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Technology and trade: An overview of the literature

2.1 Introduction

In contrast to many other fields of economic theory, international trade theory has traditionally retained the importance of technical change in explaining international trade flows or the international 'competitiveness' of a country or an industry at the centre of much economic debate. This can be explained to a large extent by the almost unique influence of 'classical' thinking in the area of international trade, with many contemporary trade theorists still expressing doubts (particularly with regard to the technology assumption) as to the actual contribution of 'neo-classical' thinking.

The fact that 'pure' neo-classical trade theory is still so prominent in international trade textbooks and is held in such esteem by policy-makers, at least until the 1970s, has little to do with the way 'factor endowments' (pure Heckscher–Ohlin–Samuelson) trade theory explains international trade flows. Its value as a *descriptive* theory, i.e. national differences in endowments of productive factors form the basis for trade, is reputedly very limited.

Like so many other fields of economic analysis, the old 'strength' of the pure orthodox theoretical framework lies primarily in the relatively straightforward normative implications – in terms of the gains from trade for both trading partners, as well as free trade prescriptions – which can be built around the model. The fact that in order to do so it has to rely on a set of extreme 'heroic' assumptions is then generally justified in terms of cost–benefit analysis: the insights gained by such a simple but complete trade/welfare picture by far outstrip the disadvantages of more realistic but more complex and less clear analyses.

Such a view, however, requires first that a 'reasonably accurate' explanation is offered for these main causal interdependencies identified by the theory, and second that the distortions and imperfections of the real world lead only to minor or 'shortlived' aberrations with relatively little consequence for the normative or policy conclusions of the theory. In the case of 'orthodox' trade theory and, rather uniquely, in nearly all fields of economic inquiry there has been growing recognition from all sides that both conditions do not hold.

Nowhere is this more clearly illustrated than in the seminal review Hufbauer (1970) presented twenty years ago, on the emerging and growing evidence and support in favour of the so-called 'neo-technology' accounts of international trade flows. In interpreting his neo-technology results, Hufbauer, himself the author of one of the most detailed 'technology gap' trade studies on synthetic materials (1966), remained, if anything, rather schizophrenic. His 'neo-technology' results, while powerful in explaining the actual trade flow and admittedly closer to the real world, represented an approach which, in Hufbauer's words, was 'not geared to answering the traditional questions of economic inquiry'. And Hufbauer added with some irony: 'It can as yet offer little to compare with Samuelson's magnificent (if misleading) factor–price equalisation theorem.'[1]

While Hufbauer's contribution was exceptional in its frankness, it was in no way exceptional in bringing out the dilemma between relevance and consistency with a general and established theoretical framework which has characterised the analysis of technical change in economic theory.

Some authors privilege the first criterion (relevance) and find in the evidence on technological change a powerful challenge pushing towards the search for a radically different theory. As Rosenberg puts it:

> in a world where rapid technological change is taking place we may need an analytical apparatus which focusses in a central way upon the process of technological change itself, rather than treating it simply as an exogenous force which leads to disturbances from equilibrium situations and thereby sets in motion an adjustment process leading to a new equilibrium. (Rosenberg, 1970, pp. 69–70)

Conversely, other economists stress, as a necessary condition for the theoretical consideration of the phenomena related to technological change, precisely their tractability within the traditional model, or simply consider the absence of any alternative as a sufficient condition for their neglect. In Bhagwati's words, writing some twenty years ago:

> the realistic phenomena ... such as the development of new technologies in consumption and production involve essentially phenomena of imperfect competition for which, despite Chamberlain and Joan Robinson, we still do not have today any serious theories of general equilibrium... . Unless therefore we have a new powerful theoretic system... we cannot really hope to make a dent in the traditional frame of analysis. (Bhagwati, 1970, p. 23)

It is only fair to say that, particularly in the area of imperfect competition, major new insights have been developed over the last twenty years, providing a major 'dent' in traditional trade theory.[2]

However, in keeping with the broad spirit of this book, as discussed in the preceding chapter, we will, in the following review, try to circumscribe 'new' trade theory contributions to the class of what we will call here 'revisionist' contributions, in the most positive meaning of the term, pursuing a gradual and progressive incorporation of an increasing number of more realistic phenomena into modified forms of general equilibrium analysis. These contributions will be opposed to the 'heretic' tradition, searching for alternative models no longer based on 'generally accepted', neo-classical assumptions. Our attempt to use such theoretical benchmarks to review a highly selected literature is of course less and less successful, in keeping with the high variance in 'degree of orthodoxy', scope and realism of the assumptions, which are being introduced, particularly on the 'new' trade theory side.

In this short review we shall start from what could be called an 'incrementalist' analysis of technology-related phenomena, broadly along the lines of the neo-classical approach.[3]

2.2 The 'pure' trade theory: neo-classical extensions and the 'revisionists'

Consider first the neo-classical 'pure' theory of trade in its simplest textbook form. There are generally four fundamental assumptions:

1. *On technology*. Differences in techniques can be adequately represented by production functions. The latter are assumed to represent the essential features of production activities of the real world, are well-behaved, continuous, differentiable, exhibit non-increasing returns to scale, etc. Moreover, they are assumed identical across countries.
2. *On behaviour*. Perfect competition prevails throughout. Agents are maximisers under budget constraints.
3. *On demand*. Identical tastes across countries and well-behaved utility functions.
4. *On adjustment mechanism*. Adjustments are such as to guarantee *ex hypothesi* the clearing of all commodity and factor markets.

This leads to the following subsidiary assumption:

> Hypotheses (1)–(4) offer a reasonably accurate description of the prevailing 'state of the world' and the main interdependencies in the international arena, so that any possible distortions or imperfections of the real world lead only to minor or 'shortlived' aberrations with relatively little consequence for the interpretative and normative conclusions of the theory.

In its simplest form, the 'pure' theory of international trade then goes on to prove some of the most 'classic' theorems of economic theory: on relative specialisation determined by relative factor endowments (Heckscher–Ohlin–Samuelson), on factor–price equalisation and the theorems of comparative statics, on the effects of changing prices on factors' returns (Stolper–Samuelson–Rybczynski theorem) and of changing endowments upon commodity outputs.

Here we will not consider the developments and refinements of all four hypotheses listed above, but will limit our review to some of those contributions which do not entirely subscribe to the derived hypothesis that distortions are short-lived and have tried to modify some of the assumptions (1)–(4). Typically, the scientific strategy is to hold the rest as true and work out the implications of the additional (more 'realistic') hypotheses. Assumption (4) remains, however, *the* core proposition which is generally left untouched, since the entire model, irrespective of how it is precisely defined, needs a link of some kind between relative scarcities and relative prices.

