances facing recipients of indirect transfers. The reason is simple. Direct transfers, in the main, centre around the import of innovative equipment from capital goods suppliers, though they may require support from other suppliers of technological skills, like for example, engineering design and consultancy firms, or plant contractors. However, regardless of the complexity surrounding the process of transfer, none of the agents involved have interest in delaying the imitative process. Suppliers of innovative machinery, in particular, will be specifically concerned to sell it regardless of the location of their customers. In some contrast to this, indirect transfers involve supplying enterprises which only agree to licence their technology when it is in line with their own strategic interests to do so. This often means, in effect, that they only licence when a particular market is closed to other forms of exploitation, or when their direct interests in exploiting it themselves are small. In particular, licensors will be concerned to avoid that they create future competitors. It follows that licensed technology transferred by the indirect route, will, other things being equal, involve a greater imitative lag than direct transfers of technology. This at least is a plausible hypothesis for
policy research, which may have particular relevance to sectoral choices for export promotion in developing countries.

Following Freeman, it is to be expected that the imitative firms in developing country industries, will have found compensating advantages to allow them to meet the competitive disadvantages arising from these imitative lags. So, if our hypotheses about the relative lags associated with indirect and direct transfers are correct, it must follow that the compensating advantages required are greater on the average for firms receiving indirect transfers. The existence of these compensating advantages in import-substituting economies is all too obvious: they take the form of effectively captive markets. And, extending this argument further, whilst keeping in mind Marshall’s warning on such matters, it is to be expected that in open economies with successful development of industrial exports, there will be a proportionately greater reliance on direct transfers - which will have an effect on the sectoral pattern of exports. These are assertions waiting to be refuted by empirical research. They are researchable by relatively simple means and they have a significance for policy.

So much for the first "line of analysis" listed above. It seems from the discussion that some interesting points and suggestive hypotheses do emerge when we confront our established approaches to technology transfer in the Third World with the conceptualisations of innovation theory.

The second line of analysis is best formulated as a question: are there similarities between the cumulative, localised learning processes described by innovation theory, and the learning processes which actually happen in enterprises in developing countries? As a first step, note that the types of imitative activity we associate with developing country firms, that is imitation in the "supplier dominated" sectors and imitation via licence agreements in other sectors, are normally accompanied by cumulative learning processes when they take place within the industrialised countries themselves. This is very clear in the case of licensee firms in industrialised countries. It is however, less clear in relation to the supplier dominated firms. On this question, note the account of these supplier dominated firms in Dosi, Pavitt, Soete (1988). They say of the supplier dominated firms (within the industrialised countries):

"...They are generally small and their in-house R and D activities are weak....They appropriate less on the basis of a technological advantage than on the basis of professional skills, privileged access to a resource, trademarks and advertising..." (Op. cit. pp. 92-93).

At the same time though, they stress the need for technological capability even in firms in this position, i.e. in firms which get their new technology from outside equipment suppliers. Thus:

"...the process of diffusion of an innovation (say a new machine) in a user sector is, in essence, a process of innovation for the user itself.....An important consequence is that the process...is also affected by the technological capabilities....and forms of production organisation of the users." (Op. cit. p.119).

So in the industrialised countries, even firms which get new technologies by buying machinery which embody it, need to have certain critical technological capabilities. The question we wish to address is whether such capabilities are also encountered in developing country firms.

The answer comes in two parts. The first part is a tentative "yes". Firm-level studies of learning processes in developing countries are unfortunately rather few. Honourable
exceptions are the case materials referred to in Katz (1987), and related work such as (inter alia) Dahlmann (1978), Maxwell (1977), and Katz and Albin (1979). These, like the work of Lall already referred to, (and see Lall, 1987) reported on firm-level studies which confronted and substantially dismissed the negative predictions of theories of technological dependency about learning and technological development. Subsequently, studies on the NIC’s, and particularly in South Korea have appeared. All these studies show evidence of learning processes which could readily be described in terms similar to those used in "innovation studies". We are plainly dealing with very similar phenomena in developing countries and in industrialised countries as far as intra-firm learning processes are concerned.

