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Introduction

Once upon a time, so international trade theorists like to tell each other,[1] there was paradise, where everybody lived efficiently, producing and trading whatever was demanded in the most efficient combination. Then an angel came and stamped a different colour on each one's forehead, you could say a national flag, allowing him or her to produce and trade only with capital and land having the same colour. The diaspora which followed led to large differences in efficiency across the world, with a huge world welfare loss. Since that unhappy moment, trade theorists – by definition economists with a world rather than national welfare vision – have been trying to show how to return to this paradisiac situation.

The first main direction of analysis, returning to classical economics, attempted to show how despite a country's poor efficiency, there could nevertheless be gains in welfare by specialising in those products/industries in which the country was, relatively, most efficient. Such gains were by and large based on the principles of division of labour applied to an international world. The *neo*-classical extension of this line of analysis introduced 'factor endowments' to explain a country's comparative advantage and establish a number of crucial links with factor-price equalisation, income distribution and growth. In terms of our parable, it could be said that trade theory illustrated how paradise could be re-established through free trade all over the world, despite national differences in 'factor endowments'.

Whatever one's views on the success of the 'traditional trade theory' explanations of trade flows and gains from trade, it is difficult not to be surprised by the large amount of trade flows which do not fit such trade explanations, and by the relatively limited nature of the estimated gains

from opening up to free trade (such as in the case of the European Common Market or the Canada–United States free trade agreement) compared to the significant structural trade gains obvious to anyone.

A second 'new' line of analysis, developed over the last ten years, started from a fundamentally different assumption, namely that most economic activities are characterised by increasing, rather than decreasing, returns. In other words, gains from trade are, in the first instance, the result of the scale economies that each national economy can achieve through free trade, whether applied to a small country such as Luxembourg or to a large one such as the United States. These gains are far more significant than traditional trade theory would lead one to believe. Many empirical studies within the 'new' trade theory tradition have pointed towards the significance of such gains (Smith and Venables, 1988; Harris, 1984; Cox and Harris, 1986). Just as in large nations, where particular activities have been concentrated in particular locations – Krugman's favourite example being mushroom production in Pennsylvania – paradise for the world as a whole can be achieved by bringing resources together, whether it be motor car manufacturing in Japan or ceramic tiles in Italy. The advantages accruing to the region or country from the 'agglomeration' of a particular set of activities, are of little importance as compared to the advantages accruing to *every* world consumer of the efficient exploitation of world economies of scale.

In this book, we concentrate on a different, i.e. third, stream of analysis. Compared to the 'new' trade theories discussed above, we place greater emphasis on the dynamics of increasing returns, particularly those associated with production technology and innovation. In terms of our parable, to the extent that technological development and growth are irreversible processes, there is no possible return to paradise: like virginity, once lost it is lost for ever. As emphasised in many locational theories, the main reasons concern the way in which industrialisation locations are 'selected' early on and how, by appropriating the available agglomeration economies, they exercise some 'competitive exclusion' – to use Arthur's (1988, 1989) term – on other locations. In other words, from a dynamic technology perspective it does matter whether a region or country is specialised in mushroom production or in silicon chips. By focussing on these dynamic 'learning' features, our analysis falls within the 'evolutionary' framework (as broadly set out in Freeman *et al.* (1982) and in an earlier book edited by Dosi, 1988), which also takes as one of its starting points the substantial evidence and insights brought together within a relatively large body of literature on the nature and process of technological change and innovation.

Is there no 'normative' world paradise to be attained in our vision

of the world? To some extent the answer to that question is 'no'. The normative counterpart of our analysis brings to the forefront the crucial role of history, of 'man-made' interventions, of institutions, of particular international investment decisions, of 'multinational' corporations, etc., of the whole spectrum of individual and collective decisions made in a complex system such as the international economic environment.

The analysis presented in this book, which is reflected in the title, thus *starts* from differences of technological capabilities and innovativeness between countries and then focuses on the effects of such differences on international patterns of trade and growth. By technological capabilities we mean the skills and knowledge necessary to develop, produce and sell products; by innovativeness we mean the actual realisation of that capacity to generate and commercialise new and better products and production processes. Innovations are produced by innovative activities, in which technology is both an input and an output.