One way of relaxing the simplest technological assumptions has been to allow production functions to differ between countries. Jones (1970) analyses some of the implications: factor-price equalisation no longer occurs, 'differential rates of technical differences between countries come to dominate the determination of comparative advantages',[4] but the Heckscher–Ohlin theorem on specialisation still applies in a modified form. Berglas and Jones (1977) embody in their model a mechanism of learning-by-doing, characterised by 'local learning',[5] on the techniques effectively in use. Findlay (1978) develops a steady-state dynamic model including technology transfers between an 'advanced' country and a 'backward' one. Chipman (1970) considers the case of moving production functions whereby technical progress is itself endogenous, along Kennedy–von Weizsäcker–Samuelson lines.[6] Purvis (1972) presents a model with international technological differences and capital mobility, illustrating that in this case, contrary to the standard model, factor mobility and trade may be complementary. The issue of capital mobility is also considered by Ferguson (1978) and Jones (1980):

interestingly, the patterns of trade turn out to be essentially determined by technology gaps and relative labour costs.

Another way of relaxing the standard assumption with regard to the production function is by introducing economies of scale. Since the analysis of the latter must be generally associated with assumptions that differ from the pure competitive model,[7] one may consider these two variations on the standard model together.[8] First, as Drèze (1960 and 1961) and Ohlin (1933) himself pointed out over fifty years ago, taken on their own, economies of scale can be an explanatory variable of trade patterns. Second, from a more normative point of view, they may well influence the welfare effects of trade so that a country may even lose from trade, as suggested originally by Graham (1923).

Over the last ten years many interesting theoretical developments have of course been produced in this area, giving rise to a rapidly expanding literature which can only be reported upon in part here, and which is generally referred to as the 'new' trade theory.[9]

Ethier (1979) and (1982a) has explored the conditions under which Graham's arguments hold: they depend on the nature of the increasing returns (which are either 'national' or 'international') and the pattern of change in relative prices due to the transition from autarky to trade. Imperfect competition due to increasing returns *may* imply gains from trade for both trading partners (cf. Melvin, 1969; Krugman, 1979a), but may also imply losses (cf. Kemp, 1969). In the case of 'imperfect competition' a large number of conclusions emerge which may be diametrically in conflict with the standard Heckscher–Ohlin–Samuelson model:[10] for example, factor prices will not be equalised, but, on the contrary, the price of the factor used intensively in the production of the export good may actually be high in each country (cf. Markusen and Melvin, 1984). Similarly, factor mobility, instead of substituting for trade (trade in factors as opposed to trade in commodities) as in the standard model, will be complementary to trade, with each country achieving an equilibrium where it is well endowed with the factor used intensively in the production of its export good. As Markusen and Melvin (1984) note: 'In the Heckscher–Ohlin model this is, of course, the basis for trade whereas in the present model it is the result of trade'.

In general, as shown by Markusen and Melvin (1984), sufficient conditions for the gains-from-trade theorems to hold are (i) marginal pricing on the behavioural side; and (ii) the convexity of the production possibility sets on the technological side. More recently, many of such 'new' trade contributions have focussed on estimating some of the gains from trade that are directly related to economies of scale, particularly within the framework of the further harmonisation of the internal EC

market (Smith and Venables, 1988) and the Canada–US free trade agreement.[11] In the specific Canadian case, for example, Harris (1984) shows, using a general equilibrium model but introducing scale economies and imperfect competition, that the gains from trade liberalisation are four times as great as under conditions of perfect competition.[12] Within the small country context, Dixit (1986b) has illustrated that for small countries there may be gains from strategic trade policy which are sometimes greater than for large countries.

On the other hand, analysis of differentiated products has led to attempts at synthesis between theories of monopolistic competition, intra- and interindustry trade. Differentiation is supposed to come from a demand for a variety of product characteristics (cf. Barker, 1977; Dixit and Stiglitz, 1977; Krugman, 1979a, 1980, 1981; Helpman and Krugman, 1985; Markusen, 1986, 1989) or from different combinations of some fundamental attributes (cf. Lancaster, 1979, 1980) embodied in each product. Thus whereas intraindustry trade is explained on the grounds of monopolistic competition,[13] the explanation for the interindustry trade flows will be left to the traditional Heckscher–Ohlin model. These models predict that intraindustry trade will be highest between similar countries (in terms of per capita income and patterns of demand; see Linder, 1961), whereas interindustry trade flows will be more important the greater the difference between countries in terms of 'endowments'.[14] An alternative (Ricardian) model of intraindustry trade is provided by Petri (1980), where intraindustrial specialisation for any given pattern of demand is determined by relative labour productivities and cost conditions within sector-specific and country-specific structures of production.

More generally speaking, it can be said that 'new' trade theory places the microfoundations of intraindustry trade in the strategic behaviours of firms operating in conditions of 'monopolistic competition', with product differentiation and, sometimes, increasing returns (Markusen and Melvin, 1984, Grossman and Helpman, 1989, and Markusen, 1989). Other 'new' trade theory versions consider oligopolistic interactions whereby countries are equated to single firms and the ensuing game-theoretic equilibria are then analysed. In these circumstances, it is shown that bilateral trade of identical products will or can take place. The formal introduction of market structures that differ from pure competition pioneered by authors who attempted to link instruments and concepts of industrial organisation (multinational corporation, oligopolistic competition, strategic behaviours) with a general equilibrium trade model,[15] has led to two separate directions. The first one, whereby results can be formally presented in terms of the traditional model with specific factors,[16] has drawn attention to the significance of the link

between industrial structures and trade flows, whatever the 'endowments'; the second one has focussed attention on a different adjustment mechanism: international capital mobility in the form of multinational investment rather than intranational intersectoral mobility. This latter direction allows, at least in principle, the consideration of *country-specific* variables of both an institutional and economic nature which as such also represent an incentive/obstacle to the location of international capital.[17]

Under the broad heading of 'industrial organisation and international trade', one must thus also mention parts of the vast literature on the origins and effects of multinational corporations. Some of the studies deviate in both spirit and constructions from the neo-classical assumptions we listed above (e.g. Hymer, 1976): technological differences between companies and countries, country-specific absolute advantages and high degrees of 'imperfection' of the markets in general and the market for technology in particular are implicit from the start. These features of the world are indeed the necessary structural conditions for the existence of multinationals. Other interpretative models also try to incorporate some neo-classical elements. This appears to be the case in Dunning's 'eclectic theory',[18] whereby Heckscher–Ohlin mechanisms of adjustment in prices, quantities and relative specialisations are considered to be *one of* the processes at work, whose relative importance depends on the sectors, the degrees of development of the countries and the nature of the technology. Finally, other interpretations – such as Rugman (1980) – attempt to reconcile the existence of multinationals, intrafirm trade, etc., with traditional analysis. Rugman recognises the widespread existence of 'imperfections' (and thus the limited validity of assumptions 1 and 2 above). However, he assumes that companies face and overcome these imperfections by *internalising* the relevant transactions. Therefore, multinationals become some sort of 'second best approximation' to the working of the standard model.