The second part of the answer refers to the failure of learning to happen in certain cases. The authors referred to above have all emphasised that the learning process is not "automatic" as is implicit in the theoretical discussion of Arrow (1962). It in fact requires a conscious allocation of resources within the firm, and careful organisation. In the absence of these, there may not be a learning process at all. Furthermore, in the absence of appropriate external institutional conditions learning processes may also fail to appear. An influential study on the failure of learning, based on Thailand case materials, is Bell (1982). The failure of learning processes in developing countries is in fact quite common. It is reflected in what is often called a "black box" approach to production technology encountered quite often in developing country firms which receive technology via licence agreements: firms may be unconcerned about how the technology works, provided only that they are able to produce with it. There are also reasons to expect that firms in developing countries may underinvest in learning processes (Cooper, 1984 amongst others). In short, whilst the cumulative learning processes associated with innovation and related activities in industrialised countries are reproduced in developing country industry, this is not automatic. Learning probably breaks down in developing countries more than in industrialised countries. An interesting question is whether innovation studies can suggest ways in which this situation might be improved by policy.

The last line of analysis suggested above, is about the relationship between the processes described in the literature on innovation, and the "accumulation of technological capability" as it is described in the development literature. Can innovation studies help in clarifying the process of accumulation of technological capabilities? In fact they probably can. One strength of innovation studies, is that they are firmly based on clear ideas about institutions, whether these are the firms which do the innovation, or the network of public and private agencies to which these firms relate. Often this has been lacking in the discussion of technological capabilities in developing countries, though the omission is clearly recognised by some. For example, Bhalla (1991) remarks: "....In addition to macroeconomic policy instruments, both governmental and non-governmental institutions play a crucial role in the accumulation of technological capacity over time.. Yet few institutional studies have been carried out".

Enos (1991) in an important recent study makes the following point (p.2):

"...there are three fundamental components of technological capability - the individual constituents, their organisation and their purpose.....technological capability resides in individuals....operating singly in a technologically complex environment individuals can produce little..they need to be brought together within an institution...(which)..may be a capitalist firm, a family enterprise..a state owned company.."

And then,
In identifying the sorts of institution within which technical skill reside the difficulty is not in enumeration but in making some sense of the list. Contributions to the absorption of technology can be expected from technical schools and professional faculties of universities, from producing firms, from their suppliers, customers and sub-contractors, from government departments, from consultants and laboratories, from specialised companies providing process and equipment design. ..

In fact, one important contribution of innovation studies in the emphasis they put on both intrafirm skills and the institutional environment, has been precisely to distinguish the different roles of these kinds of institution in their relationships to industrial production and to "..make some sense of the list". Again there seems to be a possibility of using the innovation studies framework in relation to developing country issues.

3.2 Technology and Trade

In this final section we discuss links between the approach to trade matters which has developed in association with innovation studies, and the trade concerns of developing countries. The first is an interesting parallelism between a long standing dissatisfaction with conventional trade theories in development economics and some heretical approaches to these questions resulting from innovation studies. The second, is a more specific observation of the role of technological factors in the evolution of export promoting economies. And finally, there are some points on implications for export-oriented policies in developing countries, which relate to so-called "new trade theories".

3.2.1 Parallels

First, the point about parallelism. Development economics has been characterised as an area of economic enquiry which makes a return to the great Classical themes of accumulation and economic growth, and that is of course true. But there is another strand in development economics which is less Classical in inspiration, equally pervasive and perhaps so obvious that it is virtually taken for granted. This is that development economics is always concerned with the problem of changing the relationship of nations to the international economy. This reflects a concern which is often encountered in development literature, that the traditional factor endowments framework of the Hecksher-Ohlin approach, is concerned with static efficiency, and has little to say about matters of growth and accumulation. Note, for example, the following assertion by Sukhamoy Chakravarty:

"..the directional effect of trade on growth, cannot be adequately ascertained within the framework of existing models. In general this does not imply that the traditional argument is faulty on its own premises. What it means is that when the traditional analysis is used to recommend trade as a major engine of growth, one is overstepping the bounds within which precise analysis is generally carried out." (Chakravarty, 1983, our italics).