Both historians and practitioners in industry and government are well aware of the significant influence of technology and innovative activities on international competitiveness, and on the relative efficiency and income of firms, regions and countries. From the most recent OECD, EC or UN document to the various individual countries' international think-tank recommendations, the importance of technical change as a 'chronic disturber of existing patterns of comparative advantage' (Johnson, 1975), as well as an essential factor in the achievement of the necessary adjustment to structural change resulting from technical change itself, is well recognised.[2] In a similar way, the most recent Economic Report of the President recognises the increased 'international scope of science and technology' over the 1980s and subscribes to the view already expressed ten years earlier in the Report on US Competitiveness, directly linking the erosion of the international competitiveness of the United States over the 1960s and 1970s to deficient investment in innovative activity in the United States as compared to its major industrial competitors.[3]

Despite what one may think on reading many traditional trade contributions, many economists over the past thirty years *have* become increasingly aware of the importance of technology and innovation, often partly as a result of empirical studies on the determinants of economic growth and trade performance. While some significant progress has been made in empirical studies in this area over recent years, analysis has remained constrained by two major difficulties: inadequate data measuring innovative activities, and problems with the broad theoretical framework representing the characteristics of such activities and their impact on the economy.

With regard to the latter, as Vernon noted in his introduction to the influential readings on *The Technology Factor in International Trade*: 'Researchers have an extraordinary capacity to screen out the evidence that does not fit well with their preconceptions; to relegate uncomfortable observations to the dustbins of the unconscious; or, better still, to reshape the observations so that they may be perceived in a way that eliminates the discomfiture.'[4] Twenty years after Vernon's remarks, a good deal of analysis on technology, growth and international trade has a 'reductionist' flavour, attempting more often than not to squeeze genuine dynamic problems of innovation, learning, uncertainty and change into the more familiar cloth of endowments, relative scarcities and optimisation under budget constraints.

Notwithstanding the impression of naïvety conveyed in our opening parable, there is in our mind no doubt that one of the great achievements of economic analysis has been the formulation of rigorous and coherent theories of international trade and investment. In essence, these are theories of general market equilibrium extended to explain trade in goods and exchanges of productive agents between countries. The critical insight they contain is that the direction of trade in different commodities, or the movement of productive agents, is to be explained by the existence of differences in autarky price structures, differences which free trade eliminates. In turn, different autarky price structures are to be explained by appropriate combinations of intercountry differences in consumer preferences (including the willingness to save), in process technology, and in stocks of productive agents, labour, capital goods, etc.

Certainly, the two sets of traditional trade theory (classical and neoclassical) differ in their emphasis as to the origin of price differences. The Ricardian theory stresses international differences in technology in conjunction with international differences in real wage levels, while the Heckscher–Ohlin theory assumes the international identity of tastes and technology, tracing the origins of trade to given differences in endowments of productive agencies. Non-trivial propositions may be derived concerning the determinants of the terms of trade, the distribution of the gains from trade, and the costs and benefits of policies to restrict trade. Moreover, the effect of hypothetical changes in tastes, technology and resources on these dimensions of a trading world is readily deduced. However, a critical deficiency of these theories is their treatment of technological data as exogenous to the economic system and, consequently, their failure to offer any understanding of the fact that changes in technology are properly to be viewed in terms of an economic process.

New trade theory (Krugman, 1986; Helpman and Krugman, 1985, 1989) has added an important qualification to these, by now well-

established, theories, namely, that for the most simple of theorems to hold, some of the basic assumptions of perfect competition and decreasing returns were essential. The many cases of imperfect competition and increasing returns analysed under the umbrella of 'new' trade theory have led to a plethora of 'new', sometimes reversed, sometimes similar, results with respect to gains from trade, income distribution, etc. One of the most damaging normative results for traditional trade theory has undoubtedly been the illustration by Brander and Spencer, 1983, 1985) that free trade might no longer be the only world maximum welfare gain policy, but that a 'strategic' trade policy might in some cases be justified and actually needed. As Dixit pointed out in his contribution to Krugman's book on strategic trade policy:

> Recent research contains support for almost all the vocal and popular views on trade policy that only a few years ago struggled against the economists' conventional wisdom of free trade. Now the mercantilist arguments for restricting imports and promoting exports are being justified on grounds of 'profit sharing'. The fears that other governments could capture permanent advantage in industry after industry by giving each a small initial impetus down the learning curve now emerges as results of impeccable formal models. The claim that one's own government should be aggressive in the pursuit of such policies because other governments do the same is no longer dismissed as a non sequitur. (Dixit, 1986a)

Such strategic trade theories have undoubtedly brought to the forefront many features which appear, at least at first sight, to be of particular relevance to analyses of technical change and international trade. The importance of monopoly rents, of profit sharing and strategic trade manipulation indeed seem of particular relevance to many high-technology industries. Furthermore, the actual emergence of these new theories on the US academic scene occurred at a time of increasing fear in the United States of the Japanese challenge in trade and technology (Mowery and Rosenberg, 1989).