An increasing number of the theories discussed above are now becoming formalised. In particular, a number of contributions by Horstmann and Markusen (1986, 1987a,b, 1989) have illustrated in a number of cases how conclusions are reached that are at variance with the canonic model: factor prices are not generally equalised; there are oligopolistic rents; trade patterns do not depend only on countries' endowments; and the degrees and forms of market 'imperfections' become a determinant on their own of productive locations and trade.

A different group of models adopts 'Ricardian' hypotheses on technology – with coefficients of production fixed and different between countries – while generally retaining general equilibrium assumptions on prices, determined through a market-clearing process. Dornbush, Fisher

and Samuelson (1977) present a two-country Ricardian model with a 'continuum' of commodities and the patterns of specialisation determined by relative wages and relative productivities.[19] Wilson (1980) extends the model to many countries and non-homotetic demand schedules. Jones (1979) considers the conditions under which technical progress may produce 'immiserizing growth' for either of the trade partners.

A simple but illuminating picture of the technology–trade relationship emerges from Krugman's North–South trade model (1979) and (1982). Starting with an innovative North and a non-innovative South, where the North's innovations only take the form of new products produced immediately in the North, but only after a lag in the South. Krugman (1979) shows how new industries must constantly emerge in the North in order to maintain its living standards, since the new industries decline and disappear sooner or later in the face of low-wage competition from the South. In Krugman's model, this is because the North's wages reflect the rent on the North's monopoly of new technology: 'This monopoly is continually eroded by technological borrowing and must be maintained by constant innovation of new products. Like Alice and the Red Queen, the developed region must keep running to stay in the same place' (Krugman, 1979, p. 262). In other words, while the North will be able to achieve some 'moving equilibrium' through a sufficiently large rate of innovation in order to maintain its living standards, any slowing of innovation or acceleration of technology transfer will narrow the wage differentials between North and South and might even lead to an absolute decline in living standards in the North. The most interesting aspect of Krugman's model is, perhaps paradoxically, the set of simplistic and, from a traditional trade point of view, totally 'unrealistic' assumptions behind the model: there are no differences in factor endowments because there is only one factor of production (labour); and all goods, old and new, are produced with the same function, leaving no room for differences in labour productivity; neither neo-classical nor Ricardian trade explanations are relevant; there is no fixed pattern of trade, but trade is determined by a continuing process of innovation in the North and technology transfer to the South. Yet despite these simplifications, some of the conclusions which emerge from the model are very appealing, not in the least because, as Krugman observes: 'The picture of trade seems in some ways more like that of businessmen or economic historians than that of trade theorists' (Krugman, 1979, p. 265).

Within a different analytical framework, Krugman (1982) considers the patterns of trade stemming from technological gaps and different 'technological intensities' of the various commodities in a Ricardian model, with a continuum of commodities, which shows some similarities

with the model and the conclusions that we will present in Chapter 6: for example, technological differences turn out to be a fundamental force which shape comparative advantages.

More generally, a recent stream of analysis (Krugman, 1987; Grossman and Helpman, 1989, 1990a and 1990b; Markusen, 1989) has attempted to formalise equilibrium trade patterns with endogenous technical change and monopolistic competition in the 'innovative' intermediate inputs. These models somewhat link trade theory with increasing-returns growth theories (Romer, 1986, 1989, 1990; Lucas, 1988; Aghion and Howitt, 1989): an equilibrium rate of technical change is endogenously determined and, with that, the steady-state properties of trade flows (an exception being Markusen (1989), which considers a set of equilibria which might not be steady-state ones).

It is obviously very difficult to provide a synthetic assessment of these quite heterogeneous streams of literature, characterised as they are by very different directions and degrees of 'revisionism'. However, three general conclusions may be drawn.

First, there is probably little disagreement about the inadequacy of the 'canonic' factor proportions theory to explain international trade flows *by itself*. As Krugman (1979b) puts it: '...causal observation seems to militate against a simple factor proportions theory. The emphasis on factor proportions in international trade is... not the result of an empirical judgement' (p. 14).

Second, most of the studies we reviewed implicitly highlight the lack of robustness of the major Heckscher–Ohlin results in terms of both predictions and welfare implications. Relaxation of the least realistic assumptions (i.e. perfect competition, constant returns to scale, factor immobility, immediate and free diffusion of technology, existence of well-behaved production functions) leads, generally speaking, to indeterminate prediction in relation to the direction and volume of trade. Moreover, the factor–price equalisation theorem does not generally follow. In terms of welfare implications, depending on which assumption is relaxed, conclusions about the 'gains from trade' are sometimes in accordance and sometimes at variance with the orthodox model.

Third and, from our own perspective, of more direct relevance, quite interesting results sometimes emerge, *despite* the continuing presence of highly restrictive assumptions. This set of conclusions, which will be discussed later, will prove to be even more important when placed in an alternative theoretical framework: for example, the role of technology gaps, country-specific absolute advantages and different forms of industrial organisations; the importance of economies of scale and various types of learning; the absence of any general tendency toward factor–price equalisation.

It has already been mentioned that a core assumption shared by most

of the models reviewed so far is a *scarcity* link between factors, commodities and prices, irrespective of the particular hypotheses on technology, forms of competition, etc. In this sense, the contributions reviewed above share all the points of strength and weakness of general equilibrium analysis. The strength, in our view, relates to the capacity to handle, using a simple and general theoretical device, the question of *interdependence* among national and international markets. Not surprisingly, the main question addressed by the standard Heckscher–Ohlin theory and by most of its 'revisionist' developments concerns the *patterns of specialisation* of each country in relation to some country-specific characteristics.

The other side of the coin is that such analyses, undertaken in terms of equilibrium positions, take as given that (i) there are adjustment mechanisms which generally lead to such equilibria; and (ii) these mechanisms based on price/quantity adjustments – as assumed in the standard Walrasian model – lead to the clearing of all markets. Both points are difficult to accept on either theoretical or empirical grounds. The difficulties in accounting for the adjustment processes in the standard general equilibrium framework when neither the fantastic 'auctioneer' nor a complete set of contingency markets exist[20] are well-known and need not be discussed here.[21] There is no reason to believe that such adjustment processes are any easier in the open-economy case.