Chakravarty’s concern is echoed in the innovation literature. Here, too, there is a concern with the sufficiency of factor endowment explanations of trade - which found its first expression in the so-called "Leontieff paradox" (Leontieff, 1953; see for example Hirsch, 1967, pp. 8 ff. for a discussion of the paradox, also Dosi, Pavitt and Soete, 1990). As might be expected, writers in the innovation tradition, find an answer to this putative insufficiency of traditional trade theory in "technology" - especially in the absolute advantages which innovation "leads" generate in trade between developed countries.
From this point of view, it is interesting to compare the quotation from Chakravarty above, with that from Dosi, Pavitt and Soete (1990) on page 13.

Early writers on development also drew on what we might legitimately regard as "technological" arguments. Learning curve arguments were implicit in List's espousal of the infant industry argument as a basis for protectionist policies (List, 1904, German original 1844). Preobrazhensky (1964) addressed the issue, in the course of the Soviet Debate on Industrialisation in the 1920's. In discussing, the choice between importating of means of production and making them at home, he refers to the possibility of "improving and cheapening our own products". (Preobrazhensky, 1962).

In a similar way post-war writers on development frequently rationalised their underlyin dissatisfation with traditional trade theories by appeal to "technology" arguments. Thus Rosenstein-Rodan's "big push" (Rosenstein-Rodan, 1943) and the Nurkse formulation of "balanced growth" policies (Nurkse, 1958, Chapter 1), were both in essence responses to supply side problems of economies of scale. Raoul Prebisch (1950, inter alia) was less specifically concerned with infant industry microeconomic types of argument, but technological factors played a major role in his terms of trade analysis. In the first place, Prebisch believed that the welfare gains from technological change in the world economy would mainly be to the benefit of the Centre. Thus increasing productivity in the oligopolistic industrial sectors at the Centre, which are presumed to have a high degree of control over prices, would mainly result in increased profit margins and increased real wages in the Centre's industries; whereas technological change in agriculture and primary production, where producers are inevitably price-takers, would benefit consumers and user industries, which are mainly in the Centre economies. Differential impacts of technological change also played a more direct role in the alleged tendency of the terms of trade to turn against the periphery, through product innovations (like the development of synthetic materials) which substituted for periphery exports.

The Prebisch inheritance passed to the Latin American "dependencia" school who criticised Prebisch, inter alia, for failing to see that protected industrialisation in the periphery would produce new patterns of technological dependency in the protected industries of Latin America. Technological dependency ensured that the biased distribution in gains from trade which had concerned Prebisch would simply be replaced by a biased distribution of gains from technological change - in an important degree because of appropriation of technologies of production by Centre industries. And, according to the technological dependency school, there were reasons to expect that these tendencies would be self-perpetuating (see for example, Cooper and Sercovich, 1971). There were different ways of accounting for this tendency. A purely descriptive approach, which had little to offer from the normative, policy point of view, simply listed the different ways in which availability of Centre technology would substitute for development of domestic technological capability. A more normative approach (surveyed in Cooper, 1978) focused on reasons why market forces and the institutional context in the Periphery would likely result in "socially" sub-optimal investments in local technology. Both lines of argument were subsequently overshadowed by the empirical researches which showed the existence of considerable domestic technological capability in circumstances where dependistas were predicting its effective absence (eg. Katz, 1987 and Lall, 1984)²⁷.

It is probably fair to say that the early post war intellectual history of development economics, was characterised by a series of swings from interventionist, "delinking" ideas...
to liberal open economy proposals with occasional attempts at superordination and reconciliation of the need of growth and accumulation, and the exigencies of short run allocative efficiency. In these arguments, the technology factor came in repeatedly mainly on the side of intervention and infant industry. In fact, many of the arguments which appear today in the Innovation studies literature relating to trade, have long been present in the writings of development economists.

3.2.2 Export Development and Technological Change

The second link relates to a more specific implication of technology arguments for export promoting policies in developing countries. The essence of the argument is present most clearly in point made by Chris Freeman. Recall, in particular Freeman’s statement about the need which imitative firms have for some sort of compensating advantages. In addition, note his point on the implications of reliance on imitation in international trade (see endnote 24 above).

