FACTOR PROPORTIONS AND PRODUCT CYCLE: A STUDY OF EXPORT PATTERNS IN MANUFACTURED PRODUCTS

by

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(ABSTRACT)

This dissertation seeks to empirically examine the hypotheses suggested by the model of trade in manufactured goods, based on international differences in relative abundance of labor skills and on inter-country differences in ability to develop new products.

Extensive theoretical and empirical literature shows that the traditional trade theory alone fails to provide a satisfactory explanation of modern industrial trade patterns. This study proposes that the neo-factor or skill approach, and the neo-technology or product cycle approach, treated as complementary components of a single framework, offer a potentially useful tool for examining national manufacturing export structures. The two approaches, initially meant to explain export performance of the U.S. industries, are found to perform well in the cross-country study covering a wide variety of economies.

The empirical analysis produces some tentative evidence that the neo-factor approach and the neo-technology approach are especially well suited to explain trade composition in two different classes of manufactures, "mature" and "new" products, respectively. Further, the two theories are tested against data covering 69 3-digit SITC industrial

product groups. Across countries, skill intensity of exports is found to be positively and significantly correlated with various proxies for the availability of skills. Export performance in relatively newly developed products, and in those with high R&D content, turn out to be positively and significantly correlated with various measures of innovative capability. Finally, it is demonstrated that for most of the economies in the sample, export performance over manufactured products with varying skill intensity, R&D content, and age, is subject to intertemporal changes as suggested by the notion of product cycle.

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PART I

INTRODUCTION AND SURVEY OF THE LITERATURE

CHAPTER 1

INTRODUCTION

For almost five decades, the neoclassical factor proportions theory has been accepted as a dominating explanation of export structure in manufactured products. However, following the Leontief paradox, the standard two-factor Heckscher-Ohlin model has been subjected to various criticisms, both of a theoretical and empirical nature. The theoretical criticisms include dissatisfactions with the model's restrictive assumptions, and its resulting inability to deal with such pervasive phenomena as international differences in the quality of labor and in productive technology, imperfect competition, factor mobility, and others. The model's emphasis on relative availability of productive factors, and its unwarranted neglect of other possible determinants of industrial export patterns, have also been questioned. With regard to the empirical criticisms, considerable evidence has been gathered suggesting that the traditional models of comparative advantage fail to provide an adequate account of trade in manufactured products.

Following what was perceived as a crisis of the Heckscher-Ohlin tradition, the trade theory evolved in two different directions. One approach was to refine the factor proportions framework, primarily by extending it to a three-factor analysis, the third factor being labor skills or human capital. Without denying the general validity of the factor proportions argument, this approach explicitly recognized the importance of cross-country differences in the quality of labor, and it resulted in what we will refer to as the neo-factor theory. The other, more unconventional approach, was to relate the commodity composition of industrial trade to technological leadership, recurrent emergence of new products, and ongoing change in the characteristics of the goods already produced. This view of trade, known in the literature as the neo-technology theory, is firmly grounded in the theory of imperfect markets, and it seeks to expound the dynamic nature of international competition in industrial products.

Three types of critical remarks can be made with regard to the theoretical and empirical work advanced thus far along the lines of the two theories. First, the neo-factor and the neo-technology arguments have been presented in an informal or descriptive way, and until recently, no effort was made to build some formal structure around them. Second, much empirical evidence has been generated in support of the two views of industrial trade, yet the evidence is almost exclusively based on the U.S. data. Little work has been done to explore the problem of how the two theories conform to the cross-country data, especially in the view of profound changes in the international division of labor in manufactured goods, and the emergence of the newly industralizing countries, in the 1970s. Third, the two theories have been perceived by many as fundamentally incompatible, and substitutable explanations of trade patterns. The assertion of substitutability, rationalized primarily on the grounds of some empirical findings that appear to confirm both theories at the same time, has frequently led to a search for the "better" theory. The possibility that the two may in fact be complementary to each other seems to have been largely ignored.

This dissertation attempts to address these three problems. The main objective of the study is to empirically examine the hypotheses suggested by a simple model of international trade in manufactures, based both on international differences in relative availability of labor skills and on inter-country differences in ability to develop new products. In particular, the proposition is examined that the neo-technology theory and the theory based on factor proportions are complementary in a sense of being applicable to two different classes of manufactured products, the "new" goods and the "mature" goods, respectively. Also, an attempt is made to demonstrate that if both approaches are empirically applied, in a cross-country analysis, to the same broad group of manufactures, neither can be ruled out as a potentially viable explanation of export patterns.

The dissertation proceeds in three parts and ten chapters. Part I contains the survey of the literature. In Chapter 2, the Ricardian theory, the Heckscher-Ohlin theory, and the neo-factor extension of the Heckscher-Ohlin model, along with the relevant empirical work, are reviewed. Chapter 3 presents the attempts to theoretically cope with such important aspects of manufacturing trade as international differences in technology, factor mobility, imperfect competition, economies of scale, and product differentiation. In Chapter 4, the neo-technology theory of trade, and the empirical tests of it are surveyed.

Part II outlines a simple formal model of competitive advantage, based on international differences in skill abundance and in the stock of product-specific technological knowledge, as well as on the assertion that skill intensity decreases in the process of product's maturation. Testable hypotheses are formulated.

The empirical analysis, along with the presentation of the results, follow in Part III. Chapter 6 describes the country and the commodity samples, the variables, and data used in the test. The proposed commodity specificity of the factor proportions theory and the neo-technology theory is examined in Chapter 7. The general validity of the two approaches is tested in Chapter 8. Chapter 9 contains the analysis of the implied dynamic changes in international specialization. Some concluding remarks are given in Chapter 10.

CHAPTER 2

THE STANDARD THEORIES OF TRADE IN MANUFACTURED PRODUCTS

2.1 The Ricardian Theory

Unlike some earlier theories, Ricardo's work[1] relates trade patterns in manufactured goods to factors other than natural monopoly. It is the relative labor productivity what the model treats as the determinant of comparative advantage. Relative labor productivity, in turn, depends on differences in production technology. It seems then that the Ricardian theory could be of interest if one wishes to look at the international trade pattern as a reflection of cross-country differences in technology. However, in Ricardo, the origins of the differences in technology are left unspecified. There is quite extensive literature critical of the Ricardian orthodoxy, raising this particular point.[2]

Ricardo's contribution to the tradition of pure theory of international trade was to initiate the theoretical development which was later continued by Mill, Marshall, Heckscher, Ohlin and Samuelson. The continuity in the framework of the pure theory of trade from Ricardo to the Heckscher-Ohlin model and its extensions has been stressed, among others, by Findlay (1977) and Haberler (1977). It can be argued that many of the criticisms addressed to the factor-proportions theory would apply to the Ricardian framework as well. It would be unjust, however, to dismiss the theory of comparative costs as empirically uninteresting or not amenable to extensions. In fact, it did inspired some useful investigations[3] which indicate that under certain conditions and, in certain activities (generally those based on natural resources), the model may serve as a good tool for explaining trade patterns.

The Ricardian model has been subjected to some successful empirical testing. The relevant work is surveyed in Stern (1975) and Bhagwati (1964). The two major tests, however, by MacDougal and Stern, have been given quite harsh treatment. Haberler finds them "either superfluous...or inconclusive."[4] Johnson calls the results "surprisingly successful,"[5] but later he proceeds to show that they do not confirm much more than just "the general--though almost tautologous--proposition that comparative advantage determines trade patterns (and that they do not) throw any great light on the nature and sources of comparative advantage itself."[6]

In summary, it can be claimed that, generally, the Ricardian theory provides too crude a model to cope with the complexities of modern trade in manufactured products. In particular, it fails to account for the origins of international differences in productive technology.

2.2 The Heckscher-Ohlin Theory

2.2.1 The Factor Proportions Framework

The principal thesis of the factor proportions theory regarding the commodity structure of trade is that a country will export goods which intensively use the country's relatively abundant factor. The pioneering theoretical work by Ohlin (1933) and Heckscher (1949) has been followed by numerous attempts[7] to derive the basic results within the framework of a formal 2x2x2 model. These resulted, among others, in the Rybczynski theorem, the Stolper-Samuelson theorem and the factor-price equalization theorem in the form we know and use today. These contributions added significantly to the elegance and precision of the model's structure but, unfortunately, they have left the false impression that the original work was equally dependent on restrictive assumptions and equally unable to consider possible departures from these assumptions. In Johnson's words, these theoretical refinements "disregard some of the more penetrating insights"[8] of the original formulation. According to Haberler, "the two-factor assumption especially deviates sharply from the original Heckscher-Ohlin theory."[9] Findlay goes even further to say that Ohlin's "vision of the international allocation of economic activity is much broader and richer in scope than (the factor-proportions core of this general equilibrium analysis) would imply...."[10]

However critical one might be of the way the neoclassical theory of international trade actually evolved, it has to be admitted that it has been widely accepted for half a century as the single most efficient explanation of trade patterns in manufactures. At least part of that acclaim has been due to the inability, on the part of the economic theory, to devise an approach that would be both equally straightforward and equally capable of explaining the observable facts.

The usual list of complaints about the restrictiveness of the model includes dissatisfactions about one or more of the following assumptions: (a) static and internationally uniform technology, (b) linear homogeneity of the production function, (c) internal mobility and international immobility of productive factors, (d) homogeneity of factors and products, (e) absence of factor-intensity reversals, (f) a 2x2x2 structure of the model, (g) competitive markets, and (h) homotheticity of consumer preferences.[11]

It seems clear that each of the above assumptions is at variance with casual observation and well-established facts. Extensive literature exists which questions the static and uniform character of technology. Hufbauer (1966) says that "economists of all schools now agree that substantial technical differences do exist between countries...,and the differences greatly weaken the factor proportions theory as an explanation of trade."[12] Further, Baldwin (1979) points out that

> "There is widespread agreement...that a simple two-factor... version of the Heckscher-Ohlin theory is inadequate. Such assumptions...as the homogeneity of labor supplies, constant returns to scale and international immobility of productive factors seem to be sufficiently violated...so that relative proportions of labor and capital are but one of several factors influencing the commodity patterns of trade."[13]

He also indicates inadequacy of the 2x2x2 structure of the model, but then goes on to argue that the factor content interpretation of the theory, due to Travis and Vanek, holds for the expanded model as well.[14] Krueger (1977) investigates how the model would perform under distortions in product- or factor markets.[15] Minhas' work[16] leads to the conclusion that factor-intensity reversals are the empirical reality. The restrictiveness of the preference homotheticity assumption is pointed out by Bhagwati (1964).[17] Finally, Haberler (1977) states that "if monopolistic markets cover large areas of the economy, it becomes difficult to incorporate them in the general equilibrium system."[18] Johnson (1968)[19] seems to argue along similar lines.