As we illustrated in the opening parable of this book, there is undoubtedly more affinity between a more realistic trade theory, such as 'new' trade theory, and the view presented here. At the same time, it is difficult not to remain rather critical about the way the technology factor has been introduced in such theories (see a.o. Aghion and Howitt (1989), Helpman, 1990a and b). The interpretation given to technology in the new trade vision remains in our view relatively far from the complexity of the process of technological change and innovation as described in Chapter 4. The simplicity of the way technological change is reduced either to 'learning curves' or to the generation of new intermediate inputs under monopolistic competition in 'new' trade theory is to some

extent reflected in the simplicity of some of the policy recommendations.

For us, technology plays a major role in two fundamental topics pertaining to economic analysis: (i) the problem of coordination and interdependence between agents and, by implication, between countries; and (ii) the patterns of change and transformation of each economy. Classical economists saw both questions as essential ones. One of their major analytical tasks was to explain the determinants of, and the possible regularities in, the dynamics of modern economies and, using the same theoretical framework, also to explain the pattern of allocation and the related coordination of economic activities that would produce relatively ordered and efficient outcomes from a multiplicity of decisions of individual agents. They were clearly only partly successful in making the link between such explanations of dynamic patterns and the analysis of (static) allocative mechanisms. None of them really produced a rigorous model of interaction between agents which yielded those macroeconomic 'laws of change and transformation' in which they were so interested. Moreover, their investigation was essentially developed in terms of a closed-economy model.

The main classical economist to undertake explicitly the task of analysing the open-economy case in a rigorous manner was Ricardo. His main concern was, however, the short-term mechanism and efficiency properties of the international allocation of productive activities, whenever one would allow foreign trade to take place. In his famous example of England and Portugal trading cloth and wine, he illustrated that even when a country is characterised by absolute advantages (i.e. higher production efficiency) in both commodities, the mechanism of comparative advantages would yield patterns of trade beneficial to both partners. Clearly, major international technological differences appeared in the background of the analysis, in the form of country-specific advantages/disadvantages in their input coefficients. However, neither Ricardo nor, for that matter, the other classical contributors tried to answer the more fundamental *dynamic* questions such as: Where do absolute advantages come from? What are the effects of these absolute advantages/disadvantages upon the levels and rates of growth of income? What is the relationship between the allocation of resources stemming from a given pattern of absolute advantages and the long-term evolution of the latter?

Within neo-classical theory, on the other hand, the analytical attention focussed upon the issue of coordination/interdependence between the agents, elegantly formalised under highly simplified hypotheses on the nature of the technology and the behaviour of the agents. The theory of international trade became one of the sub-headings of the general model – General Equilibrium Analysis – confined to the original

Ricardian question, namely: what is the pattern of comparative advantage in the allocation of productive activities between countries and what are its efficiency properties? Not only that: the standard neo-classical answer to the question ruled out *ex-hypothesi* the existence of international technological differences. Trade patterns were simply explained by the relationship between factor endowments and factor intensities. In the standard model, 'technology' appears only as the exogenously given form of the production function. Moreover, even when technological differences between countries were allowed into the model, one hypothesis had to be retained, namely the existence by assumption of a generalised market-clearing process, necessary to the explanation of equilibrium prices and quantities in terms of relative scarcities.

Within such a framework it is hardly possible to accommodate dynamic, evolutionary questions related to change and transformation, other than by means of a reduction to exercises of comparative statics between different equilibrium positions. As mentioned above, in its essence the Heckscher–Ohlin model of international trade is nothing but a particular illustration of an open-economy general equilibrium, with all its usual assumptions, restrictions and beliefs. As Lerner (1953) put it:

> The constructions ... apply to any kind of trade, between individuals, towns, regions, countries and continents as well as between social classes or between people at different points in time; and ... it is only historical accident of the development of the Economics Theory that all these problems are called 'International Trade'.[5]

Prevailing contemporary economic theory, facing the two 'classical problems', concerning (i) the mechanisms of coordination and interdependence between the agents, and (ii) the pattern of transformation of the economy, addresses mainly the former and tackles it with elegance and rigour, formulating its underlying assumptions without any reference to technological and behavioural evidence.[6] This applies even more so in relation to the international context. There are probably few pieces of prevailing economic thought that are in more direct contrast with available empirical evidence than the hypothesis of identical production functions across countries.