On more empirical grounds, it is difficult to believe that relative prices are explained by relative scarcities in a world characterised not only by various forms of static and dynamic economies of scale, but also by continuous technical progress and by national economies which are themselves often characterised by some degree of unutilised labour or labour *and* capital.

The very formulation of the standard model in its 'timeless' form becomes even harder to accept whenever one of the factors of endowment – capital – is a set of reproducible (and heterogeneous) commodities. The question has been discussed in a 'capital controversy',[22] with many points in common with the famous 'Cambridge debate' on capital theory, focussing on the problems arising from the heterogeneity of capital goods[23] to the measurement of the 'aggregate capital' which must appear among the 'endowments'.[24]

Another feature common to practically all the models reviewed so far is the behavioural assumption concerning maximising agents. This is equally true for the models of 'pure' competition as it is for those based on imperfect competition or oligopolistic strategic interaction. With regard to technical change in particular, this assumption becomes rather questionable. As argued at greater length elsewhere[25] and following Nelson and Winter (1982), it is difficult to maintain that maximisation

procedures are an adequate representation of the general behaviour of the agents whenever one accounts properly for the fundamental features of technical change (including uncertainty about choices and outcomes, patterns of search generally embodying tacit heuristics, various kinds of irreversibilities, etc.). It is not only, or even primarily, a matter of realism of assumptions. The fundamental point is that behaviours are also directly relevant in terms of the equilibrium positions towards which the system might tend to converge. In other words, even the sequences of 'attractors' for the microeconomic adjustments of the system may well be *path-* and *behaviour-dependent*.[26]

2.3 The less pure theory: the 'heretics'

The discussion so far has focussed upon that stream of economic analysis concerned primarily with one theoretical question, namely *the determinants of specialisation*, and one functional mechanism, namely the adjustment processes induced in the latter by the *interdependencies between markets*, both within each country and between countries. It is a line of enquiry which – despite the great differences in the assumptions on technology, demand and nature of the markets – links Ricardo, the neo-classical school and all those new, 'revisionist' contributions based on a general equilibrium framework. One of the fundamental premises of such a stream of thought is that trade (or the notional transition from autarky to trade) affects the intersectoral (and, sometimes, international) allocation of inputs, quantities, and prices, but *does not* affect the rate of utilisation of the stocks of inputs themselves (and, thus, the rates of macroeconomic activity).[27] This is straightforward in modern general equilibrium analysis, where, as already discussed, full employment of all factors is assumed by hypothesis. It is equally true for that part of Ricardo's *Principles* that is concerned with international trade, based, as it was, on the assumption that

> no extension of foreign trade will immediately increase the amount of value in a country, although it will very powerfully contribute to increase the mass of commodities, and therefore the sum of enjoyments. As the value of all foreign goods is measured by the quantity of the produce of our land and labour, which is given in exchange for them, we should have no greater value if, by the discovery of new markets, we obtained double the quantity of foreign goods in exchange of a given quantity of our's. (Ricardo, 1951, p. 128)

Since in Ricardo's model production techniques are given, the assumption concerning an unchanged 'amount of value of a country' is

precisely equivalent to an assumption of constancy of the rates of macroeconomic activity throughout the notional transition from autarky to trade. In the history of economic thought, however, one can also identify another group of contributions that are highly heterogeneous in scope and nature, seldom thoroughly formalised, heretic in spirit and often produced by outsiders of the dominant economic tradition. In this composite group one may include early economists from the eighteenth and nineteenth centuries, such as the Reverend Tucker, Count Serra of Naples, Ferrier, List and Hamilton, as well as parts of the analysis of Adam Smith. In more recent times one finds an equally heterogeneous set of writers ranging from some technology-gap and product-cycle authors (Posner, Freeman, Vernon, Hirsch, Kaldor, Cornwall and Thirlwall) broadly in the post-Keynesian tradition; 'structuralist' writers in development economics, especially within the Latin American tradition; economic historians, such as Gerschenkron, Kuznets and Balogh; some modern French writers such as Bye, de Bernis, Lafay and Mistral. Obviously, these contributions are highly different in nature and scope. However, one may state that they have in common, explicitly or implicitly, one or several of the following assumptions:

1. International differences in technological levels and innovative capabilities are a fundamental factor in explaining the differences in both levels and trends in the exports, imports and income of each country.
2. General equilibrium mechanisms of international and intersectoral adjustment are relatively weak, so that trade has important effects upon the rates of macroeconomic activity of each economy. Putting it in another way, the growth of each economy is often balance-of-payment constrained and this constraint becomes tighter or looser according to the levels and composition of the participation of each country to world trade flows. The weakness of price/quantity adjustments between sectors and between countries has to do partly with the nature of technology (fixed coefficients, irreversibilities, etc.) and partly with the nature of demand (sticky baskets of consumption, etc.). As a result, what adjust in the international arena are world market shares within each sector and, through that, the levels of macroeconomic activity generated by foreign demand.
3. That same weakness of general equilibrium mechanisms is such that the intrasectoral distribution of trade shares between countries and their evolution through time can be explained by a set of country-specific absolute advantages/disadvantages and without explicit reference, at least in a first approximation, to price/quantity adjustments between sectors and between factors' returns.

4. Technology is not a free good.
5. The allocative patterns induced by international trade have dynamic implications which may either yield 'virtuous' or 'perverse' feedback in the long term.

These assumptions have generally been stated in a rather confused way by the early writers, who did not share the rigour and depth of Ricardo or Samuelson, and were often motivated simply by policy issues such as protection versus free trade. None the less, they had precious, if confused, insights into complex problems of economic dynamics which were later neglected in the cleaner but more restrictive formalisations of modern trade theory. For example, Tucker (1774) (quoted also by Hufbauer, 1970) assumes that there is a macroeconomic link between technological advantages, international competitiveness and incomes, and discusses whether the product-cycle effects induced by the lower wages of the 'poor country' will eventually reverse the competitive position of the 'rich' vis-à-vis the 'poor'. His answer is reassuring for the United Kingdom: continuous technical progress, higher capabilities of accumulation and institutional factors will ensure an absolute advantage there, despite the lower wages of the more backward countries. Ferrier (1805) deals with the relationship between trade and rates of macroeconomic activity in the light of the historical experience of the Continental Blockade, arguing that there is a direct negative link between import penetration and employment levels in the relatively backward country due to a generalised technological disadvantage and to the long-term effect that despecialisation in the most advanced products (in this case, manufactures) exerts upon the capability of progress and accumulation: 'I compare a nation which with its money buys abroad commodities it can make itself, although of a poorer quality, with a gardener who, dissatisfied with the fruits he gathers, would buy juicier fruits from his neighbours, giving them his gardening tools in exchange.'[28]

Interestingly, Adam Smith was equally aware of the dynamic implications of trade,[29] and his position appears to be almost symmetrical to that of Ferrier, from the 'advanced country' point of view. First, he argues, trade has a beneficial effect upon the rates of macroeconomic activity and employment because, in contemporary words, exports increase aggregate demand. This is close to what Myint (1958) later defined as a 'rent-for-surplus' model of trade. Second, the enlargement of the market due to international trade feeds back upon the domestic division of labour and thus on the trends in productive efficiency.