The manufacturing trade we wish to focus on in this paper exhibits all the characteristics of modern industrial competition: new products, superior production technology, monopolistic competition, international differences in labor quality and consumer preferences, the competitive role of scale economies, and international factor mobility. Hence, from the theoretical point of view, the original version of the factor proportions framework will be insufficient as a sole explanation of trade in manufactured products. It seems appropriate, however, to allow for its role in determining specialization patterns whenever and wherever the significance of the above mentioned factors ceases. One is encouraged to treat the Heckscher-Ohlin orthodoxy this way by what Ohlin himself admits in his retrospective view of his early work, "In my old analysis of international economic relations (1933), I chose to disregard the causes of differences in technology....This was, of course, a conscious but serious omission."[20] After all, as Linder says,

> "...nobody has in earnest questioned the basic principle of the factor-proportions theory. Not even Leontief...dared to conclude that the factor-proportions approach was unsatisfactory. There are, however, alternative ways of explaining differences in relative price structures. The factor-proportions account is only one of the many."[21]

Similarly, Hufbauer, summarizing his impressive empirical work, points out that "...many different characteristics express themselves in export patterns. No one theory monopolizes the explanation of manufactures trade."[22] Therefore, a broader model of specialization in trade is called for, in which a place for the factor proportions component would be secured for the purpose of explaining trade in products conforming to the set of Heckscher-Ohlin assumptions. We will argue later that trade in manufactures strongly affected by the violations of these assumptions is better explained by forces other than factor proportions.

There is another reason for having elements of the factor-proportions account in the analysis like this. We will be interested in trade between countries where factor abundance differences, measured by the factor price ratios, are particularly pronounced. Specifically, the case will be exemplified by a developed innovating economy on the one hand, and the less developed or newly industrializing and imitating economy on the other. Helleiner makes a remark that "it can plausibly be argued that trade in manufactured goods between developed and less developed countries is more likly to be explicable in terms of factor proportions theory than is such trade among the developed countries themselves."[23] If a DC and LDC, and particularly a newly industrializing country (NIC) are partners in trade, it is possible that as production technology differences in a product life cycle disappear and a good becomes relatively less skill-intensive, the "low-wage trade" consistent with the Heckscher-Ohlin prediction will follow. This appears to be more likely than in trade among equally advanced countries where the relevant country characteristics are not so dissimilar.[24]

In summary, it can be concluded that, from a theoretical point of view, the standard Heckscher-Ohlin model remains a potentially useful explanatory device, although the scope of its applicability is probably narrower than it was originally presumed. In Chapter 3, we will further explore some modifications of the factor proportions framework aimed at dealing with technology differences and other complications of the economic reality. Before that, however, a brief review of the empirical research of the conventional model, and of its neo-factor version is in order.

2.2.2 Empirical Work

The famous finding by Leontief[25] that, contrary to the Heckscher-Ohlin model's prediction, U.S. import-competing industries were more labor-intensive than imports, sparked a series of further investigations. Surveys of that work are provided in Stern (1975), Bhagwati (1964), Caves and Jones (1981),[26] Woodland (1982),[27] and Deardorff (1984). Similarly disturbing results have been confirmed for other countries, among them Japan, India and West Germany. Also, many studies followed that were aimed at explaining the Leontief paradox. This has been done either by attempting to reconcile it with the neoclassical model or by showing that, in fact, there is nothing paradoxical about it. The latter approach boils down to indicating the model's restrictions which are responsible for Leontief's result. It is from this family of studies that the neo-factor approach originates. This approach focuses on international differences in labor skills or human capital. In some sense, the Leontief paradox and the literature that followed have also given rise to the so-called neo-technology account of trade, which emphasizes the role of international differences in technology and R&D effort. Both these theories will be reviewed later in this survey. Other attempts to explain the paradox include those which deal with inter-country differences in natural resources and consumer preferences, the possibility of factor-intensity reversals, and the mutlilateral character of trade. Hence, the Leontief paradox proved exceptionally fruitful in stimulating research and being more or less directly responsible for the emergence of many fine theories.

Leontief's methodology has been reapplied by many authors and in most cases the results have reaffirmed the paradox. Especially interesting are the tests which contrast the Heckscher-Ohlin model with the alternative explanations of trade patterns within a single testing framework. Perhaps the most celebrated is that by Hufbauer (1970), using the 1958 U.S. input-output table and 1963 trade data. Hufbauer reached the conclusions similar to Leontief's original findings. The U.S. exports failed to show any pronounced lead over imports in terms of capital intensity. He found, however, that the model performs surprisingly well in accounting for export patterns of the sample of 24 countries examined as a group.[28] National fixed capital per man turned out to be strongly correlated with capital embodied in countries' exports. A weak point of this test is that capital intensity and skill intensity are correlated on a commodity basis. Hufbauer himself admits that the good performance of the Heckscher-Ohlin theory may be due to the cross-correlation with human skills.

Baldwin (1971, and especially 1979) repeated the test on the expanded sample and obtained results confirming Leontief's paradox. Also he showed that R&D is an important source of U.S. comparative advantage, and that human capital variables play a significant role in establishing trade patterns of most of the countries in the sample.[30]

Balassa's "stages approach" to comparative advantage[31] represents another follow-up to Hufbauer's test. As proxies for the physical and human capital-intensity, Balassa used Lary's measure of value added per worker,[32] and value of the capital stock plus the discounted value of the difference between average wage and unskilled labor wage, divided by the number of workers. He estimated multiple regression equations for manufactured exports of 36 countries and discovered that the physical capital variable, if coupled with the human capital measure, explains a significant part of export structure. However, Hirsch (1974a) found that if physical capital is considered separately from human capital it fails to perform satisfactorily, while human capital performs quite well on its own.[33]

Finally, it may be of interest to note Hesse's (1974) analysis of the Heckscher-Ohlin model's ability to explain intra-industry trade.

His conclusion is that the explanatory value of the model is low and, instead, the hypotheses based on product differentiation, technical progress, and economies of scale are of importance.[34]

There is no question that the tests sampled above, like most of the empirical work in trade theory, suffer from various types of deficiency, whether it be imperfections and paucity of data, or misconceptions surrounding the choice of proxies. Nevertheless, it is hard to contest the basic conclusion from these findings. The standard Hecksher-Ohlin model shows a rather poor performance in explaining trade patterns, especially if other possible determinants of trade patterns are allowed for in the empirical framework. Consequently, in futher discussion we will concentrate our attention on some modified versions of the Heckscher-Ohlin model.

2.3 The Neo-Factor Theory

2.3.1 Extentions of the Factor-Proportions Framework

Many extensions of the conventional factor proportions framework are concerned with obtaining the standard Heckscher-Ohlin results from the model structure incorporating more than two factors, and two or more goods. N-factor extensions are due to Vanek (1968) and Trent (1972). Among the latest studies, Dixit and Norman (1980) have developed the general factor-abundance hypothesis, and Dixit and Woodland (1982) have analyzed the multi-product, multi-factor version of the Heckscher-Ohlin model. The follow-up to that work came in Svensson (1982) where the generalization of the Heckscher-Ohlin theorem has been derived and, additionally, trade in factors has been considered.

In the context of the present study, it is especially interesting to look at the genre of models which extend the Heckscher-Ohlin orthodoxy to three precisely specified factors. Except for physical capital and unqualified labor, the new third factor included in these analyses is human capital, or labor skills. Other assumptions of the factor proportions framework remain essentially intact. This approach to explaining trade in manufactures will be referred to as the neo-factor theory or, alternatively, as the skill or human-capital account of trade. Central to this theory is the proposition that international differences in the quality of labor may be an important determinant of trade patterns.

Leontief, himself, suggested that his finding might be due to relatively high labor productivity in U.S. exports. In fact, he showed that U.S. exporting industries employed comparatively more skilled labor than import-competing industries.[35] At the same time, Kravis (1956b) reported higher wages in the production of U.S. exported goods than in import-competing goods.[36] Both findings pointed to potential importance of the "third factor," labor skills or human capital, in explaining trade patterns. Models investigating this possibility are surveyed in Branson (1977). As Haberler put it, it was believed that "...the Leontief paradox would largely disappear if labor skills were taken out of labor supply and put into the capital coefficient where they belong."[37] The conventional Heckscher-Ohlin prediction was replaced by the hypothesis that a country which is relatively skill-rich would export relatively skill-intensive goods.

The labor-skills factor was studied by Keesing (1966, 1968). A theoretical rationale for altering the Heckscher-Ohlin model is developed there, and a descriptive model is worked out conceptually.[38] Bhagwati (1977) focused on possible demand and supply-side implications of labor's quality for LDC's trade.

Kenen (1965, 1968, 1970) made some efforts to rescue the Heckscher-Ohlin tradition by adopting a somewhat different approach. He argued that "anomalies and contradictions that generate dissatisfaction with the Heckscher-Ohlin model appear to derive from the peculiar concept of capital used in that model."[39] Then he treated a capital good in his model not as actually entering the production function, but merely "improving" the natural endowments of land and labor. Viewing capital as the "progenitor of other inputs, having an indirect marginal product"[40] derives from Becker's and Schultz's theory of human capital, which stresses complementarity between capital and labor.

Hirsch (1974a) makes a similar point. He includes human capital as a distinct determinant of export performance, and argues that skill and capital, or human and material capital, are complements.[41] This is the assertion he uses to explain the superior performance of variables other than factor proportions and, specifically, the technology-related variables in his study. The argument goes as follows. Technology is relatively less mobile across countries than material capital. Hence, if skill and capital were substitutes, the scarcity of skills in a less developed economy could be compensated by investing more in creating skills. However, because of the complementarity, the "...increase in the availability of (skills) is necessary before the productivity of (capital) can be increased."[42] Hirsch argues that this requires investment in training, R&D and technological knowledge. Therefore, the ability to do this is what ultimately matters for a country's comparative advantage. Thus by singling out human capital or skill as the third factor, he comes up with quite a surprising result. Namely, he points out that the ability to innovate in a product and/or production process might have an even stronger explanatory power than factor proportions within the three factor model itself.

A compelling feature of the neo-factor analyses is that they transcended the rigid two-factor framework and, by doing that, indirectly helped to recognize the importance of the determinants of trade other than factor proportions. This was accomplished mainly through the results of the empirical research, to which we now turn.

2.3.2 The Empirical Work

The empirical tests of the neo-factor theory have been customarily performed by relating, through the correlation or regression analysis, the relative skill abundance to skill intensity of exported goods. Alternatively, as in Kravis (1956b), the skill contents have been computed for an analyzed country's exports and imports, and subsequently examined for consistency with the country's presumed relative abundance of skills.

Irrespective of the exact empirical approach, a formidable problem to overcome in testing the neo-factor theory is that of the empirical representation of skill intensity of exported commodities, and of skill abundance. Given the lack of direct data on these two, various proxies have been experimented with. The most frequently used have been those based on skill ratios, wage differentials, and value-added statistics. Here is a brief review of some more important studies.

Keesing (1986b) distinguished eight occupational groups varying in skills, and studied the U.S. skill requirements for 46 manufacturing industries in 1960. Then, he computed the "net balance of requirements" for each skill in trade of ten leading industrial countries. These he defined as the skills required to produce a country's total exports of manufactures minus the skills that would be required to replace its imports of manufactures. In accordance with his expectations, he found that the countries in his sample were net exporters in all or most of the skill classes.[43] In another article, Keesing (1965) used the skill ratio data as a proxy for industries' skill intensity, and he confirmed that trade patterns can be explained in terms of countries' skill availabilities and industries' requirements of this factor.