The significance of these technological considerations in trade as far as developing countries are concerned appears in a set of observations on the different patterns that seem to be emerging amongst economies following export promotion strategies. It appears to be possible, on empirical grounds to distinguish between two “ideal types” amongst export oriented economies. The first type is exemplified by the successful NIC’s, especially South Korea. Korean export performance is well known. The export volume index for manufactures grew at nearly 20 per cent a year for 20 years after 1969. Less well known is that the real wage in manufacturing has also grown at an historically unprecedented rate of approximately 8 per cent per year over the same period. This is approximately the rate of growth of labour productivity so that the shares of wages and capital in value added have remained more or less constant (wages share is about 25 per cent) over the period. Similar, though less dramatic performances were achieved in other South East Asian NIC’s. The second type of export promoting economy may be exemplified by Chile. Here in the period from 1981 to 1987 there was a growth in export volumes at 17 per cent per annum, but in this case the growth was accompanied by a fall in the real wage at about 5 per cent per annum with a very low growth in value added per worker. Plainly this type of growth process has strict limits.

An important difference between these two experiences lies in the success of Korean technological policies and the virtual absence of policy on technology in Chile. The high rate of growth of value added per worker in Korea is (at about the rate of the growth in real wages), is ascribable to cost reduction by new processes, and also - possibly more importantly - by a changing composition of exports to goods of higher value added. In the course of this shift Korean technology imports showed an interesting change in character. In the early phase of Korea’s export expansion, most technology transfers were of a "direct" kind and involved "supplier dominated" sectors. Subsequently the shift in product composition was associated with a shift towards licensing and other forms of "indirect" transfer (Dahlmann and Westphal, op. cit. pp. 127 -128). This shift is what innovation studies would lead one to expect. Of course a critical factor in the Korean case has been the successful local learning processes associated with these indirect technology transfers.

In Chile, with very limited productivity growth, real wage reductions were the only way in which international competition could be met. Both economies would rank fairly high
on the conventional scales of "openness", so that the difference in the behaviour of real wages and other growth characteristics cannot readily be explained by appeal to performance in terms of static measures of comparative advantage. It is, however, quite easy to distinguish between the two cases in terms of technology policy, which has been virtually absent in Chile, but a permanent concern in South Korea. The accumulation of technological capabilities - or what amounts to the same thing - the cumulation of innovative skills, is not merely important from the point of view of aggregate growth; it is also an important precondition for equitable functional distribution of income.

3.2.3 Export Promotion and Barriers to Entry

Innovation studies, as we have seen, strongly emphasise the disequilibrium nature of competition as a search for temporary unique advantages through new products and processes. It is not suggested that short run cost minimisation, which is the central focus of traditional microeconomic theory, is irrelevant to competitiveness, but only that it is an insufficient basis for understanding the behaviour of firms in the real world, and especially in those industrial sectors where technological change is rapid. It is in general conceded that the traditional theory comes closest to explaining actual behaviour in industrial sectors where innovation is slow or absent. At the same time, many authors argue that with the advent of generic new technologies like microelectronics and the biotechnologies, even erstwhile "traditional sectors" have ceased to be non-innovative.

The widespread incidence of innovative competition has been one of the main influences underlying recent reconsideration of trade theory, and especially the incorporation of imperfect competition. Paul Krugman notes:

"...In many industries competitive advantage seems to be determined neither by underlying national characteristics, nor by the static advantages of large scale advantages, but rather by the knowledge generated by firms through R and D and experience." (Krugman, 1986, p.8).

This has the implication that policies for the promotion of manufactured exports from developed countries must be expected to include "strategic" elements - that is, selective state interventions designed to capture larger national shares of the rents accruing under imperfect competition. In addition, promotion of manufactured exports will also involve examination of barriers to entry in international markets characterised by competition between the relatively few. These considerations will weigh more heavily in innovative sectors than in sectors where technological change is slow, and where therefore traditional factor costs will remain important.
4. SOME CONCLUDING REMARKS

This essay does not pretend to have "proved" very much in a strict and scientific way, but it did not set out to do so. Accordingly, these conclusions can be brief.