One can also easily see the intrinsic difficulty of accommodating a reasonable account of technological progress into prevailing economic theory: How can we maintain a notion of 'scarcity' when technical progress concerns, precisely, a continuous improvement in the productive efficiency of the inputs? Does the model make any sense in explaining trade between countries that are often characterised by excess supply of

labour or labour and capital? How can one account for the fact that differences in innovativeness are often much more important than primary endowments as determinants of trade flows?

But it is at the empirical level in particular that the difficulties of the traditional trade view appear, as already indicated above, most serious. After Leontief's well-known findings that the total capital intensity (direct plus indirect capital content, via input/output flows) of US exports was lower than US imports,[7] a good deal of research effort went into the attempt to explain away what was curiously termed a 'paradox' instead of the, probably more accurate, description of a 'falsifying test' of the endowment theory.[8] In a sense, 'neo-factor proportion' theories, which added some technology-related variables to the list of primary endowments, became the conventional analytical answer to 'facts' which did not conform to the 'endowment theory' in its original and cleanest form.

Until the late 1970s, nearly all empirical tests of 'neo-factor' and 'neo-technology' trade theories for industrially advanced countries were based on country-specific, cross-sectoral trade data, together with measures of technology intensity derived from sectoral patterns of research and development (R&D) expenditures in the United States. This form of analysis was dictated largely by the inadequacy of R&D statistics, and of other measures of innovative activities, across country, sector and time. Unfortunately, it meant that theories that explained sector-specific differences between countries were tested with data that measured country-specific differences between sectors. It also meant that the sectoral patterns of R&D intensity in the United States were generally assumed to hold in all countries, and to reflect technology intensity in all sectors accurately.

Since the late 1970s, systematic data on innovative activities have improved considerably, as a result of three interrelated factors: first, the painstaking activities of the OECD in developing internationally comparable time-series on R&D activities; second, the 'science indicators' movement, which was instigated in the United States through the National Science Board, with the purpose of exploring and improving a wide range of statistical indicators of scientific and technological activities; and third, the pioneering activities of academic and commercial organisations in developing systematic counts of scientific papers, citations, innovations, etc.

As a result of this progress, the inadequacies of previous data and analysis not only became clearer; the opportunities for more complete, satisfactory and novel analysis also became greater. In particular, it became possible to test the sensitivity of the results of empirical analyses to the use of different measures of technological activity, and to undertake more ambitious statistical analyses based on the rich and detailed data on other science and technology indicators.

In this book we make detailed use of this evidence within the framework of a theoretical analysis of innovation, trade and growth, which differs in some important respects from most traditional analyses.

First, we share Nelson's (1981a) concern, in particular that the widely accepted representation of 'technical progress' as a shift in the production function resulting from disembodied or embodied technical change inadequately represents the more complex and interesting reality that emerges from a variety of industry and firm-based studies, as well as from the more systematic international evidence now available. It is, as we have already indicated above, a popular economic assumption to represent technology as exogenously generated and applicable either as information or embodied in producers' goods. In most sectors, however, technology is generated endogenously; it is often firm-specific, differentiated and tacit in nature; and is practically, by definition, cumulative in development.

Second, we reject the assumption that the generation of technology is independent of investment and production. In most sectors, it is strongly dependent on them.

Third, the assumption that firms' technical choices are exogenously determined and optimal is rejected in favour of the proposition that such choices are generally discretionary and non-optimal, given the impossibility of foreseeing the nature and likelihood of all possible future technological and market developments.

