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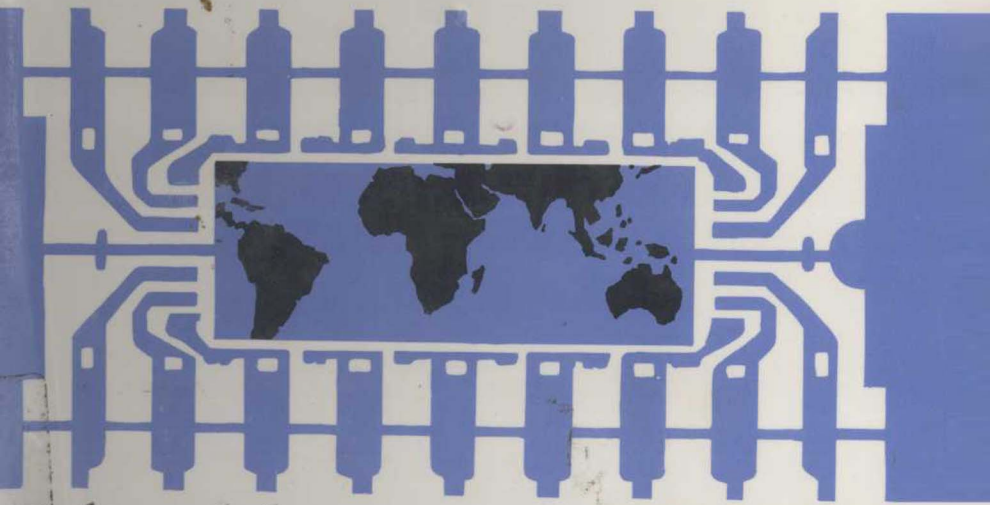
Technology and Innovation in the International Economy



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Technology and Innovation in the International Economy

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Foreword

This book deals with some important aspects of the impacts of new technologies on economic and social development, especially in the Third World. It presents materials which played a significant part in the early evolution of a new policy research institute set up in the Netherlands by the United Nations University, and which have subsequently been revised and brought up to date.

The United Nations University Institute for New Technologies (UNU/INTECH) was established by the Council of UNU in October 1990 as a Research and Training centre devoted to the economic and social implications of new technologies. The Institute is funded through income from an endowment fund generously contributed by The Netherlands Ministries of Education and Science and of Development Co-operation, and by the Government of the Province of Limburg. The Institute is housed in an excellent building provided by the City of Maastricht. It has a small resident research faculty mainly from developing countries engaged in research projects which typically involve networks of Third World Institutes and individual scholars.

Since the 1960s, technological advances in microelectronics, biotechnology and other disciplines have had far-reaching impacts on a broad range of production and service sectors, and innovations have transformed many sectors of the global economy. For developing countries, these new technologies present both a threat and an opportunity. On the one hand, their adoption in industrialized economies can reduce or eliminate the already slim competitive advantage enjoyed by developing countries, which is based mainly on low-wage production. On the other hand, adoption of new technologies can offer the less-developed countries (LDCs) opportunities for rapid and flexible production, which can be the basis for expanding exports and growth of higher productivity high-waged, skilled employment

opportunities. This latter pattern is exemplified well by the experience of some of the newly industrialized countries (NICs) in the 1980s.

The UNU/INTECH research will attempt to confront this duality. It will seek a better understanding of (1) the implications of new technologies for development strategy and industrialization policy; (2) the factors that influence diffusion of new technologies to developing countries; and (3) the impacts of new technologies on socioeconomic variables, such as output, trade, employment and distribution of welfare. Improved knowledge in these areas will provide the information that the LDCs need to develop sustainable economies, generate industrial capacity, improve their global competitiveness, and, ultimately, reduce poverty and improve people's welfare.

To address these issues, UNU/INTECH's programme comprises three principal components: (1) research; (2) advanced academic training; and (3) information dissemination. During its first biennium, the Institute's activities have centred around two main goals: development of its research and training programmes, and establishment of an institutional infrastructure in which those programmes could be carried through.

The focus of the UNU/INTECH research programme was worked out in the course of a feasibility study. It includes: work on the economics of technological change, innovation and diffusion, particularly in industry in the developing countries; studies on the politics of technology policy; and studies on how technological change influences the division of labour in society and in productive activities — especially related to womens employment.

The chapters of this book originate from work started in the feasibility study period, which has subsequently been updated and considerably developed. The first chapter, by Charles Cooper, deals with recent developments in the economics of innovation and diffusion of new technologies, and attempts to build a bridge between the study of Technology in the industrial sectors of developed countries — and the type of technology policy needed in the developing countries. Chapters 2 and 3 deal with particular fields of new technology. Chapter 2, by Martin Fransman, examines biotechnology; Chapter 3, by Jeffrey James, looks at microelectronic technology. Both are

reviews of the literature on the diffusion and economic impacts of these technologies in the international economy.