Katrak (1973) also used the skill ratios to examine, by the correlation and regression techniques, the human skills model. He found that the theory had a partial success. He concluded that "the analysis of international trade flows in terms of industries' requirements of skilled/unskilled labor and countries' relative endowments of labor skills may be more meaningful than the earlier analysis in terms of physical capital and labor alone."[44]

Rather than using skill ratios Kravis (1956b) looked at wage differentials. He showed that the U.S. exporting industries were characterized by relatively higher wages, which would confirm the neo-factor approach inasmuch as wages are correlated with skills. Kravis proposed, however, that the result may be due to labor-saving technical change raising productivity in these industries, and/or to the fact that these industries tend to produce newer, improved goods.[45] If this presumption were true, it would be indicative of complementarity between the neo-factor and the neo-technology determinants of the composition of trade. There is some evidence of correlation between the relevant commodity characteristics that seems to be supportive of such thesis. We will look more closely at this problem later in the discussion.

Hufbauer (1970) discussed wage differences versus skill ratios as the alternative proxies in skills theory. Despite some limitations, both interpretations yield good results in his study. Skill abundance is strongly correlated with skills embodied in exports. Hufbauer concludes that, with little ad hoc empirical manipulation or theoretical amplification, the skill theory goes a long way to explain trade in manufactured goods.[46] Yet it is worth pointing out that other accounts of trade and, specifically the neo-technology or the product cycle approach, also show a good performance in Hufbauer's comparative study.

Branson and Junz (1971) performed multiple regressions on Keesing and Hufbauer's data and found a positive relation of the U.S. net exports to human capital per man.[47] Later, responding to some criticisms of that test, Branson (1971) repeated the exercise by scaling the variables in the regression to reflect industry size, and strengthened earlier results.

Kenen (1965), using a 9 percent discount rate to compute human capital from the wage data, aggregated physical and human capital and discovered that, as expected, U.S. net exports were capital-intensive. Lary (1968) reached the same conclusion by taking value added as a return on total capital input.[48] However, value added per employee performed poorly in the multi-variable regression ran by Helleiner (1976) for manufactured exports of LDCs. He concluded that an average wage would be a more useful proxy for skill-intensity, at least in the case of less advanced countries.

Hirsch (1974a) distinguished three groups of industries according to the correlation between Balassa's index of revealed comparative advantage and per capita value added, the latter being taken as a measure of physical and/or human capital intensity of an industry. Paradoxically, it turned out that the classification of industries into these three groups was more consistent with their ranking by the percentage of R&D in income than with the ranking implied by value added per employee.[49]. Although a positive correlation between human capital endowment and export performance of human capital-intensive industries was confirmed, Hirsch found that the neo-technology variables again performed better in his test than the neo-factor model.

The neo-factor account also receives some support from the empirical analysis by Lowinger (1975). In this study, performance of the U.S. export industries appears to be positively related to human capital-intensity, while physical capital-intensity has a negative coefficient.[50]

Baldwin (1979) found that human capital variable was largely responsible for the direction of trade of most of the countries in the analyzed sample. In his earlier study[51] he found, too, that the U.S. trade balance was negatively related to industry capital/labor ratio and, the coefficient for "scientists and engineers" was positive, although not significant at the 10 percent level. Harkness and Kyle (1975) reanalyzed Baldwin's 1971 data. They broke down labor force into several disjoint skill groups and used a binary measure of comparative advantage.[52] The result was that all types of skilled labor were sources of the U.S. comparative advantage.

In summary, there is a strong empirical evidence supporting the neo-factor model and pointing at its superiority over the two-factor formulation of the factor proportions theory. However, it appears from these findings that a more realistic and accurate account of trade could be obtained if this model was combined with and, in some instances perhaps even substituted for, the neo-technology approach. This pertains primarily to trade in the industries in which innovation and technology differences among countries are essential. This possibility will be explored further in the paper.

Now, we will devote some attention to selected aspects of industrial trade which the original factor-proportions and neo-factor models seem unable to deal with. The remaining two chapters in Part I attempt to track down the evolution of trade theory in response to the growing realization of the complex nature of trade in manufactured products.

FOOTNOTES

[1]Ricardo (1971), particularly Chapter 7. A thorough discussion of the model is provided in Bhagwati (1964). A refinement of the Ricardian framework within the model with factor specificity has been made by Haberler (1936).

[2]See, for example, Johnson (1968), p. 8. Also, Walker (1979), pp. 2sqq.

[3]E.g., the analysis of technology creation and diffusion in a Ricardian world by Pugel (1982) and the investigation of "Ricardo goods" by Hirsch (1974b).

[4]Haberler (1977), p. 2.

[5]Johnson (1968), p. 8.

[6]Ibid., p. 28.

[7]The most important are those by Rybczynski (1955), Samuelson (1948, 1949), and Stolper and Samuelson (1941). Also, Jones (1973).

[8]Johnson (1970), p. 11.

[9]Haberler (1977), p. 3.

[10]Findlay (1977), p. 57.

[11]Without going into details, note that particular results of the model do not hinge upon all of these assumptions. Some efforts aimed at relaxation of certain restrictions will be discussed later.

[12]Hufbauer (1966), p. 20.

[13]Baldwin (1979), p. 40.

[14]Ibid., p. 41. For more on the "factor content interpretation" vs. the "commodity interpretation" of the theory, see Deardorff (1984), p. 479.

[15]Krueger (1977), Chapter III.

[16]Minhas (1962). It has to be noted, however, that there are empirical reasons for certain amounts of skepticism about factor-intensity reversals. Hufbauer finds them, at most, "relatively unimportant." See Hufbauer (1970), p. 152.

[17]Bhagwati (1964), p. 19.

[18]Haberler (1977), p. 11.

[19]Johnson (1968), pp. 12-13.

[20]Ohlin (1977), p. 39.

[21]Linder (1961), p. 16. Linder goes on to apply the Heckscher-Ohlin account to trade in natural resource-intensive products. However, for manufactures, he formulated an alternative approach which I shall describe later in the paper.

[22]Hufbauer (1970), p. 194.

[23]Helleiner (1976), p. 511.

[24]Implicit in this generalization is an assertion that in the latter case the intra-industry trade, if any, would be a more likely outcome. The reason is that in this case partners enjoy similar relative factor prices and there is less scope for inter-industry specialization according to the factor proportions prediction.

[25]Leontief (1953, 1956).

[26]Caves and Jones (1981), pp. 144-151.

[27]Woodland (1982), pp. 378-381.

[28]Hufbauer (1970), pp. 162-172.

[29]Ibid., pp. 161, 164.

[30]Baldwin (1979), p. 46. In fact, in his further analysis, Hufbauer also found neo-factor and particulary neo-technology variables to be extremely relevant. See Hufbauer (1970), p. 195.

[31]Balassa (1977c).

[32]Lary (1968). For a critical discussion of this measure see Hirsch (1975), pp. 313-314. Hirsch points out that value added per employee may represent both capital and skill-intensity. It is therefore, not clear which theory is tested if this measure is used. Lowinger logically argued that only wage and salary component of value added can be taken to represent human capital-intensity, while the non-wage component reflects physical capital. Lowinger (1975), p. 229.

[33]Hirsch (1974a), p. 551.

[34]Hesse (1974), pp. 47, 59.

[35]See Leontief (1956), p. 399.

[36]Kravis (1956), p. 145. Kravis went one step futher to say that it is differences in productivity, not being offset by equivalent differences in wages, that will be the proximate cause of trade. Hence, these (rather than wage differences themselves) are likely to determine market shares enoyed by countries producing similar goods (see pp. 146-147). The alternative view might be that wage differences are the product of skill differences so that the former can be used as a measure of the latter in testing the labor-skills theory. For example, see Hufbauer (1977), p. 5.

[37]Haberler (1977), p. 5.

[38]Keesing (1968), pp. 5-11.

[39]Kenen (1965), p. 440.

[40]Kenen (1968), p. 101.

[41]Hirsch (1974a), pp. 556-557.

[42]Ibid., p. 557.

[43]Keesing (1968b), pp. 16-17.

[44]Katrak (1973), p. 351.

[45]Kravis (1956b), p. 152.

[46]Hufbauer (1970), p. 175.

[47]Human capital was defined as the difference between the average wage in the industry and the median income, capitalized at the 10 percent rate. See p. 755.

[48]Lary (1968), pp. 20-43.

[49]Hirsch (1974a), p 545.

[50]Lowinger (1975), p. 233.

[51]Baldwin (1971).

[52]In their logit analysis, they are interested only in whether an industry is a net exporter or a net importer, while ignoring the magnitude of export performance.

CHAPTER 3

SELECTED ISSUES IN MODELLING TRADE IN MANUFACTURED PRODUCTS

3.1 Departures from the Idealized World of the Factor Proportions Theory

In Section 2.2.2, we looked at some studies assessing the empirical validity of the traditional two-factor Heckscher-Ohlin Model. In comparative studies, its performance has generally been below the expectations, and also not as good as that of some new unconventional approaches. It can be argued that this may have been due to the restrictive assumptions underlying this theory, and due to its failure to account for some crucial factors, all being unquestionably important characteristics of the modern division of labor in manufactures. These factors are: international differences in technology, imperfect competition, economies of scale, factor mobility, and product differentiation. Their presence suggests the need for new unorthodox ways to explain trade patterns in manufactured goods.

3.1.1 The Technology Factor and Innovation

In the neoclassical theory of trade, authors have frequently referred to technological progress and international difference in technology as factors that might alter the results. Yet these factors have been rarely explicitly admitted in the analysis itself. Some models deriving the comparative statics results with technical progress are listed in Bhagwati (1964). Other studies of that type are those by Amano (1964),[1] Jones (1970),[2] and Markusen and Svensson (1983).[3] The basic weakness of these models is that they all are of static nature and fail to recognize endogeneous technology variations.[4] Due to their complex structure, they are not readily amenable to testing and, to my knowledge, they have not been subject to any serious empirical investigation.

International differences in production technology that are of special importance to trade patterns are those introduced by innovative activity. That, in turn, should be viewed as induced by economic forces, rather than exogeneous. Casual empiricism suggests that innovative ability is not evenly distributed among countries. Firms in some countries are particularly capable of performing basic and applied research as well as development activities leading to innovations, whether they be of a product or a process type, or both.[5] Other factors being equal, each type gives the innovator a competitive edge over potential producers abroad. The process innovation may do that by cost reduction through the productivity gain and/or through factor substitution. The product innovation does that by leading to the invention of a new commercially valuable product.

The access of foreign firms to the innovation will be limited if legal (patent law) or natural (imperfect information) barriers exist. Therefore, at any given moment, production functions will differ internationally. Moreover, firms of some countries will lack technological knowledge necessary to produce goods successfully marketed by firms originating from other countries.[6] Technological knowledge in its various embodiments may be however, transferred through licensing, imitation, as a free good, or as a factor accompanying foreign direct investment. Logically, the speed of technology diffusion to any particular firm not being an innovator affects inversely the duration of this firm's competitive disadvantage. Advantage shifts from one country to another if the technological knowledge needed to produce a new good at cost comparable to that of the innovator, is acquired by firms in a country with factor supply advantage. Before that happens the good may have matured and become more standardized. Market demand for it stabilizes. The productive technology becomes more stable and exhibits economies of scale. Skill intensity is likely to have decreased. A resumption of the production by the relatively skill-scarce imitator becomes economically justified. The shift of the advantage from one country to another may trigger the international movement of capital, while the inventive effort in the innovating country is channelled to another product. The scenario indicates that the actual trade patterns in new products may be inconsistent with the simple factor-proportions prediction. However, trade in mature goods might be in accordance with that prediction. The model developed in Chapter 5 explores the problem in more detail.