The implications of these and other discrepancies between traditional 'economic theory' assumptions and what we view as the 'stylised' empirical reality have already been the subject of the book *Technical Change and Economic Theory* (Dosi *et al.*, 1988) in which two of us participated. Building on some of the contributions in this book, and on Nelson and Winter's celebrated evolutionary theory of firm behaviour and economic change (Nelson and Winter, 1982),[9] as well as on some of our own earlier work (Dosi, 1982; Pavitt, 1984; Soete, 1981a; Dosi and Soete, 1983, 1988; Pavitt and Soete, 1982),[10] we attempt in this book to develop a model of trade, the fundamental features of which are international technology gaps, reflecting superior and inferior techniques and what we will call cost-based adjustment mechanisms. International differences in innovative capabilities, in the sources and uses of innovations, in corporate strategies and institutional conditions contribute to determine these gaps. In turn, the latter are, we will argue, of fundamental importance in explaining the participation of each country in international trade flows, and international differences in income levels.

From a microeconomic perspective, we believe, a satisfactory theory will need to be based on assumptions, on behaviours and on the characteristics of technology, innovation and competitive processes that can account for the prevailing observed behaviour at the level of the firm, and the observed characteristics of the pattern of international trade. In our view, the key features of such a theory must be as follows:

- Technological decisions in firms are not generally about adjustment along a given and widely accessible production function, but, rather, about movements to techniques that are superior under almost any income distribution and relative prices, and to products characterised by superior performances.
- Movements by firms to these superior techniques are not automatic, given that techniques are generally firm-specific in nature, and are both cumulative and uncertain in their development.
- Patterns of strategic interactions on international markets are generally influenced by an *asymmetric* distribution between firms and between countries of technological, organisational and financial capabilities.
- Static and dynamic efficiency are not necessarily simultaneously compatible with certain behavioural patterns and economic signals.

In many ways, the emphasis of our analysis is opposite to the conventional one. As argued in greater detail in the next chapter, the century of economic discussion which has focussed primarily on allocative optimality *for given techniques* has obscured the importance of differences in techniques and product characteristics between countries, and has neglected the analysis of their origin. It is quite evident, for example, that the wide international differences in per capita income stem primarily from the joint effect of differences in the degrees of capital accumulation and differences in technology rather than from differences in relative prices only (or 'distortions' in the price mechanism).

However, the investigation of these phenomena developed separately from trade theory, which until recently did not take technology gaps as one of the fundamental facts from which to begin theorising. This, as we indicated above, applies in different ways to both 'classical' and neoclassical theories. For the validity of the most general theorems such as international factor-price equalisation to hold, the latter excludes from the core of the model the implications of straightforward inferiority/superiority of techniques between countries. The former allows the existence of such international technological differences, but – as in the 'neo-Ricardian' reformulations[11] – takes a rather general and agnostic view, describing the equilibrium specialisations, irrespective of the nature of the techniques available in each country.

In this book we will discuss some hypotheses on the determinants of trade flows in those cases, which evidence suggests are rather widespread, where techniques and product-technologies can be univocally ranked, irrespective of domestic income distribution and relative prices.

Technology gaps, we will argue, are of paramount importance in determining the participation of each country in international trade flows and, through that, the maximum levels of income that each country can attain, compatible with the foreign balance constraint. Our empirical results, admittedly based on highly imperfect data, point to the dominance of a set of absolute advantages over the factors pushing towards comparative advantages and specialisation. In other words, the international composition of trade by countries within each sector appears to be essentially explained by technology gaps, while comparative advantage mechanisms appear to be of lesser importance.

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. However, the 'virtuous circle' between technological levels, foreign competitiveness and domestic growth is not entirely automatic and endogenous to the process of economic development. As we will argue at length, country-specific and sector-specific innovative or imitative capabilities can be isolated as one of the single most important factors which originate these 'virtuous circles' and contribute to explaining the patterns of international convergence or divergence in terms of trade performance, per capita incomes and rates of growth.

From such a perspective, 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. The latter are indeed once-and-for-all gains, by their very nature: their dynamic relevance, if any, concerns the link between the 'static' pattern of allocation and the long-term performance of the economy.

Here again, a close link between the analysis presented in the following chapters and 'new' trade theory can be envisaged. Indeed, the characteristics of technology and innovation that we describe below, generally imply forms of industrial organisation that differ from perfect competition and, hence, also 'strategic' behaviours by individual agents. However, contrary to 'new' trade theories, which often assume 'equilibrium' interactions amongst symmetric agents, our argument will be consistent with more 'evolutionary' microfoundations, whereby firms with different technologies and organisational traits interact under conditions of persistent disequilibrium.