The main purpose we have pursued is to demonstrate a convergence of interest and concepts in the approach to technological factors in developing countries and in industrialised countries. We have argued that the empirically based tradition of "innovation studies" centred largely on materials from industrialised economies and raising rather fundamental questions about the relevance of equilibrium forms of analysis, has much to offer technology policy studies in developing countries. In particular, a more systematic examination of developing country technology questions against the background of the expanding body of theory in innovation studies could be of great practical value. Intuitively speaking, it is likely that the spin off of ideas will be most rewarding in two main fields: in the study of technology transfers to developing countries; and in understanding the role of technology in export promotion.

The trade point is perhaps the more substantial. The dissatisfaction amongst some development economists, which has - quite correctly - continued despite the recent and probably temporary fashion for a return to concepts of static comparative advantage, is of long standing. Its roots can be traced back to the nineteenth century, and it has been a recurring concern (we have not been able to do full justice to its distinguished intellectual ancestry in this essay). It is a concern which appears to have support from a relatively new area of empirically founded theory - the theory of innovation. That line of enquiry has produced a very similar dissatisfaction with the static theories of comparative advantage, and moreover, has also produced some alternative proposals for policy. These alternatives do not necessarily reject relative factor price policies of the static kind as being irrelevant, but they most certainly put in question the sufficiency of those policies to the processes of economic growth and capital accumulation. If they are correct in this they will have important implications for development policy.
1. "A model which took account of all the variegation of reality would be of no more use than a map at the scale of one to one". Robinson (1962) with a reference to Lewis Carroll, 'Sylvie and Bruno'.

2. Sanjaya Lall has shown in a series of important papers for 1979 onwards, that Indian technological capabilities have accumulated to the point where India is an exporter of technologies. (See, for example Lall, 1984).

3. Dosi, Pavitt and Soete (1990) make the suggestion that Marshallian competition might be a limiting case appropriate to situations in which innovation has ceased.

4. Economic theory has often lagged behind changes in economic systems, or changes in policy. There are many examples, of which the Prebisch justification for import substitution is especially well known. For speculation along these lines about the Prebisch-Singer thesis, see Cooper and Fitzgerald (1989), p.12. More appositely, it is worth noting that changes in perceptions of the innovative process are quite frequently ascribed to historical changes affecting industry structures. See for example Freeman, op cit. p.10, on Schumpeter’s change in view on sources of innovation, in particular his recognition of the role of intrafirm R and D.

5. There are useful surveys in Dosi (1988) and Dosi, Pavitt and Soete (1990).

6. The concept of "quasi-monopoly" as applied to the temporary advantage of an innovating firm, was first used by Vernon. See Vernon,1966.

7. The specifications which follow are drawn in part from the discussion in Dosi, Pavitt and Soete (1990), Chapter 4 on "The Innovative Process", which in turn draws on a large body of theoretical and empirical literature.


9. David makes much wider inferences, going well beyond the idea of localisation: "Choices of technique become the link through which prevailing economic conditions may influence the future dimensions of technological knowledge". (op.cit., p.4)

10. Rosenberg (1982, pp. 120 ff.) broadens the concept to cover "learning by using". The automaticity of the learning process as formulated by Arrow (op. cit) has been strongly criticised by a number of authors by a number of authors, including for example Bell, Scott-Kemmis and Satyarakwit (1982) and Bell, Ross-Larsen and Westphal (1984).


12. In his first formulation of the economics of innovation, Schumpeter was much concerned to explain monopolistic rents from innovations as a return to the entrepreneurship (Schumpeter, op. cit.). In a modern setting, the role of these rents is much simpler to understand: they are perceived by businessmen as the "return" to the (often massive) allocation of resources (like R and D resources) to the production of innovations.

13. The history of industrialisation (and of industrial technology is in a sense an account of sectoral patterns of innovation which change over time: Industrial Revolution innovations in the UK, were centred in the textiles sector itself. Later as the capital goods sector emerged, innovations in textiles machinery and of course in many other types of equipment came more and more from machine making sectors. Further in response to bottlenecks in textile inputs (bleaching agents and dyestuffs in the first instance), the chemicals industry - the first "science-based" sector emerged. The story continues: it is hardly surprising that there should be intersectoral differences in innovation in modern industry which is a product of the historic process.