The dynamic process sketched above, and set in motion by inter-country disparities in innovative capability, raises the problem of the forces inducing technological innovation. Majumdar (1982) and Haeffner (1973) stress the significance of an identifiable market "need" for innovation.[7] The need is generated by rising income per capita and the emerging bias of customers' preferences toward products of higher quality or "new" goods; i.e., goods providing new sets of attributes. This is on the demand side. On the supply side there is a variety of factors. One is the availability of the necessary technological knowledge which may be viewed as a function of R&D expenditures. Although investment in R&D does not necessarily lead to innovation, it can be looked at, similary as "need" as a necessary condition for it. In particular, as Phillips (1971) points out, basic research, exogeneous to firms, and usually government sponsored, lays the ground for endogeneous applied research by firms. Hence, the availability of discretionary funds for basic research at the national level seems to facilitate the speed of ultimate industrial innovations.[8] The importance of the market need on the one hand, and R&D on the other, explains why DCs, where there is a particular drive to enhance the technology of consumption, where the share of industrial R&D in sales is relatively high, and where significant basic research is done, are also world leaders in innovating processes and products.

Another possible explanation of the distribution of innovative activity is that based on relative factor costs. Hicks (1932) was the first to notice responsiveness of innovation to factor endowments. Later, Habakkuk (1962) discussed that type of relationship. Davidson (1979) tried to demonstrate that the link between the domestic relative factor costs and the direction of the innovative effort may result in trade patterns which contradict the Heckscher-Ohlin prediction.[9]

Rather than studying innovation, Findlay (1977) looks at determinants of the imitative effort. He argues that the "rate of technological progress in the backward region is an increasing function of the gap or distance between its current level of technological efficiency and that of the advanced region."[10] Later, he offers a suggestive analogy between diffusion of technology and contagion, as in the spread of an epidemic, with multinationals being the major "carriers." Other factors being identical, then, the technical progress in a country would depend positively on the level of openness to economic penetration by foreign firms. This hypothesis seems to square with rudimentary observations from the Asian newly industrializing countries, as opposed to some other less advanced economies, at which we will look more carefully later in this chapter.

Finally, it is useful to notice the relevance of Arrow's (1962) theory of endogenous change in productive knowledge through the process of learning-by-doing. Learning is, among others, a product of experience and as it proceeds it causes intertemporal and international shifts in production functions. In Arrow, it is just a by-product of ordinary production and, other factors affecting the accumulation of knowledge, like R&D or international transfer, are suppressed.

In summary, by accounting for the responsiveness of innovation to one or more of the factors listed above (market need, R&D, relative factor abundance, the extent of the technology gap, and learning by doing), one may treat international differences in technology as an endogeneous phenomenon. As we have tried to show, the standard trade theory based on factor proportions fails to accomplish that.

What remains to be done here is to address the problem of measurability of innovative activities. This is important for international comparisons and for empirical testing. Some of the related problems are raised by McCulloch (1978), Walker (1979), Pavitt and Soete (1980), and Piekarz, Thomas and Jennings (1982). In general, the available measures are of input type (R&D expenditures, scientists and engineers engaged in R&D, scientific and professional publications), or output type (patent statistics, major innovations, sales of technical information, productivity level). Clearly, neither of these two types is perfect. This is due to the limited accuracy of the former, and sometimes poor correlation with actual output of innovations; and due to paucity of data on the latter. Since input proxies are burdened with various types of biases,[11] it would be optimal to be able to use data on the output of innovations. That, however, is hardly available on an internationally comparable basis. Given that, statistics on industrial R&D have become widely accepted as the most useful measure of innovative activity. There is some evidence showing the relevance of the R&D-based proxies for assessing innovative activity and the resulting changes in the productive technology.[12]

3.1.2 Factor Mobility

In this section we are concerned with foreign direct investment (FDI) and its implications for trade theory. Since the Heckscher-Ohlin theory is being blamed for assuming that factors are immobile internationally, a proper question to ask is why it is important to consider the possibility of factor mobility in a trade model.

One general reason is that trade flows could be affected by factor flows if the latter exist. This results from the fact that these two are rarely unrelated. Mundell (1957) showed them to be complete substitutes within the Heckscher-Ohlin-Samuelson model with identicity of production functions. A similar result has been obtained by Krugman (1979) in the model with internal economies of scale. Purvis (1972) demonstrated that factor- and product-mobility may be complementary to each other if production functions differ. Kojima (1975) explored both possibilities and formulated conditions under which FDI is "trade-oriented" or "anti-trade-oriented." Similar exercises, examining conditions for trade and factor movements to be substitutes or complements within rigorous models, have recently been done by Svensson (1982), and Markusen and Svensson (1983). Empirically, Baldwin (1979) verified that U.S. net exports and FDI can be essentially explained by the same variables. Both tend to be relatively high in industries employing well-educated labor.

Given the above, it is possible that trade performance alone may be a misleading proxy for a country's comparative advantage. The advantage may encompass both the ownership-specific factors (e.g., know-how internalized in a firm) and the location-specific effects (e.g., factor endowment in the country of production). This distinction is important as it recognizes that goods are produced, and possibly exported, not by countries but by firms which may operate across national boundaries. This reflects the weakness of the factor proportions theory which focuses on national characteristics rather than on attributes which can be internationally transferrable at a micro level.[13] This also suggests that export may be, in fact, substituted or complemented by non-trade foreign activity. Parry (1974) was perhaps the first to empirically examine the overall foreign performance in order to reveal the U.S. comparative advantage representable by both trade and non-trade foreign activities.[14] Theoretically, the problem of relationship between trade and the location of international production has been explored by many authors. One example is Vernon's (1966) product cycle hypothesis which is presented in more detail in Section 4.2.3. Others include Caves (1971), Dunning (1973), and Hirsch (1976). Interrelatedness between the trade theory and the theory of FDI, brought about largely by development of the neo-technology approach to trade, has been analyzed by Helleiner (1973),[15] Caves (1974),[16] Erdilek (1976), Dunning, (1977), Ohlin (1977),[17] and Majumdar (1982).[18]

3.1.3 Imperfect Competition

The assumption of perfectly competitive markets is critical to the conventional trade theory. On the other hand, the reality of international exchange in manufactured products abounds in examples of goods being subject to imperfect competition, whether it be due to product differentiation or technological leads and lags. This means that, at best, the domain of empirical applicability of the neo-classical theory is restricted to exchange in which market imperfections are less pronounced. Haberler (1977) has gone so far as to argue that the factor-proportions approach is inadequate in the case of modern trade in manufactures because of the existence of imperfect markets. Gray (1973) proposes that Chamberlinian monopolistic competition, rather than perfect competition, is an appropriate notion to underly any trade model purporting to explain the essentials of real-life specialization in manufactures. The new genre of trade models involving imperfect competition have appeared in recent years, the examples being Krugman

(1979), Markusen (1981), and the intra-industry trade literature. Krugman (1983) gives a brief review of these approaches. The earlier, and formally less rigorous, contributions which derive more or less directly from the notion of monopolistic competition are reviewed by Johnson (1967). Finally, the neo-technology approach to trade, more thoroughly presented in Chapter 4, deserves credit for embracing the notion of empirically observable market imperfections. By focusing on technological superiority of one trade partner over another, and by allowing for new products to emerge, virtually the entire body of the neo-technology theory shows interest in product differentiation as a means of monopolistic competition.

Most of the approaches referred to above may lack that unique mixture of simplicity and formal rigor which characterizes the factor proportions theory. They seem to mark, however, major progress in bringing about a more viable empirical account of trade in manufactures.

3.1.4 Economies of Scale

The Heckscher-Ohlin model assumes homogeneity of degree one of production functions, thus suppressing the possibility of variable returns to scale. There are few exceptions, like Panagariya (1980) and Horn (1983), where the basic comparative statics results of the Heckscher-Ohlin model are examined under non-homotheticity. Scale economies are important as they may result in export patterns which cannot be explained by the traditional factor proportions theory. With all other factors being identical between two economies, one may gain competitive advantage, and possibly start exports in a good in which it enjoys more advantageous economies of scale in the production or in R&D.

The central hypothesis of the scale-economy explanation of trade is that countries possessing large home markets with high purchasing power tend to produce and export goods whose production is characterized by increasing returns to scale. Clearly, this hypothesis is valid only to the extent that tariffs or other barriers prevent small economies from producing this type of good for export. The hypothesis has been suggested by Dréze (1961) who blended it with the commodity standardization argument into what explained exceptionally well Belgium's specialization in semi-finished manufactures. The story goes as follows. A small country is unable to affect tastes in world markets,and where it can benefit from scale economies is in the internationally standardized products. In turn, if a good is differentiated (e.g., by brands, tastes, or technical standards) the bigger countries will tend to exploit scale economies because of their ability to impose the differentiating factor on export markets. Hence, it will be a bigger country, with substantial purchasing power in the home markets, who specializes in relatively differentiated goods. This illuminates the proximity of Dréze's hypothesis to what the neo-technology account predicts; namely that the developed economies export more differentiated goods than the less advanced countries. The latter, small in a sense of limited domestic purchasing power, and with preference bias towards cheaper standardized goods, specialize in commodities produced according to international standards.

Another view of the economies of scale and their impact on trade patterns in manufactures, has been advanced by Posner (1961). Posner proposed the dynamic scale economy hypothesis, according to which the current cost reduction may be due to the extent of past production experience in a product. The pattern of cost advantage depends then on when, relative to foreign competitors, a country initiated the production.[19]

3.1.5 Product Differentiation

The traditional factor proportions theory relies on the assumption of homogeneous products. The concept of product differentiation was developed in detail by Chamberlin (1948). One of the first attempts to explicitly incorporate it into the international trade theory in manufactured products was made by Johnson (1967). Some convenient tools for the analysis were later provided by Lancaster's (1971) "new theory of consumer demand."[20]

Gray and Martin (1980) discuss some measurability questions and the working of trade in differentiated products. Their conclusion is that Chamberlinian product differentiation may result in trade within the same Lancasterian commodity grouping. This concept constitutes the core of what is known as the intra-industry, or two-way trade theory. The literature on intra-industry trade has become quite extensive over the 1970s and includes, among others, Grubel (1967, 1970), Gray (1973), Grubel and Lloyd (1975), Finger (1975), Aquino (1978), Giersch (1979), Loertscher and Wolter (1980), and Krugman (1981). Alternative ways to explain intra-industry trade are explicated in Hesse (1974). Lancaster

(1980) himself made a contribution to explaining intra-industry trade in the model which integrates monopolistic competition and product differentiation. He came up with some results which are clearly not in accord with Heckscher-Ohlin predictions. For instance, he claims that "for countries having factor endowments ratios which are not too dissimilar, the Heckscher-Ohlin component in the overall trade pattern may be almost swamped by the reciprocal (two-way) trade in manufactures."[21]

The product differentiation argument points to another weakness of the traditional factor-proportions model, the assumption of identical and homothetic preferences. If the assumption held, there would be no product differentiation within one Lancasterian commodity group since there would be a single product specification most preferred by everybody. Linder (1961) has suggested that, in reality, preferences are biased in different countries toward different sets of commodity attributes within one product group. Furthermore firms in a country tend to have a competitive edge over foreign firms in a product variation which is most preferred in the domestic market.[22] Thus, the resulting trade structure in differentiated products may reflect the cross-country differences in consumer preferences, with relatively newly developed and more sophisticated product variations being likely to be exported by economies with high per capita income.