The argument of German and nationalist List (1904) was directly opposed to those of Ricardo and Say. The practical matter at stake,

as was well known, was the political advocacy of protectionism and industrialisation. In List's view, there is nothing in the adjustment mechanisms on the international market (in List's terminology, the adjustments 'based on the theory of exchange values') which guarantees dynamic convergence between nations in terms of productive capabilities and incomes (the 'growth of productive forces of a Nation'). In several respects, this view involves much more than an 'infant industry argument', the idea being that the long-term position of each country depends jointly on its degrees of capital accumulation, its global, technical and learning capabilities,[30] and a set of institutional factors (social consensus, factory discipline, political conditions). According to List, the adjustment processes set in motion by international trade, might well be detrimental to the development of these aspects of the 'national productive forces'. Putting it in modern terms, static and dynamic economies of scale and differing income elasticities of the various commodities, under free-trade conditions will lead to divergence rather than factor–price equalisation, and growth polarisation, with concentration of production in one country rather than welfare gains for both partners.

In a similar perspective, these points have been emphasised in much of the early development/trade/dependency literature,[31] and in the historical analysis of the early industrialisation/opening of trade process in the United Kingdom.

More recently and along the lines suggested by Kaldor (1970, 1975 and 1980), Thirlwall and Vines (1983) have formalised such views in a multisector North–South model and have studied the 'consistency conditions' between the two countries and the various sectors. The Kaldor–Thirlwall–Vines approach, while incorporating some ideas similar to earlier 'two-gap' models of development – whereby the growth of industrialising countries is shown to be constrained by either saving/investment capacity or foreign exchange requirements[32] – embodies a general hypothesis on world growth as being determined by 'asymmetrical' patterns of change in technical coefficients and demand composition. In this view, processes of interfactorial and intercommodity substitution in response to relative prices and excess factor supplies are of minor importance. What adjusts is the level of sectoral and macroeconomic activity.

An ambitious multisector model along similar lines is that of Pasinetti (1981), whose open-economy version determines the relative rates of growth between economies in terms of evolution of relative productivities and income elasticities of the commodities that each country produces. Such a model also generates 'comparative advantages' as the endogenous result of sector-specific dynamics and country-specific dynamics of technological change.

In all these models the difference in the income elasticity of the various commodities plays a fundamental role and is assumed to dominate over price/quantity adjustments in consumption baskets. Thus, as Thirlwall (1980) shows, the income elasticities enter into the determination of the foreign-trade multiplier of each economy (via import propensities and export elasticities to world income). The other fundamental factor is obviously technology. 'Polarisation' in innovativeness is shown to imply 'polarisation' in growth.

Interestingly, while both the Ricardian and neo-classical perspectives focus upon the determinants of the *patterns of specialisation*, the set of contributions reviewed above focusses on the relationship between trade, levels of activity and growth. In terms of adjustment mechanisms, both Ricardo and the neo-classical school hold the rates of activity constant and study trade-induced changes in relative prices and relative quantities; conversely, the 'heretic' stream often assumes away price/quantity adjustments and studies the link between trade and rates of activity in both the short and long terms.

In order to highlight these differences, one may represent the early heretic model as follows. Imagine, two countries, Portugal and England, producing two commodities, wine and cloth, with labour only. Suppose that, at the beginning, the two countries are absolutely identical: the same technical coefficients, same relative prices, same patterns of consumption, same absolute prices as expressed in their respective currencies whose exchange rate is equal to one. Suppose also the existence of a non-reproducible asset, say gold or, alternatively, tradeable shares representing titles of ownership over the productive activities. Finally, suppose that each economy has some surplus labour which can be mobilised without any extra cost whenever this is required. Clearly, the two countries, even if opened to international markets, will not trade. Assume now an across-the-board improvement in the Portuguese technical coefficients which leaves *unchanged relative productivities* and *relative prices*. In the perspective of both Ricardo and the neo-classicists, still no trade will occur. As Findlay puts it, '...greater technological efficiency cannot be the cause of trade if the relative difference is the same in both goods'.[33]

On the contrary, in what we could call a Smith–Ferrier–List model of trade a *one-way* trade occurs, with Portugal progressively gaining market shares on the English market in *both* wine and cloth. Correspondingly, gold or ownership titles will move from England to Portugal. The rates of macroeconomic activity will grow in Portugal and fall in England. The adjustment process to the Portuguese technological advance will not stop until the exchange rate has entirely adjusted to the new purchasing power parity determined by the new levels of productivities in Portugal as compared to English ones. It is easy to define the

dynamic counterpart of the model. Imagine a *continuous* flow of technical improvements in Portugal. One will observe a continuously increasing market penetration of Portugal on the English markets. Essentially, the adjustment process takes three forms.

First, the English currency continues to devaluate. Second, gold or ownership titles continue to flow out of England. Third, rates of activity in Portugal continue to grow and the English ones continue to fall. Notably, the increasing technological gap is reflected in the changing world-market share of *each* commodity, even if no international specialisation occurs. One could broaden the model, for example by introducing a third commodity, whisky, which only England can produce due to some natural advantage. Then, under the above assumptions, England will slowly converge toward an absolute specialisation in whisky while its short-term rate of activity and its long-term growth will depend upon the levels and changes in the Portuguese propensity to drink whisky as compared with the English propensity to drink wine and wear clothes.

Needless to say, such a model embodies gross oversimplification. However, it illustrates the evidence of the free-trade adjustment processes following major technological polarisations better than the Ricardian alternative. This is precisely what continental writers from the early nineteenth century had in mind: given the European backwardness vis-à-vis England, *laissez-faire* regimes would not have yielded mutual gains from trade, but, rather, would have reduced Europe to a condition more similar to that in India.

A major factor counteracting this link between polarisation in technology and in income levels is of course the international diffusion of technology. Indeed, most modern technology-gap models focus on the crucial time element between innovation and imitation abroad, as trade and income-polarising 'reversal' factor.