14. Discussions of these Chapters of Capital can be found in Rosenberg (1982), in an Chapter 2, an essay reprinted from the Monthly Review, 28, July-August 1975. See also Cooper (1971). Marshall also reflects on the emergence of new forms of industrial organisation and their relationship to the application of science to production. (Marshall,1899, Book IV, Chapters VIII and IX).
15. Freeman (1989) points to the relationship between innovation and product differentiation. He describes "defensive" innovation (which is highly R and D intensive, as follows: "Defensive R and D is probably typical of most oligopolistic markets and is closely linked to product differentiation" (p.176).

16. There is an attempt to link the Sylos Labini framework as developed by Modigliani(1957) to explain barriers to entry and intra-industry patterns of competition in Cooper (1974)

17. See Mansfield et al (1981): "It has long been recognised that the costs of imitating new products have an important effect on barriers to entry... (If)...firms can imitate an innovation...substantially below the cost to the innovator of developing the innovation, there may be little or no incentive for the innovator to carry out the innovation".

18. On the importance of incremental improvements to production processes see Enos(1962).

19. In fact, Freeman distinguishes six types. His sixth category, Opportunist strategy is not necessary for our discussion.

20. Freeman may understate the significance of innovation in the traditional sectors, or at least, the technological pressure under which such firms have come, especially in recent times. Traditional firms are generally "supplier dominated", and may from time to time be faced with a critical need to adopt new technologies as a matter of survival (or as an interim measure to drive costs down as far as possible by real wage reductions). This is evidently happening in a number of sectors because of the incidence of new microelectronic control systems, which widen the range for mechanisation (see Hoffman, 1981) for a discussion of the garments industry).

21. An early attempt to specify "Channels and Mechanisms of Technology Transfer", which draws this distinction is in Cooper and Sercovitch (1971). There is a survey of literature on this question in Stewart (1981).

22. There is some evidence that European technology supplier firms to Indian industry are increasingly sensitive to the creation of potential competitors, especially in view of increasing competitions from the NIC’s in their (European) home markets. On this see Cooper (1988). But Bell and Scott Kemmis (1988), express doubts on whether this is true of British firms.

23. "It is obvious that there is no room in economics for long chains of deductive reasoning" (Marshall, 1890, edition 1966, p.644). It is a little unclear whether Marshall intended this as a statement of fact or as a normative judgement. As a statement of fact, it has not been borne out by recent developments in economics, many of which bear witness to a willingness to pursue long chains of deduction, to the almost total exclusion of embarrassing facts. Since Marshall was well aware of the methodological weaknesses of economists, it seems to me more reasonable to regard this as a normative statement - a stern warning in fact.

24. An important qualification to this is implicit in Freeman’s further remarks that: "Unless imitators enjoy significant market protection or privilege they must rely on lower unit costs of production...", and, in relation to innovative strategy in developing countries: "...even a successful imitative strategy, although it may lead to industrial development, will reach a point where export competitiveness in labour costs may increasingly conflict with the goal of higher per capita incomes..." (op. cit p. 170 and p.184). For a development of these arguments applied to trade patterns see later.

25. See for example Dahlmann and Westphal (1982), and Bell (1982) for a review of some of these. Also Dahlmann, Ross-Larsen and Westphal (1987)

26. A particularly interesting recent excursion into this intellectual terrain is in Martin (ed), (1991). See particularly the introductory essays by Martin and Fitzgerald.

27. And subsequently, arguments about tendencies to sub-optimal investments as a justification for interventions by a social welfare state, were largely brushed aside by the crude empiricism that "bad markets are better than bad governments". This of course is just as impossible of proof as was the crude delinking argument of the Descriptive dependency school.


30. Note the particularly interesting remark in Dahlman and Westphal (1982), p. 128: "...Korea’s recent experience in promoting technologically successful industries...may involve greater reliance on licensing as a way of acquiring technology... (It) remains possible to substitute for licensing by replicating foreign technology through local effort...".
BIBLIOGRAPHY


Freeman, Christopher (1982), "The Economics of Industrial Innovation" (2nd edition), Francis Pinter. London.


Katz, J., and Ablin, E. (1979), "From infant Industry to Technology Exports: the Argentine Experience in the International Sale of Industrial Plants and Engineering