3.2 Some Evidence on Changing Patterns of Trade in Manufactures: The Asian Newly Industralizing Countries

Perhaps the most important empirical challenge for the traditional Heckscher-Ohlin theory was a dramatic change in international division of labor in manufactures, and the emergence of newly industralizing countries in the 1960s and 1970s.

Assessments of international manufacturing trade with the emphasis on the role of newly industralizing countries (NICs) have been made by Lary (1968), Hong (1968), and later by Balassa (1979a, 1980, 1981), Keesing (1979, 1983), Keesing and Chenery (1979), Hamilton and Kreinin (1980), Stein (1981), Lall (1981), and Hsiao and Hsiao (1983). All these studies indicate the unprecedented performance of the group of Asian newly industrializing countries (ANICs) in exports of manufactured goods over the last two decades.

During the decades of the 1960s and 1970s, the four ANICs[23] progressed markedly in concentrating their exports on manufactures. The share of manufactures in exports of Taiwan, Korea and Singapore increased dramatically over the years of 1960-75, to reach levels of 81, 82, and 43 percent, respectively. In Hong Kong, it went up by 17 percentage points, to 97 percent.[24] The value of exports grew at fantastic annual rates of 65 percent for Korea, 34 percent for Singapore, and 42 percent for Taiwan. These were, on average, significantly higher than in other NICs.[25] In 1975, the share of these four countries in exports of manufactures by all LDCs was 46 percent, compared to 35 percent ten years earlier. More importantly, their shares in some relatively skill- and R&D-intensive activities were even higher.[26]

Even these fragmentary data show that the ANICs have formed a distinct group within LDCs. Some attempts have been made to theoretically explain their spectacular emergence as the new powers in world trade in manufactures. Balassa (1971, 1977a, 1981) emphasized the role of export incentives adopted in the four countries. The role of liberal economic policies and/or outward-looking foreign trade regimes in the ANICs has also been raised by Frank (1975), Krueger (1977), and Lall (1980). After the completion of the first stage of import-substitution, Korea, Singapore, and Taiwan chose export-oriented policies relying on relatively liberal economic systems both in the internal and external sector. This was partly, as Fels (1974) points out, due to limited domestic markets, not allowing for a continued import-substitution. As a result, foreign investment and diffusion of foreign technologies have been encouraged. Indeed, the chronology of liberalizing steps taken in these countries coincide with the beginnings of the radical improvement in their export performance. In Korea, Taiwan, and Singapore, that occurred in 1964-66, 1958-60, and 1965, respectively.[27]

The explanation why the described policies could result in a vigorous expansion of the ANICs' industrial exports lies, according to the traditional trade theory, in the relatively low labor costs these countries have enjoyed. These result from relatively low wage levels, accompanied by high, at least by the LDCs' standards, labor productivity. Indeed, the ANICs' competitiveness in the industries which are intensive in unskilled labor has long been demonstrated, and it is consistent with the implications of the factor proportions theory. The theory, however, finds it far more difficult to cope with new disturbing evidence that the decade of the 1970s brought. In the 1970s, the growth rate of LDCs' exports was highest in either high-technology capital-intensive products (switchgear, telecommunications, vehicle parts, etc.), or high-fashion "new" consumer goods (home appliances, electronics).[28] Chenery and Keesing note that, while in most developed countries the four product groups representing "new manufactures" comprise over 40 percent of total manufactured exports, the ANICs are among only a few LDCs exhibiting the same characteristic.[29] Marris (1979) says that these countries "have gone beyond the stage of competing solely on the basis of low wages, and labor intensive products such as textiles, footwear and clothing."[30] Balassa (1977c) suggests that countries like Korea and Taiwan may be gradually taking Japan's place in successfully exporting on a large scale relatively human capital-intensive products.[31] Hsiao and Hsiao (1983) provide the evidence that this has, in fact, been happening. Among 39 items they analyze, there are only 8 in which Japan still holds the larger share in the U.S. market. The rest is dominated by the ANICs, and includes, among other goods, electric motors, most types of radios, transformers, pocket calculators, transistors, diodes, etc. The ANICs' exports increasingly rely upon more skill-intensive and R&D-intensive industries. Having followed the pattern of Japan's development, these countries emerge now as Japan's and other DCs' prime competitors in an array of relatively new sophisticated, high-technology products. The accompanying deterioration of many DCs' export performance in such goods in the 1970s has been reported by many authors, among others Aho and Rosen (1979), Aho and Carney (1980), and Davis (1982).

Contrary to a popular belief, the expansion of skill- and technology-intensive exports by the ANICs cannot be fully explained by the fact that these countries merely engage in assembly-type subcontracting schemes, utilizing the low local labor costs and the capabilities brought in by foreign multinationals. There is growing evidence that the imitative effort, investment in R&D, and specific commercial strategies adopted by the national firms are of primary importance.[32] These, in turn, are facilitated by the liberal economic systems, creating the economic climate which is conducive to successful technological imitation. Clearly, factor proportions alone fail to provide an adequate explanation of the phenomenon.

FOOTNOTES

[1]He allows for a shift parameter in the production function, representing the level of productive technology. Among the results, there is a prediction that relative technological advantage may generate comparative advantage. Also, formal conditions are presented under which Leontief's paradox can be explained. See pp. 393, 397.

[2]Jones modified the basic Heckscher-Ohlin model to take account of differences in production functions between countries. As in the previous study, Hicks-neutral and Hicks-biased technological change is treated as exogeneous to the model.

[3]Here also, it is demonstrated that countries will, on average, export goods in which they have superior technology, but the exogeneous character of that superiority is retained.

[4]Some dynamic models are mentioned in Section 4.2.5.

[5]For discussion and geometrical exposition of process- and product-innovation see Borkakoti (1975).

[6]By focusing on international trade, I disregard possible technology-gaps among firms within one national economy.

[7]Majumdar (1982), pp. 36-41.

[8]For more discussion on the relationship between R&D and innovation, see Haeffner (1973), p. 19sqq.

[9]Davidson (1979), p. 765.

[10]Findlay (1977), p. 66.

[11]These are due to inter-industry differences in firms' size and productivity of R&D, as well as in the distribution of time lags after which results of R&D effort appear.

[12]See Pavitt and Soete (1980) and Piekarz, Thomas, and Jennings (1983). Also, Mansfield (1968), and Griliches (1979).

[13]See Caves (1974) pp. 17sqq; Erdilek (1976), p. 285; and Dunning (1977), p. 400.

[14]Parry analyzed operations of American firms on some DCs' markets. Interestingly, best export performance was revealed in standardized goods, while the index of non-trade performance was higher in industries characterized by differentiated products. See p. 167.

[15]Helleiner (1973), pp. 21sqq.

[16]Caves (1974), pp. 17-24.

[17]Ohlin (1977), pp. 38-41.

[18]Majumdar (1982), pp. 46sqq.

[19]For more on this point see Section 4.2.2.

[20]The "characteristics approach" to consumer theory elaborated by Lancaster, was hinted before by Johnson (1968) in his much celebrated Wicksell Lectures. See pp. 22-24.

[21]Lancaster (1980), pp. 171-172.

[22]See Section 4.2.4.

[23]South Korea, Hong Kong, Singapore, and Taiwan.

[24]Chenery and Keesing (1979), p. 22.

[25]Based on data from Balassa (1977a).

[26]Keesing (1979), pp. 27, 29.

[27]Hong Kong had started large-scale industrial exports well before the 1960s.

[28]Lall (1981), p. 183.

[29]Chenery and Keesing (1979), p. 31. For further evidence and discussion, see Amsden (1982), p. 1, and Lall (1981), p. 207.

[30]Marris (1979), p. 30.

[31]Balassa (1977c), p. 26. Some of the most spectacular examples from the early 1980s are success stories of the Korean firms in the American market: Goldstar in color TV sets, Samsung in video cassette recorders, Daewoo in personal computers, and recently Hyundai in compact cars.

[32]See Sharpston (1975), p. 130, Balassa (1979b), p. 28, Nayyar (1978), p. 62, and Keesing (1983), p. 339.

CHAPTER 4

THE NEO-TECHNOLOGY THEORY OF INTERNATIONAL TRADE IN MANUFACTURED PRODUCTS

4.1 A Note on the Origins and Objectives

Following the Leontief paradox, the theory of international trade in manufactured products developed in two basic directions. One was to include more than two productive factors in the analysis. Except for this modification, the resulting neo-factor account of trade maintained virtually all the remaining assumptions of the traditional Heckscher-Ohlin model.

The other direction was to fundamentally break with the neo-classical tradition and relate trade patterns to determinants other than factor proportions. This required that many departures from the set of neo-classical assumptions be dealt with. The notions that have become crucial for this new unconventional approach to manufactured trade include international differences in technological knowledge, with the resulting differences in productive technology and the emergence of new products. Other relevant concepts are imperfect markets, factor mobility, economies of scale, product differentiation, and international diversity in consumer preferences. Following Hufbauer (1970),[1] this approach will be referred to as the neo-technology, or product cycle theory of trade.

The neo-technology approach has by now evolved into a fairly coherent paradigm, purporting to explain some phenomena the neo-classical tradition was unable to deal with, primarily the trade patterns in new technology-intensive manufactures. Krugman (1979) gave what appears to be an accurate synthesis of the contribution the neo-technology theory attempts to make:

> "...existing models, while well suited to the analysis of once-for-all changes in technology, are less suited to the analysis of on-going technical change. Also, the kind of technical change which can be analyzed in conventional models involves increasing efficiency in production of a given range of goods, while the product-cycle literature stresses the development of new products."[2]

An important weakness of the neo-technology theory is that, in order to cope with the complexity of trade resulting from the relaxation of many simplifying assumptions, it had to sacrifice the analytical elegance which characterizes the Heckscher-Ohlin model. As a result, the approach suffers in terms of precission of its predictions, and that tends to pose some conceptual problems in empirical testing.

The weaknesses of the neo-classical tradition and the need for a new, less simplistic account of industrial trade, had been noticed even before the Leontief paradox. In fact, some relevant references can be found in Alfred Marshall's Industry and Trade. Discussing the origins of "industrial leadership" of a few selected economies, Marshall referred to new products developed by the French inventors which were later imitated on a large scale in Germany, America and Britain, in a process quite similar to the modern product-cycle concept.[3] At about the same time Taussig (1927) noticed similar mechanisms working in the specialization in capital goods, "...the more machinery becomes automatic the more readily can it be transplanted. Is there not a likelihood that apparatus which is almost self-acting will be carried off to countries of low wages, and there used for producing articles at lower price."[4] Also, Williams' (1929) discontent with the neo-classical doctrine led him to study "leads and lags" of innovation and their implications for trade theory.