The basic assumption of most modern technology-gap trade accounts is that technology is not a freely, instantaneously and universally available good, but that there are substantial advantages in being first. Thus, in Posner's seminal model it is suggested that while technical changes and developments may influence some industries and not others, it is the technical change originating in one country and not in others which will induce trade 'during the lapse of time taken for the rest of the world to imitate one country's innovation' (Posner, 1961, p. 323).

A similar point is made in Freeman's case study of the plastics industry: 'Technical progress results in leadership in production in this industry, because patents and commercial secrecy together can give the innovator a head start of as much as 10–15 years' (Freeman, 1963, p. 22). Once imitation has taken place, more traditional factors of adjustment and specialisation would again take over and determine

trade flows. In Hufbauer's words: 'Technology gap trade is...the impermanent commerce which initially arises from the exporting nation's industrial breakthrough and which is prolonged by static and dynamic scale economies flowing from the breakthrough' (Hufbauer, 1966, p. 23). There is of course nothing necessarily 'impermanent' about these static and dynamic scale economies. Coupled with new or improved product innovations they might well lead to a more or less continuous trade flow.

Product cycle theories (Hirsch, 1965; Vernon, 1966) provide an articulated trade picture along similar lines. They also integrate foreign direct investment and view technology as part of a wider set of market structure factors, including entry, product differentiation/standardisation and nature of demand. Vernon's original model is primarily demand-determined: high levels of income and sophisticated demand patterns induce innovative responses from domestic firms. More recently, the introduction of supply factors has dealt with some of the weaknesses of the original model (for a critical assessment see Walker, 1979). Further developments within this perspective are based on explicit theories of technological innovation and are likely to involve extensions of post-Schumpeterian 'evolutionary' models[34] to the international field, where the emphasis is on the dynamic nature of international competition.[35]

Another recent direction of investigation relates to the importance given to the import and export of technology in shaping a country's future trade pattern. It opens the way for a future integration of foreign investment theories,[36] technology transfer and catching-up models,[37] and dynamic diffusion models[38] within a theoretical trade framework. In particular, explicit dynamic analyses of the interactions between company-specific and country-specific advantages (Cantwell, 1989), and their bearing on the explanation of both trade flows and international investments, seems a highly promising direction of inquiry which is indeed highly complementary to the interpretation presented in this book.

2.4 The empirical evidence

The picture which emerges from the numerous empirical trade studies is, as one might expect, far from uniform. Moreover, the correspondence between theoretical models and empirical tests is generally poor. As Deardorff notes in his thorough review of trade studies:

> Empirical tests of the theories are often faulted on the grounds that they test propositions that do not derive rigorously from the theories. The

> reason is not usually that empirical models are sloppy. Rather, the problem seems to lie in the theories themselves, which are seldom stated in forms that are compatible with the real world complexities that empirical research cannot escape. (Deardorff, 1984, p. 468)

We will organise our review of an even more selected literature with reference to the same themes and approaches discussed above.

Not surprisingly, a major stream of research has been concerned with the explanation of the so-called 'Leontief paradox' within a mainly orthodox factor-proportions framework. As is well known, Leontief (1953) found that the composition of trade in the United States, clearly a capital-abundant country, was biased in favour of labour-intensive exports and capital-intensive imports. While the typical research strategy in the theoretical field was simply to neglect the potentially disruptive implication of such a falsification of the theory, the empirical strategy focussed upon additional variables which could explain away the 'paradox'. This has been one of the analytical procedures which has drawn attention toward technology-related variables, typically labour skills and what has become known as 'human capital'. Many empirical studies, primarily concerned with the US case, found these latter variables to be significantly correlated with the American composition of trade.[39]

Moreover, Leamer (1980) has recently argued that a proper test of the Heckscher–Ohlin model must not be based on the factor content of trade but on the relative factor intensity of production as compared to consumption. Using this criterion, Stern and Markus (1981) found that the Leontief 'paradox' did hold for 1958 but not for 1947 and 1972. These empirical findings and refinements seem, at first sight, comforting to the prevailing theory in its generalised version, including a 'technology-production' factor and extending the concept of capital not only to human capital, but also to 'intellectual capital', defined as the 'capitalised value of productive knowledge created by research and development'.[40] However, one must have severe reservations about these 'revisionist' attempts to accommodate the evidence with a traditional factor-proportion view of trade flows.

First, as regards the conclusions based on Leamer's methodological suggestions the results are far from 'non-paradoxical' and depend crucially on the chosen years. They therefore appear to be not particularly robust.

Second, as argued by Deardorff, the 'acknowledgement of additional factors of production cannot in theory explain Leontief's paradoxical results regarding capital and labour'.[41]

Third, the higher the distance of the underlying model from the original labour/land framework, the lower appears to be the plausibility

of the basic assumptions. As already discussed in Section 2.3, one can hardly consider 'capital' as an endowment when it is actually produced under conditions of non-decreasing returns. It is even harder to define R&D as an endowment, for its 'size' depends on highly discretionary decisions of firms and public institutions.

Fourth, proper 'tests' of the Heckscher–Ohlin model must be based on direct *plus* indirect factor contents. As discussed at length by Momigliano and Siniscalco (1984) this correct procedure has been followed by only a few studies.[42] The majority of studies simply consider direct product characteristics. This methodological difference matters. Thus, for example, Italy's trade performance is *negatively* correlated with the direct R&D content of each commodity but is *positively* correlated with the total content (direct plus indirect, via input/output flows).[43]

Finally, there is the question as to whether empirical analyses of trade flows can be usefully carried out at the level of intracountry intersectoral studies only. This methodological issue has been raised at a general level by Leamer (1974) and Leamer and Bowen (1981). The problem stems from different technology-specific characteristics which are likely to influence trade flows and can be accounted for only in intercountry intrasectoral analysis.

Given all these methodological problems and caveats, it is fair to conclude that most of the empirical studies based on cross-sectoral analyses relating trade flows (either measures of comparative advantages or net exports) to a menu of product characteristics, while useful in presenting the possible *regularities* in the structural features of domestic supply and their statistical correlation with the patterns of competitiveness, are far from useful in highlighting any causal mechanism *explaining* international competitiveness and specialisation.[44]

The empirical validity of the endowment-based theory of trade remains, therefore, very much subject to debate.[45] As Hufbauer puts it: 'Leontief's findings dealt an apparently telling blow to the simplistic two-factor version. Various authorities have sought to repair the damage; their work in some respects resembles the tortured efforts of pre-Copernican astronomers.'[46]

A different line of empirical enquiry has been concerned with the patterns of relative intersectoral specialisations based on a simple Ricardian framework. MacDougall (1951–2) showed that the sectoral ratio of US to UK exports was well correlated with relative American and British labour productivities. These results, confirmed by Stern (1962) and Balassa (1963) do not, of course, explain the *sources* of intersectoral differences in productivity and – as has been argued – could also be consistent with a Heckscher–Ohlin model of trade. On

the other hand, they could also highlight the mechanisms leading to comparative advantages on the grounds of sector-specific gaps or leads in technology.