The empirical findings presented in Chapter 3 are broadly consistent with the theoretical model. The most important conclusions can be summarised as follows:

1. A variety of science and technology measures – R&D, patenting and innovation counts – gives a consistent picture of the aggregate international distribution of innovative activities among countries. Innovative activities are concentrated in relatively few countries. Although there have been significant changes since the beginning of this century in the relative importance of these countries, there has been only one major newcomer to the group – Japan.
2. International differences in innovative activities are reflected in differences in shares of world exports in most sectors, and in manufacturing as a whole.
3. Export performance is positively associated with differences in per capita innovative activities and differences in labour productivity.
4. Changes in trade performance are more strongly associated with changes in innovative activities than changes in relative labour costs.
5. Since the beginning of the century, international differences in per capita income have been closely related to international differences in per capita innovative activity. International differences in the rate of growth of per capita income have been associated with similar differences in the rate of investment and in the rate of growth of innovative activities.

We are only too well aware of the imperfections and gaps in our analysis. Both the theoretical model and its empirical test can be extended and improved. More attention needs to be devoted to the characteristics and mechanisms of the international diffusion and adaptation of innovation, and to identifying the determinants of international differences in technology and, in particular, in the level and pattern of innovative activities. On a theoretical level, a major effort is still required to develop a complete theory of the relationship between the international pattern of economic change, and its microeconomic, 'microtechnological' and institutional foundations.

After half a century of unchallenged rule of neo-classical trade theory, the 1980s has led to a revolution in thinking about the determinants of international trade flows and the gains from trade in a world dominated by imperfect competition and increasing returns. This revolution is far from over. It has led to the laying out of an alternative, more realistic, but still primarily static framework, within which international trade flows should be studied. The first dynamic models in this area are now being developed (see, e.g. Grossman and Helpman, 1990a and b; Markusen, 1990). Coming from a completely different analytical perspective, the economics of technological change, we hope to provide here some first building blocks for a more complete dynamic picture of the interactions between technology, trade and growth.

For our part we hope that the 1990s might see a further change in ways of thinking of the dynamics of international competitiveness, technology and growth. The issue of the internationalisation of technology has to some extent only come to maturity in the 1980s. It is now high on any policy agenda,[12] with frequently challenging questions put to both the economic theoretician and the empirical researcher. By concentrating on some of the empirical measurement issues and on the, in our view, essential consistency of theoretical assumptions with empirical observation, we also hope to provide some first responses to these new policy challenges.

Notes

1. The parable is from Paul Krugman, who quotes Paul Samuelson.
2. In the OECD Report's words:

> Both the need for adjustment and the possibilities of achieving it are strongly influenced by the underlying pace and directions of technological change, by its rates of diffusion within different national economies, and by the ease with which the technology is transferred from one country to another... . The countries of the OECD have become partners in a world system of dynamic interdependence based upon continued innovation and the unimpeded flow of technology within and across frontiers. In such a system, successful adjustment will depend on the ability of governments to mobilise the inventive, entrepreneurial talents of their people by creating an appropriate climate for technological innovation. (OECD, 1979, p. 44)

3. According to the Report of the President on US Competitiveness:

> Many indicators of U.S. trade competitiveness such as export market shares suggest that there has been an erosion of U.S. competitiveness in world markets. The increased international competition facing U.S. producers is mainly the result of changing world resource supplies and technological capabilities. Because of higher rates of growth in investment and expanded research activity in other countries, the United States has experienced a relative decline in its trade performance over the past two decades even though the level of U.S. exports has increased substantially in recent years. (US Department of Labour, Report of the President on US Competitiveness, 1980, pp. 1.1, 1.2)

4. Vernon (1970), p. 2.
5. Lerner (1953), also quoted in De Marchi (1976).
6. An important exception is the so-called 'new' growth theory; see also Romer, 1986, 1987, 1990 and Lucas, 1988.
7. See Leontief (1956).
8. As argued, among others, by Leamer (1984) and Deardorff (1984), it is true that Leontief's analysis is incomplete as a rigorous test of the Heckscher–Ohlin–Samuelson model. However, it is equally certain that 'The Leontief

test, though not perfectly controlled, is probably about as clear an example of a "crucial experiment" as one is likely to encounter in economics' (De Marchi, 1976, p. 113).

9. Nelson and Winter (1982)
10. Dosi (1984), Soete (1981a).
11. cf. Steedman (1979) and (1980).
12. See for example Ostry (1990) and Mowery and Rosenberg (1989).