More immediate foundations for the product-cycle hypothesis have been laid by the 1950s' "dollar shortage" literature by Kindleberger (1950), McDougal (1957), and Hoffmeyer (1958). The latter author, for instance, has looked at R&D-intensity of the U.S. industries in order to explain both the chronic dollar shortage and the Leontief paradox.

Last but not least, the Schumpeterian flavor of the neo-technology literature of the 1960s and 1970s needs to be pointed out. The neo-technology argument represents an elaboration of Schumpeter's theory of capitalist development,[5] based on the notions of technical innovation and "creative destruction," and it attempts to apply the Schumpeterian tradition to international trade.

The principal contributions to the neo-technology theory of trade are those by Kravis (1956a), Posner (1961), Vernon (1966), Hirsch (1967), and more recently Krugman (1982). Some will be briefly reviewed in the following sections.

4.1.1 Kravis' Availability Hypothesis

Kravis' (1956a) theory was a product of dissatisfaction with the Heckscher-Ohlin framework following Leontief's findings. Kravis argued that the commodity composition of trade is determined by the fact that certain goods are simply not available in certain economies. Some goods are "unavailable in the absolute sense (for example, diamonds), others in the sense that an increase in output can be achieved only at much higher costs (that is, the domestic supply is inelastic)."[6] Among the reasons for such unavailabilities, technical change and product differentiation are cited. One particular example of unavailability in question is that related to the absence of some specific type of technological knowledge necessary for the production of a good.

The evident shortcoming of the theory is that it has not provided any precise hypothesis which could be tested. This weakness has been corrected by Posner (1961) and Vernon (1966) in the models which incorporate the availability argument, and go directly into the reasons of Kravis' "inelasticity of supply" namely into innovative and imitative processes.

4.1.2 Posner's Technology-Gap Model

Posner (1961) was the first to apply the concept of technology-gap to the analysis of international trade. In short, his argument goes as follows. Development of new productive methods or new goods does not occur simultaneously and uniformly in all countries. Hence, trade may be caused by the existence of relevant technological knowledge in some countries and its absence in others. Innovative ability is not randomly distributed among nations and it is very probable that some countries will enjoy the access to some valuable pieces of technological information not available elsewhere. In particular industries, distribution of innovative ability is quite systematically biased towards particular countries. The knowledge of what the bias is, and what it hinges upon, might permit one to predict trade patterns.

With technical progress, unit costs of a firm may fall, according to Posner, because of three reasons:

> "(a) general technical progress (in the industry) during the lapse of time; (b) because this particular firm can draw on its experience of yesterday's production; and (c) because this

> particular firm develops new methods (or goods, for that matter) independently of its previous experience in this line of output."[7]

It is type (b) of cost reduction that Posner calls the "dynamic economies of scale." It has been pointed out elsewhere[8] that this type of scale economies may be more accurately viewed as a function of the time span of past production rather than as Posner suggests, of the cumulative output.

The notion of dynamic scale economies is important for the reason that its relative importance (relative to other sources of cost reduction, like common "static" scale economies) affects durability of an innovating firm's competitive advantage in a new good. The higher the relative weight of dynamic scale economies, which are by their nature internalized by the innovating firm, the longer the firm's advantage will persist.

The other important element of the logic of the technology-gap model is that concerned with imitation activity. As demand for a new product grows, foreign firms[9] react by attempting to imitate it. However, it requires time to develop a commercially useful imitation; that time Posner calls the imitation lag (IL). During that time, the innovator satisfies demand as a monopolist and possibly benefits from static scale economies. These tend to prolong his competitive edge over potential imitators. Now, let us define the demand lag (DL) as time from innovation to the moment when the new good can be successfully sold in the imitator's market. Let us call the difference (IL - DL) the net lag (NL). If NL is positive, the technology-gap trade may result namely, one-way exports by innovating firms. Of course, it can be stipulated that, if NL is negative, imitation occurs without the original innovation generating any trade at all. Similarly, if differences in tastes between two countries are very large, there will be no trade either.

Now, we allow not just a single innovation but instead a flow of innovations. Innovations occur consecutively within each of many industries. "Clustering" of innovations, if it happens in one country, systematically supports the innovator's dominance in exporting new goods. Net lags will follow each other, or overlap. Posner argues that if the length of net lags and the "innovation's importance," measured by the amount of trade generated per time period differ among industries, there will be at least one pattern of innovations which leads to a constant flow of trade.[10] Thus, with innovations being the only stimuli to trade, this model can generate a stable trade equilibrium between two countries.

The important weakness of the technology-gap model is that it overemphasizes the role of imitation and undervalues the possibility of production being transferred from the innovating country to others. It fails to recognize that direct foreign investment may ultimately come into the picture and affect trade patterns. The latter point is more carefully approached by Vernon's product cycle model.

4.1.3 Vernon's Product Cycle Model

Vernon's (1966) main argument is that the location of production and trade patterns depend not on the imitation behavior but on the characteristics of the production process, and of the product itself, associated with different stages of product's lifetime. These characteristics are relevant to the decision whether to export or invest.

In the original formulation of the model, U.S. firms are considered as having particular propensity to innovate. This is for two reasons: (1) high income per capita generates demand for a wide variety of sophisticated goods; and (2) relative scarcity of labor encourages search for labor-saving innovations.[11] Hence the model is concerned with two specific types of innovations. First, innovations in "products associated with high income," and second, those which substitute capital for labor.[12] More generally, the product-cycle hypothesis does not seem to lose much of its explanatory power if applied to many new products belonging to the broad class of innovations which are responsive to market need and to relative factor costs.

Here is a brief summary of the product cycle argument. Production of a new good requires relatively large inputs of scientific and engineering know-how. External economies, e.g., the proximity of research facilities, are essential. Production runs are short and risk is high as the market "need" for the product is still virtually in the process of being revealed. Technology is unstable, and frequent modifications of the product take place. The level of product differentiation is relatively high. International differences in technological knowledge are substantial. Unskilled labor and capital are of minor importance, while knowledge and skills are what matter most. Prime candidates for producing such new goods are firms in a country enjoying abundance of factors necessary both for developing a new good and marketing it (R&D funds, high income per capita, marketing skills, etc.). It certainly should not harm but rather strengthen the innovative ability, if wages are relatively high. According to Vernon, the U.S. firms are the most likely producers of such new, highly differentiated, skill-intensive, and R&D-intensive product. The evidence from the 1970s, however, indicates that firms in some other DCs, and even in ANICs, may have acquired such capability as well. It is probable that these firms will sell first in the home markets, where demand is better known and the feed-back from consumers easier. Later, exports will start, initially to some foreign markets with similar characteristics and similar demand patterns. Before the foreign competitors catch up, the innovating firms are likely to temporarily enjoy a technological monopoly. Exports generated this way may be referred to as technology-gap trade.

As the production of the new good expands, the level of differentiation is likely to decline. Stable and growing demand reduces risk, the production runs can be longer, allowing for scale economies. Skill-intensity becomes lower and technology more stable. Producers tend to be increasingly concerned with the production costs, rather than with production characteristics. If the marginal cost plus transportation of the exported good is higher than the average cost of prospective production abroad, the innovator will consider foreign investment. Less innovative DCs, and NICs, may at this point become suitable locations for the production.

At the final stage, the stage of maturity or complete standardization, information is readily available, technological knowledge is more evenly distributed, technologies are stable, markets well-articulated, and the product becomes capital- and crude labor-intensive. The price becomes the fundamental instrument of competition. A less advanced economy, relatively rich in unqualified labor, poor in labor skills, and with less efficient mechanisms for the acquisition of technological knowledge, may now be able to start producing the good. As the traditional factor-proportions determinant of comparative advantage gains importance, such a country, being a low-cost location, may initiate foreign sales of the product. This type of exports may be referred to as the Heckscher-Ohlin, or low-wage trade. Unlike the technology-gap trade, triggered by what may be called the "availability advantage," this trade is based on the "cost advantage."[13]

In summary, at any point in time, the scenario implies clear international specialization in manufactures which differ in newness, skill- and R&D-intensity and the level of differentiation. Even though by focusing on new products Vernon played down the role of factor proportions in determining trade patterns, it is apparent that the implications of the model do not need to systematically contradict the factor-proportions prediction. In fact, to the extent that the least innovative economies are also relatively rich in unqualified labor, and physical capital is internationally mobile, the product-cycle explanation of trade in mature, crude labor-intensive products practically coincides with the neo-factor hypothesis. The main contribution of the product cycle theory is in its attempt to address the problem of the emergence of, and trade in, new products.

In his retrospective article, Vernon (1979) speculated that, in the view of the global spread of multinationals, and disappearing differences between national markets, his original version of the product cycle argument may have been losing importance.[14] Giddy (1978) also raised some objections regarding the relevance of the model in today's world. Yet, in the new economic reality, as Vernon points out, the model continues to square well with many empirical observations, and specifically with the behavior of some rapidly industralizing economies like Korea, which demonstrate a considerable capability to absorb or produce innovations, and utilize them in accordance with the product cycle hypothesis.[15]

4.1.4 Linder's Preference Similarity Hypothesis

Unlike Vernon, Linder (1961) did not address the problem of precise commodity patterns of trade. Precise commodity patterns, he argued, depend on some intangible factors like "...technological superiority, managerial skills, and economies of scale."[16] Instead, he focused on the determination of the volume or intensity of trade in manufactures between pairs of countries. The central thesis is that the intensity of trade, measured as a ratio of trade volume to national income, between two countries is higher the greater the similarity in demand patterns in home markets of these countries. Similarity of demand structures can be measured by similarity of per capita income levels. The reasoning is this. The precondition for a manufacture to be exported is the presence of the home demand. "International trade is really nothing but an extension across national frontiers of a country's own web of economic activity....to the extent that production of a good is based on invention, we have an additional reason to believe that home market demand is necessary,"[17] says Linder. Second, it follows that representative demand patterns at home will determine the range of commodities that constitute potential exports. Linder introduces the notion of representative demand, presumably with the intention to exclude commodities for which the home demand is not large enough, and to narrow the range of potential exports. Third, the larger the overlap in the commodity compostion of representative demands between two countries, the bigger the potential volume of trade obtains between them. Fourth, the larger potential volume of trade will imply larger actual trade, other factors held constant. And Linder's thesis follows. Let us notice that for two countries whose representative demands are strongly dissimilar, trade may be negligible or nonexistent.

By accounting for cross-country differences in consumer preferences, and for product differentiation, Linder's theory helps to understand the foundations of intra-industry trade.[18] A country's industrial exports are likely to be heavily concentrated around products, and product variations, which cater to the peculiar tastes prevailing in the domestic market.

The relationship of Linder's theory to Vernon's product cycle model is evident in that both models highlight the importance of domestic demand for a new good to be developed, and subsequently exported to a foreign market with similar demand characteristics. This particular proposition has been criticized by Majumdar (1982), who argues that the presence of domestic demand is no more a necessary condition for a product innovation, or an imitation for that matter.[19] This point is best exemplified by the behavior of some less advanced economies, especially the ANICs, which had begun the production of a series of relatively new manufactures well before the home demand became significant. These products were from the start geared to tastes typical for more advanced overseas markets. This observation suggests that in order to deal with trade phenomena of the 1970s and 1980s, the product cycle model may have to undergo some minor modifications. One would be to play down the role of the home market need for an innovation or imitation, and instead emphasize the importance of the ability to acquire necessary technological knowledge and to channel the R&D effort in accordance with the relative factor endowments.