Empirical studies using the technology-gap trade framework or product-life-cycle theory, on the other hand, emphasise in the first instance the intercountry differences in innovativeness as the basis of international trade flows. Rather than interindustry variations in the technological 'endowment' of a specific country, it is the variation in innovativeness within each sector across countries which seems crucial.[47] Most sectoral studies (e.g. on chemicals, plastics, process plants, electronics products, semiconductors) highlight the dynamic relationship between early innovative leads,[48] economies of scale, learning by doing, oligopolistic exploitation of these advantages, and international competitiveness. As referred to in the introduction, one of the most ambitious attempts of intercountry and intersectoral comparison of technology-based and product-cycle-based models as compared to the other explanations of trade flows was carried out by Hufbauer (1970).

Hufbauer found that the commodity characteristics, by country, were related to a set of country characteristics, including variables related to technology, economies of scale, product differentiation and patterns of domestic demand. Whereas some of the proxies used implied high levels of 'heroism', they pointed to the widespread existence of country-specific advantages/disadvantages related to technological innovation, national 'context' conditions and forms of corporate behaviour that differed from 'pure competition'.

Similarly, the findings by Gruber and Vernon (1970), while broadly in line with the Leontief 'paradox', highlighted the homogeneity in the structure of exports (and production) among the major industrial countries and their general correlation with per capita GDP. Walker (1979) critically analysed the sectoral evidence on product-cycle patterns of production and exports, finding that there are groups of products which do conform with the prediction of a 'flow' from advanced to intermediate and backward low-wage countries, while other groups appear more in line with straightforward technology-gap theories, whereby the advantage remains over long periods in the most innovative country(ies).

Irrespective of whether the analysis deals with intracountry, intersectoral comparisons or international, intersectoral ones, an important methodological issue concerns the proxies used for the technology variable.[49] With the exception of Davidson (1979), Pavitt and Soete (1980) and Soete (1980 and 1981a), most empirical studies use technology *input* proxies, such as R&D expenditure or R&D employment. Yet, the exact relationship between technology input and technology output remains unclear. However, by emphasising the crucial role of new products and process innovations, most technology-gap models make explicit the need to use a technology output proxy instead of an input proxy in explaining international trade flows.

2.5 Conclusions

There are many gaps in our understanding of the role of innovation in international trade. Despite much progress, particularly over the last decade, we are only beginning to analyse (i) the determinants of different national capabilities to innovate, imitate and generally exploit innovation efforts competitively; (ii) the nature and relative importance of the various adjustment mechanisms within and between countries following such innovative processes; (iii) the relationship between sector-specific patterns of competitiveness and 'general equilibrium' factors, in the broader sense linked to relative prices, intersectoral capital and labour mobility, etc; (iv) the implications of economies of scale, dynamic increasing returns, oligopolistic forms of marked organisation, international investment and all the factors which are generally gathered under the headings 'imperfect competition' and 'new' trade theory; (v) the relationship between innovation, trade and growth. All these issues, of course, present an empirical counterpart which is also in need of more detailed study.

The ability to carry out such studies is obviously very much subject to data availability. Nevertheless, over recent years many new data sources have come into existence. The data are never perfect and rarely conform to what is ideally needed. However, perhaps the major bottleneck can be found in the lack of *joint* development of empirical analysis and strictly consistent theoretical models. In this respect, highly 'eclectic' methodologies trying to reconcile the orthodox framework with the evidence by means of an increasingly cumbersome apparatus are likely to yield rapidly decreasing returns.

In Kindleberger's words,

> neo-factor proportion theories assume that there is a standard world technology and that factor endowments determine the direction of trade. Neo-technological theories assume that technology is continuously changing unevenly, and that these changes alter the trade pattern. Innovations lead to exports; the spread of technology to the world establishes a pattern based on factor proportions, which may or may not differ from that included by the initial gap. To the extent that the pattern based on factors differs from that based on innovation, the neo-factor and neo-technological explanations differ rather than harmonize. (Kindleberger, 1970, p. 281)

Recognising this divide which, no doubt, an increasing number of 'new' trade theories are trying to bridge,[50] one cannot avoid choosing which 'vision' one deems is nearest to the evidence. We hope it is clear from this chapter which vision we believe conforms best to reality and is theoretically consistent. Our general theoretical propositions are as follows. *First*, the 'microfoundations' of international trade analyses, easily consistent with the available evidence, should be found in the extension of an 'evolutionary' interpretation to the international arena. *Second*, in such evolutionary dynamics, what appears to be, *ex-post*, a 'comparative advantage' is in no proper sense the result of any 'endowment' but rather the outcome of processes of learning – innovation, imitation, organisational change – which have both sector and country specificities. *Third*, the innovative process, by allowing various sorts of (static and dynamic) increasing returns, generally also entails forms of market interactions that differ from perfect competition. *Fourth*, these same properties of technical change imply the possibility of those *irreversible processes* discussed, for example, by Arthur (1989) and thus also, from a normative point of view, the possibility of 'virtuous' or 'vicious' circles in innovativeness, competitiveness and growth. *Fifth*, the *micro*economic and sectoral levels and changes in international competitiveness, so determined under conditions of continuous technological learning and limited short-term substitution in both production and consumption, also represent the microfoundations of those *macro*economic analyses, with some 'Keynesian' ascendancy whereby (western) economic systems seldom hit any powerful scarcity constraint, but, on the contrary, are often limited in their growth by aggregate demand and foreign balance requirements.

Admittedly, most of the theoretical analysis of these propositions and processes is still to be done. In the following chapters, we turn to a more detailed discussion of these propositions and the insight they contain in interpreting the links between trade patterns and processes of innovation, industrial evolution and patterns of growth. First, however, we turn to a brief 'empirical' review of some 'stylised' and 'less stylised' facts on technology, growth and trade.