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1. Relevance of Innovation Studies to Developing Countries

Charles Cooper

1.1 INTRODUCTION

Studies of industrial innovations in industrialized countries, and similar studies in developing countries, tend to be done in isolation from one another. The isolation is not total, of course: there is a small number of authors for whom the relevance of studies of innovation in industrialized countries to the situation in developing countries is virtually taken for granted - see for example Katz (1987) or Pack and Westphal (1986). Nevertheless, the isolation is sufficiently noticeable in academic writing, to raise the question whether researchers concerned with technology policies in developing countries might not benefit from a more systematic exploration of what have been called 'innovation studies' (Dosi, 1988). The purpose of this chapter is to map out the territory of 'innovation studies' that could be useful in research on developing countries. This chapter attempts to relate studies on innovation and technological change in developed countries and those in developing countries. It also attempts to connect technology studies to the broader stream of development economics.

By their nature, maps are imperfect reflections of the scale and detail of underlying reality. That, as Joan Robinson once pointed out, is their whole point.[1] 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 drawn in this article is vulnerable to those criticisms, for it is the outcome of a preliminary reconnaissance, and not a comprehensive survey. If that

is so, we must hope that it at least reveals those parts of the terrain worthy of further exploration.

There have of course been good surveys of the issues of technology policy as they relate to developing countries. A particularly valuable, and quite recent, one by Martin Fransman (1986) covers part of the area of this chapter, but not all.

This chapter is set out as follows. The next section is a summary and discussion of recent literature on innovation in industrialized countries, which focuses on attempts to synthesize 'innovation studies' into a coherent theory. The theoretical structures that emerge from 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.

The subsequent section then deals with the possible relevance of this body of theory for developing countries. It addresses two questions. The first is how relevant are innovation studies to processes of technological learning in developing countries.[2] The second is how important is technological change in the trading relations of developing countries. The final section draws conclusions.

1.2 INNOVATION AND TECHNOLOGICAL CHANGE

The microeconomic processes involved in the adoption of innovations, which we are inclined to describe today as Schumpeterian, were, it seems, clearly recognized by Classical economists. In his chapter 'On Machinery' in the *Principles of Political Economy*, Ricardo (1830; edition 1971) 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.
>
> (Chapter XXXI, pp. 378-379)

Marx expanded considerably on this notion in Book One of *Capital* (Marx, 1858; edition 1961, p. 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, then

> 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. ... If therefore the capitalist who applies the new method sells his commodity at its social value ... he sells it ... above its individual value (i.e., cost) ... and thus realises an extra surplus value.

In both of these accounts, 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) essentially concerns 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 the production of the means of production). The basis for this conclusion is that innovations in general ultimately leave the 'rate of surplus value' unaffected due to the reassertion 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 'Entrepreneurial 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 entrepreneurship, he placed considerable emphasis on the tendency of the industry to return to equilibrium. 'The second act of the drama' of innovation (op. cit., p. 131) comes when imitators enter production, thus 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 *reorganization* takes place in the reestablishment of an equilibrium might suggest that Schumpeter had in mind a more considerable process of adjustment than that described by Ricardo or Marx; but the return to equilibrium is still the keynote.

Subsequently, however, Schumpeter's thinking moved towards 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 reestablishment of equilibrium is preempted 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 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: that is, 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 cost of production is largely overshadowed by the process of competition between technologies.

The second major difference between 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 preempt the attainment of microeconomic equilibrium altogether.

Christopher Freeman puts these points in the following terms:

> In Schumpeter's framework it is disequilibrium, dynamic competition ... between entrepreneurs, primarily in terms of industrial innovation, which forms the basis of economic development.
>
> (Freeman, 1989, 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 such as electronic capital goods, chemicals, pharmaceuticals, biotechnology, and the like. This explanation may seem less convincing in what development economists often call the 'traditional' sectors. Nevertheless, as I will argue later, even here innovative competition occurs, mainly in the form of adoption of innovative plant and equipment originating in the capital goods sector.[3] 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 (i.e., 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 (i.e., twentieth-century) industrial economy than they were, say, during and after the Industrial Revolution. The emergence of Schumpeterian thinking may reflect — with a considerable time-lag, of course — historic changes in the nature of competition itself.[4] 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 firms' behaviour[5] 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.[6] The idea that firms continually search out innovations in this way has been shown in a seminal study by Nelson and Winter (1982) to generate a plausible explanation of economic growth processes.

There has, of course, been 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 for more in-depth discussion:[7] (1) the idea that technological change is *localized*; (2) the notion that innovation at

the level of the firm is the outcome of a *cumulative* process; and (3) the different incidence of factors determining the *appropriability* of new technologies. After discussing these three elements, which primarily concern 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.

The idea that technological change may be *localized* was put forward in a theoretical article by Atkinson and Stiglitz (1969), who contended that a localized 'bulge' in the neoclassical industrial production function may represent technological change better than simply a 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.[8] At the same time as Atkinson and Stiglitz, Nathan Rosenberg (1969) put forward an economic historian's empirically founded notion of localization. These ideas were subsequently used by David (1975), who proposed an explanation of localization 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.[9]
>
> (David, 1975, p. 4)

It is helpful, at this stage, to keep in mind that learning *cum* localization 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 localization within the particular technological fields relevant to the industry's production activities. There are many cases in which different patterns of localization coexist. An example is the simultaneous emergence of the Apple Macintosh computer system and the IBM PC system; another is the coexistence of several different methods of 'catalytic cracking' in various major chemical firms during the 1970s. Sometimes one or more of the competing variants on the basic technology will prove to