4.1.5 Models of Dynamic Competitive Advantage

Contrary to what the traditional factor proportions theory seems to imply, the neo-technology account of trade suggests that the pattern of competitive advantage is not static. Competitive advantage, whether it be "availability advantage" or "cost advantage" emerges and shifts among countries as a result of dynamic forces affecting it (innovation, imitation, progressing product-cycle standardization). Attempts have been made to build formal models accounting for this type of processes. The more important examples were Oniki and Uzawa's (1965) dynamization of the neo-classical framework; Chipman's (1970) trade model with induced technical progress; Bruno's (1970) model of "policy for dynamic comparative advantage"; Klein's (1973) dynamic model with the "learning factor"; Teubal's (1975) neotechnology model of comparative cost; and Claudon's (1977) dynamic model of trade in homogeneous and heterogeneous goods. More recently, Krugman (1979b, 1982) has tried to formalize the basic neo-technology argument by developing a model of international trade in which trade patterns are determined by a continuing process of innovataion, accompanied by imitation and/or technology transfer.

4.2 Empirical Work

In the 1970s and 1980s, various aspects of the neo-technology theory were empirically investigated by numerous authors. Some relevant studies are reviewed in Stern and Maskus (1979), Deardorff (1984), and Leamer (1984).

The basic procedure applied in most of these investigations was to correlate trade patterns, usually represented by various proxies for export performance, with their determinants suggested by the neo-technology theory (R&D intensity, level of product differentiation, relative newness of goods, etc.). A complete test would require examining consistency of thus obtained correlation or regression coefficients with the relevant characteristics of the analyzed country; e.g., with a country's relative innovative capability. This has rarely been done in a systematic manner. Many authors simply infer a country's technology-related characteristics, and the resulting pattern of competitive advantage, from the results obtained through the cross-commodity correlation or regression analysis. The test performed in Chapter 8 attempts to avoid this type of drawback.

Rather than going into details of the extensive empirical work, we will present it in a tabular form. Table 4.1 contains a comprehensive

Table 4.1

Tests of the Neo-technology Theory of Trade in Manufactured Products

Test	Country and Commodity Samples Tested	Attributes Tested	Result
Hirsch (1967)	U.S.; electronics industry	Product cycle (maturity)	positive
Keesing (1968)	U.S.; 18 industries	R&D	positive
Ozawa (1968)	Japan; 9 industries	technology diffusion	positive
Wells (1969)	U.S.; consumer durables	product cycle	positive
Gruber, Metha & Vernon (1970)	10 exporting areas including DCs, Mexico and Brazil; 24 categories of manufactures	factor intensities, skill ratio, production stage	weak**
Hirsch (1970)	Israel; 190 industrial firms	skill intensity, commodity characteristics	positive**
Hufbauer (1970)	24 countries; 102 3-digit groups in SITC 5-8	scale economies, production stage, technology gap (first trade date), product cycle (differentiation), human skills	positive**
Branson (1971)	U.S.; 101 3-digit SITC groups	skill intensity, R&D, scale economies	weak***
Adler (1972)	U.S.; SITC 5-8	product cycle (price and income elasticity of demand for exports)	positive
Morrall (1972)	U.S.; 20 SIC 2-digit groups	human capital intensity, skill intensity, R&D effort	positive**
Mousouris (1972)	Greece; total manufactured exports	product cycle, preference similarity	positive**
Stobaugh (1972)	U.S.; petrochemicals	product cycle	positive

Continued on next page

Table 4.1 (Continued)

Test	Country and Commodity Samples Tested	Attributes Tested	Result
Torre (1972)	U.S.; 32 industrial sectors	marketing function	positive
Tsurmi (1972)	Japan; 40 3- or 4-digit groups within SITC	R&D	positive
Katrak (1973)	U.K. and U.S.; 17 industries	R&D; skill intensity, scale effects	negative*** positive
Hirsch (1974a)	29 countries; 25 industries	factor intensity including skills; R&D	positive*
Hirsch (1974b)	North America, Japan, EEC, EFTA; chemical & engineering products	capital and skill intensity	positive*
Leamer (1974)	12 Atlantic area countries; 28 SITC groups	national expenditures on education; R&D effort	positive**
Parry (1974)	U.S.; 9 industries	product cycle; trade and non-trade performance	weak
Hirsch (1975)	28 countries; Hufbauer's 1970 industry data	capital and skill intensity	positive*
Finger (1975)	U.S., Japan; 88 3-digit groups	product cycle, skills, R&D	positive**
Lowinger (1975)	U.S.; 16 industries	R&D, skill intensity	positive*
Goodman and Ceyhun (1976)	U.S.; 15 industires	R&D effort, employment of scientists and engineers, patents, skill ratios	positive*
Helleiner (1976)	U.S., Canada, "other OECD"; 106 3-digit groups in SITC 5-8	factor intensities, scale economies firm size, first trade date, differentiation	positive*
Balassa (1977b))	OECD countries; research-intensive industries	R&D	positive

Continued on next page

Table 4.1 (Continued)

Test	Country and Commodity Samples Tested	Attributes Tested	Result
Wolter (1977)	West Germany; 27 manufacturing industries	human capital intensity, R&D intensity	positive**
Baldwin (1979)	35 countries; 27 industries	factor intensity, skill intensity, economies of scale	weak**
Majumdar (1979)	U.S., Japan; electronic calculators	availability advantage, cost advantage, innovation and imitation	positive
Walker (1979)	10 OECD countries; 15 product groups	R&D	positive
Hulsman-Vejsova and Koekkoek (1980	Netherlands, 17 manufacturing industries	human capital intensity, R&D intensity	positive**
Pavitt and Soete (1980)	OECD countries; 40 industries	R&D, patent statistics	weak
Soete (1981)	OECD countries; 40 SIC groups	patents	positive
Holroyd (1983)	U.S.; 5 high-technology product groups	R&D	positive

Note. Asterisks in the last column refer to studies which empirically confront the neo-technology theory with the neo-factor approach. Single asterisk denotes studies which found the neo-technology theory dominant. Double asterisk is associated with cases where both accounts perform well. Triple asterisk indicates results dominated by the neo-factor model.

list of the most important contributions. In the case of each study, the type of result arrived at according to its author is indicated.

Out of the 34 tests sampled, 33 appear to have led to results confirming the neo-technology theory, or at least not disproving it. Some studies address the problem of how, comparatively, the neo-technology and the neo-factor hypotheses perform in explaining a commodity composition of various trade flows. These are marked with asterisks in Table 4.1. In the next section we will argue that, to the extent such studies rely on the notion of substitutability between the two theories, their implications may be misleading. Nevertheless, it should be noticed that only two of such comparative tests, by Branson (1971) and Katrak (1973) point to the superiority of the neo-factor hypothesis. Results of the remaining 16 comparative studies show that either the neo-technology account is dominant, or that both hypotheses make equally important contributions to the explanation of industrial trade patterns.

In summary, the existing empirical literature has produced overwhelming evidence in support of the neo-technology theory. Unfortunately, this evidence originates almost exclusively from the U.S. export data and, to a lesser extent, from data covering a handful of other advanced economies. There have been no multicountry analyses empirically examining the problem of how the less advanced countries participate in the product cycle type of process, and whether the neo-technology theory is capable of explaining trade across countries. Both these questions are addressed in the empirical analysis in Part III.

4.3 The Neo-Factor Approach and the Neo-Technology Approach: Substitutes or Complements?

Much of the empirical work just presented relies on the not-so-obvious notion that the neo-factor theory and the neo-technology theory are two basically incompatible and substitutable explanations of industrial trade. Many authors include in their empirical models variables associated with the two theories and find both to perform well, but they either do not address the problem of the relationship between the two, or implicitly assume that they are substitutes and point to the better one on the basis of sometimes marginally higher correlation or significance coefficients. I wish to argue that such an approach and the view underlying it are objectionable, and that an integrated model including elements of both accounts as its complementary components is possible. Moreover, such a model seems to provide the most realistic view of trade in manufactures between countries differing both in capability to create or acquire technological knowledge and in factor endowments.

The role of the neo-technology theory as a new, alternative approach to trade may have been overemphasized by many authors in the 1960s and 1970s. Excessive fascination with the new paradigm was probably responsible for the many misunderstandings surrounding the problem of the relationship between the neo-classical tradition and the new theory. Yet as early as 1968, Johnson noticed the complexity of this problem and warned that the theory based on cross-country differences in productive technology and innovativeness may, in fact, be merely complementary to the existing factor proportion theory.[20]

A case for a combined model, incorporating neo-factor and neo-technology components can be made at two levels, theoretical and empirical. The theoretical argument is to show that a certain type of inter-country difference in productive technology, crucial for the working of the product cycle model, is not inconsistent with the basic structure of the neo-factor framework. The argument can be advanced as follows. To examine the Heckscher-Ohlin model's assumption of no factor intensity reversals, Minhas (1962) performed the empirical study of elasticities of substitution and obtained the result which led him to the rejection of the strong factor intensity hypothesis. However, as Hufbauer (1970), Morrall (1972), Katrak (1973) and Fortune (1976) point out, the inclusion of additional factors in the model (e.g., labor skills or human capital) significantly strengthens the case for the strong factor intensity hypothesis.[21] On the empirical grounds it appears, then, that the human capital model correctly postulates that industries can be unambiguously ranked according to their skill, or human capital intensity, and that the ranking is generally identical across countries. At first view, this implies that technologies are identical as between countries because if they were not, factor intensity reversals would be likely to occur. Note, however, that such an implication is false because, with the strong factor intensity assumption being satisfied, technologies are still free to differ internationally in a factor-neutral or Hicks-neutral fashion; i.e., by a multiplicative constant.[22] Therefore, there is no major inconsistency between the human capital approach and international variation in technology of that simple neutral type. Consequently, there is no reason why the possibility of such homothetic technology differences should not be explicitly admitted in the three-factor model, especially since the presence of such international variations in the production function may provide an additional and potentially useful explanation of competitive advantage.

Many authors have argued that, theoretically, an integrated model in which the Heckscher-Ohlin orthodoxy would be combined with the product cycle argument is both possible and needed. Hirsch (1974b) and Lowinger (1975) suggest that such a model would stipulate three rather than two productive factors, labor skills or human capital being the third factor.[23] Also, Jones (1970) indicated that the "Heckscher-Ohlin model could be applied to Vernon's concept of produce cycle," and it is clearly a three-factor framework with labor skills that he has in mind.[24] Yet to my best knowledge, the only example of actual formal work advanced in that direction is that by Claudon (1977).

In Chapter 5, we attempt to stylize the neo-technology argument and combine it with the neo-factor model along Claudon's lines into a framework that seeks to explain determination of competitive advantage in manufactured exports. In the model, the pattern of competitive advantage and its dynamic nature are attributable to two sources: (1) the appearance of new products in response to the production function's homothetic differences between countries, that in turn being a result of continuous accumulation of technological knowledge which proceeds at different rates in different countries, and (2) relative availability of skills, along with a continuous decrease in goods' skill intensity in the process of maturation, specified in such a way that both the ranking of commodities by skill intensity and linear homogeneity of the production functions are being preserved.