Notes

1. Hufbauer (1970), p. 197.
2. The position taken 20 years later by Bhagwati is also interesting to note, Bhagwati (1989).
3. Extensive reviews of the trade literature can be found in Bhagwati (1964), Chipman (1965–6), Stern (1975) and Jones and Kenen (1984); more specifically on the issues related to technology and international trade, in Hufbauer (1966) and (1970), Chesnais and Michon-Savarit (1980), Aho and Rosen (1980), Soete (1985) and Lyons (1986).
4. Jones (1970), p. 84.
5. Cf. Atkinson and Stiglitz (1969).
6. Cf. Kennedy (1964), von Weizsäcker (1965), Samuelson (1965).
7. Of course this is necessarily so if the economies of scale are internal to each firm.
8. For a thorough review, see Helpman (1984). An interesting collection of some of the 'state-of-the-art' contributions in the field can be found in Kierzkowski (1984).
9. See, among others, Dixit and Norman (1980), Chapter 9, Krugman (1979a), (1980), (1986), Helpman and Krugman (1985), (1989), Brander (1987), Markusen and Venables (1988), Markusen and Melvin (1988).
10. For 'imperfect competition' models, among others, Markusen (1981), Lancaster (1980), Helpman (1981), Helpman and Razin (1980), Melvin and Warne (1973). The implications of economies of scale in a neo-classical open-economy growth model are analysed in Krugman (1984a), Grossman and Helpman (1989, 1990a and b).
11. There exists not surprisingly an extensive literature on this subject. With respect to Europe see Jacquemin and Sapir (1988), Smith and Venables (1988) and Onida (1990); with respect to the United States and Canada, see Harris (1984), Cox and Harris (1986) and Stern, Tresize and Whalley (1987).
12. See also Markusen and Wigle (1989).
13. Grubel and Lloyd (1975).
14. See Helpman (1984a). This line of enquiry is in many ways an attempt at a synthesis between the Heckscher–Ohlin–Samuelson model and Linder's model (cf. Linder, 1961). For a model accounting also for multinational investment, see Helpman (1984). A general discussion of intraindustry trade and its interpretations can be found in Greenaway and Milner (1986). Results of empirical applications of the intraindustry literature to the Nordic countries can be found in Andersson (1987).
15. Cf. the special issue of *The Journal of Industrial Economics* edited by Caves (1980) and since then Brander (1981), Jacquemin (1982), Brander and Krugman (1983), Harris (1984), etc.
16. That is a general equilibrium model with sector-specific and intersectoral immobile factors (see Jones and Neary, 1984).
17. See also Jones (1980).
18. See Dunning (1977), (1981) and (1981a), Buckley and Casson (1976).
19. Krugman (1979, p. 262).
20. See Hahn (1984), Leijonhufrud (1981).
21. We refer the interested reader to the book edited by Dosi *et al.* (1988).
22. On this issue, for a 'Cambridge view', see Steedman (1979) and (1980), Metcalfe and Steedman (1981), and the replies by Ethier (1981) and Dixit (1981).
23. Interestingly, the standard neo-classical way out of the difficulties with regard to capital measurement has been, in the closed-economy case, through general equilibrium models of Walrasian ascendancy. This possibility is generally precluded in the field of international trade, since the specification of a long vector of 'endowments' implies nearly tautological conclusions. It is of little interest as Corden puts it crudely to have a 'theory' which says, 'that Switzerland has a comparative advantage in

watches because she is watchmaker-intensive or that the United States exports 747s because she is intensive in firms or engineers capable of making 747s' (Corden, 1979, p. 9). In trade-related capital theory the standard procedure is simply to assume that the measurement problem does not exist *ex hypothesi*: 'Suppose that ... the common technology has no factor-intensity reversal ...' (Ethier, 1981, p. 274).

24. This is not the place to discuss these issues. Suffice to make one remark. With time and reproducibility of capital (in the form of machines, etc.) the 'dynamic' equivalent of the timeless Heckscher–Ohlin model becomes one where the 'scarcity constraints' are the rate of growth of the labour supply and the savings rate. This strictly pre-Keynesian view of the growth process raises many questions: How does one account for those periods and those many countries in modern history characterised by structural unemployment of one kind or another? Do 'scarcity constraints' functionally define the system, even in the presence of continuous technical progress and widespread economies of scale? Where is there proof that it is the rate of saving which determines the rate of investment and not vice versa, such as in the Keynesian–Kaleckian view? Where is the evidence that countries characterised by higher saving propensities also present higher capital 'endowments' and relatively capital-intensive exports?
25. Dosi (1984) and Dosi *et al.* (1988).
26. On this point, cf. Nelson and Winter (1982) and Dosi and Orsenigo (1988).
27. Obviously, this assumption is necessary to base the analysis on unit functions, indifference curves, isoquants, etc.
28. Ferrier (1805), p. 288.
29. Adam Smith (1937), volume I.
30. For a reappraisal of List's view on the importance of the national techno-scientific systems, cf. Freeman (1982a).
31. Cf. Prebisch (1950).
32. See Chenery and Bruno (1962), Chenery and Strout (1966), Findlay (1973). For a thorough critical analysis of the debate on North–South differences, terms of trade, development, see Bacha (1978). A review of the trade/development literature, cf. Findlay (1984).
33. Findlay (1973), p. 57.
34. See Nelson and Winter (1982), Dosi (1984) and Silverberg, Dosi and Orsenigo (1988).
35. See B. Klein (1977) and (1979). Klein's work focusses on individual firm behaviours in relation to industrial innovation. For an overview of this line of enquiry, see E. Graham (1979).
36. Cf. Buckley and Casson (1976 and 1981), Dunning (1981).
37. Cf. Cornwall (1977), Gomulka (1971), Koizumi and Kopecky (1980).
38. See Nelson (1968), Nelson, Winter and Schuette (1976), Nelson and Winter (1982), Metcalfe and Soete (1984) and Metcalfe (1988).
39. See, among others, Keesing (1965) and (1967), Baldwin (1971), Harkness and Kyle (1975), Branson and Monoyios (1977), Stern and Maskus (1981).
40. Johnson (1970), p. 14.
41. Deardorff (1984), p. 481.
42. Cf. Horn (1976), Stern (1976), Bodenhofer (1976), Wolter (1977).
43. Cf. Katrak (1973), Horn (1976), Owen, White and Smith (1978).
44. Cf. Hulsman-Vejsova and Koekkoek (1980).
45. Cf. Horn (1976).

46. Cf. Helg and Onida (1985). Some scattered and less convincing evidence also exists for Sweden (Bergstrom-Balkestahl, 1979) and Canada (Hanel, 1976). Thorough reviews can be found in Deardorff (1984) and Onida (1984).
47. See Momigliano and Siniscalco (1984).
48. See, among others, Freeman (1963) and (1965), Hirsch (1965), Hufbauer (1966), Tilton (1971), Dosi (1984).
49. For a more detailed argument along these lines, see Chapters 3 and 4.
50. See, e.g. Markusen and MacDonald (1985) or Markusen (1989).