Thus, as will be seen, both the product cycle and the factor proportions may potentially underlie the emerging competitive advantage. Complete international uniformity of production functions is not essential for the factor proportions model. Homotheticity is. Therefore, no fundamental assumption of that model seems to be violated, except that the analysis is somewhat dynamized; but that should be viewed as an attempt to introduce some sense of time into the model rather than as a rejection of the factor proportions argument. The idea proposed by Vernon's product-cycle model, that some countries are systematically more innovative than others due to international differences in demand patterns, will be essentially abandoned. This is because the factor-proportions framework calls for identical preferences. Instead, the argument regarding innovation will be entirely based on relative abundance of productive factors, namely unqualified labor and labor skills.

Apart from the theoretical considerations, an incentive to experiment with the factor-proportions model extended to include the neo-technology argument seems to be provided by the empirical findings. Morrall argues that "...there...appears to be no statistical conflict between the two approaches, giving further weight to the fruitfulness of synthesizing the two theories."[25] Indeed, there exists some tentative empirical evidence indicating that the explanatory power of a trade model is raised as the neo-technology variables are included along with the factor proportions characteristics.[26] Furthermore, the combined model may exhibit superiority over the conventional three-factor model if its two components are applied to different classes of manufactures rather than to the overall manufactured exports. This type of commodity specificity of the factor proportions and the neo-technology theories has been suggested by, among others, Leamer (1974) and Soete (1981).[27] This question is examined in Chapter 7, where export performance indices are regressed on a series of commodity characteristics independently for the "high-technology" and the "low-technology" manufactures.

The problem with using both theories simultaneously for a given set of commodities or industries is that the variables associated with the two theories may be sometimes strongly correlated, thus leaving an empirical researcher with the question of which hypothesis is actually being tested. In such cases, a conceptual and empirical distinction between the evidence supporting one theory and that supporting the other may be difficult and, for practical purposes, the two theories may appear to be substitutable. Some correlation results indicating that have been reported by Hufbauer (1970), Morrall (1972) Goodman and Geyhun (1976), and Pavitt and Soete (1980).[28] The problem is compounded by the frequent lack of clarity as to what the particular product cycle and neo-factor proxies used in tests capture. Much confusion has especially surrounded the link between an industry's skill intensity and the incidence of innovation.[29] Yet the one empirical study more careful in this respect, namely Wolter's (1977) test for West Germany, suggests that, contrary to popular beliefs, human capital intensity and innovativeness need not be strongly correlated across industries after all. If so, the neo-factor and the neo-technology theory are complementary not only in a sense of being commodity specific, or applicable to different industrial trade flows, but also in a sense that they offer significantly different explanations for trade performance in the same set of industries.[30]

Since both the neo-factor model and the neo-technology account have been shown to be empirically sound and theoretically compatible, and since they may exhibit certain complementarity properties, examining the implications of an integrated framework incorporating both of them is warranted. Before specific empirical questions are addressed, we will give some formal structure to the postulated model.

FOOTNOTES

[1]Hufbauer (1970), p. 195.

[2]Krugman (1979), p. 254. Elsewhere Krugman points to further complications that arise when the conventional Ricardian or two-factor models are used to assess consequences of technical change. See Krugman (1982), p. 3.

[3]Marshall (1919), pp. 118-119, 132-133.

[4]Taussig (1915). As Cooper's (1971) historical study indicates, the 19th century trade in manufactures was heavily structured by technological leads, the difference being that the U.S. was at a disadvantage, compared to Great Britain for example, and imitation lags were significantly longer than today.

[5]Schumpeter (1934, 1950).

[6]Kravis (1956a), p. 143.

[7]Posner (1961), p. 329.

[8]Kaldor (1962).

[9]Without the loss of generality, I suppress Posner's story about intra-country imitation. I assume all home firms in the industry to be identically apt in adopting the innovation.

[10]Posner (1961), p. 336.

[11]Vernon (1966), p. 192.

[12]Ibid., p. 193.

[13]Majumdar (1979), p. 565.

[14]Vernon (1979), p. 255.

[15]Ibid., p. 266.

[16]Linder (1961), p. 103.

[17]Ibid., p. 88.

[18]For relevant comments, see Hufbauer (1970), p. 197, and Lancaster (1980), pp. 152sqq. For a criticism of Linder's hypothesis as an explanation of intra-industry trade, see Balassa (1979b), p. 24.

[19]Majumdar (1982), p. 44.

[20]Johnson (1968), p. 14. Elsewhere, he suggests that "...the strong conflict between neo-factor proportions and neo-technology accounts...may reflect merely the domination of trade theory by the narrow concept of capital, inherited from English classical, neo-classical and now neo-Keynesian economists." See Johnson (1970), p. 17. Johnson attempts to reconcile the two accounts by using the Fisherian notion of capital which incorporates a human component.

[21]Morrall (1972), pp. 7sqq. Also, see Hufbauer (1970), p. 152, Katrak (1973) p. 344, and Fortune (1976) p. 581.

[22]Morrall (1972), pp. 8, 10. It will be seen that it is only in the multiplicative parameter that production functions differ internationally in the model presented in Chapter 5. Morrall suggests that the assumption of solely factor-neutral technology differences is empirically questionable. Note, however, that the existence of more fundamental differences in productive technology across countries would be likely to force the departure from the conventional factor-proportions model.

[23]Hirsch (1974b), p. 68, Lowinger (1975), p. 225.

[24]Jones (1970), pp. 84sqq.

[25]Morrall (1972), p. 25.

[26]For example, see Hirsch (1970), Finger (1975), and Baldwin (1979).

[27]Soete (1981), p. 639.

[28]See Hufbauer (1970), pp. 164-165, Morrall (1972), pp. 57, 131, Goodman and Ceyhun (1976), pp. 529-537, and Pavitt and Soete (1980), p. 42.

[29]Here are some examples. For Goodman and Ceyhun (1976), "...skilled labor inputs can also serve as a measure of capability to innovate in sophisticated manufactured products" (p. 532). Also in Lowinger (1975), "the skill intensity factor acts as a stand-in for the ability of an industry to push the productive frontier further out through the generation of new disembodied knowledge" (p. 277). Wage per man, which has been used in many studies as a skill variable, is linked by Lutz (1976) to relative newness or youth of an industry.

[30]See Wolter (1977), p. 261. Also, see the application of Wolter's test to Netherlands' export data, by Hulsman-Vejsova and Koekkoek (1980).

PART II

SPECIFICATION OF THE MODEL AND TESTABLE HYPOTHESES

CHAPTER 5

THE MODEL OF COMPETITIVE ADVANTAGE WITH LABOR SKILLS AND PRODUCT CYCLE

5.1 A Two-Country Framework

5.1.1 Competitive Advantage

We will start by proposing a series of simplifying assumptions, and defining some concepts that will be used throughout the analysis. Consider the setting with two countries, i and j, one good, and three productive factors: physical capital K, unqualified labor L, and general labor skills S. Each country has a finite number of identical firms producing the commodity. The production process at time t in each country is described by the linearly homogeneous Cobb-Douglas production function. For example, in country i the production function is given by

$$Y_t^i = A_t^i \, K^{a_t} \, L^{b_t} \, S^{c_t} \qquad (5.1)$$

The multiplicative scale parameter or, as Minhas (1962) calls it, the neutral efficiency parameter A_t^i is looked at as a factor representing the stock of commodity-specific technological knowledge affecting the level of technological efficiency in country i at time t. Hicks-neutral technological change is obtainable through an increase in the stock of knowledge. Knowledge can be acquired through investment in R&D.[1]

Physical capital is assumed mobile internationally so that physical capital rentals are equalized between countries, $w_k^i = w_k^j$. The price of labor skills is assumed higher in j than in i, $w_s^j > w_s^i$, and the price of unqualified labor higher in i than in j, $w_l^i > w_l^j$. Prices are held constant over time.[2] Therefore, variables w_s and w_l, country i's "skill advantage" and country j's "labor advantage," respectively defined by

$$w_s = \log(w_s^j/w_s^i),\ w_l = \log(w_l^i/w_l^j), \tag{5.2}$$

are both positive and fixed. Clearly, this implies that the skill differential in j is bigger than in i, $w_s^j/w_l^j > w_s^i/w_l^i$. Country i is skill-abundant and labor-scarce, relative to country j.

As the good matures, its production is assumed to become less skill-intensive, while preserving linear homogeneity. With $a_t = \bar{a}$ for all t, this can be written as[3]

$$\partial b_t/\partial t = -\partial c_t/\partial t > 0. \tag{5.3}$$

Since this sort of maturing process is fundamental to the product-cycle hypothesis, it can be called for convenience the "product-cycle effect." At any t, parameters b_t and c_t in the production function are assumed identical as between countries.[4]

The last three assumptions that we need at this point are that there are no restrictions to trade, transportation is costless, and consumer preferences are identical between countries.

The constrained cost minimization problem yields the marginal costs at optimality in each country in terms of the parameters of the production function and factor prices.[5] With marginal cost pricing in domestic markets, and with free trade, variable D_t^{ij}, defined for any time t as the difference between the logarithms of the autarkic marginal costs at optimality in j and in i, and represented by[6]

$$D_t^{ij} = \log A_t^i - \log A_t^j + b_t(\log w_l^j - \log w_l^i) + c_t(\log w_s^j - \log w_s^i), \tag{5.4}$$

will be interpreted as the "competitive advantage" variable.[7] Positive (negative) D_t^{ij} means that the period t marginal cost in country i is below (above) that in country j. Consequently, firms in i will be said to have competitive advantage if D_t^{ij} is positive. Similarly, firms in j will enjoy competitive advantage if D_t^{ij} is negative. The sign of D_t^{ij} unambiguously determines the production locus of the commodity at time t. With preferences being identical in the two countries, this indicates the exporter and the importer of the commodity.

5.1.2 Internationally Identical Production Functions

Let us now consider the case of internationally identical production functions. If the production functions are identical between the two countries, that is, if $A_t^i = A_t^j$ for all t, then D_t^{ij} collapses, by (5.4) and (5.2), to $(c_t w_s - b_t \tilde{w}_l)$. This will be denoted by V_t which may be referred to as the variable of "factor proportions advantage" in the production of the good under question. Therefore, with identical production schedules, and given parameters b_t and c_t, competitiveness and the direction of trade are fully determined by factor prices. By virtue of the product-cycle effect, V_t is a monotonically decreasing function of time, and thus it systematically changes in favor of country j. This is because, by relationship (5.3),

$$\partial V_t/\partial t = (w_s + w_l)\partial c_t/\partial t < 0. \tag{5.5}$$

Hence, even if V_t is not negative initially, it becomes so eventually as the good becomes increasingly labor-intensive and less skill-intensive.[8] When the sign of V_t is switched from positive to negative, the reversal of competitive advantage will occur, and the direction of trade will change. Country i's exports of the commodity cease, and firms in country j become exporters. The familiar Heckscher-Ohlin feature is being preserved: the pattern of advantage reflects an interaction between country characteristics and commodity characteristics. Specifically, a relatively more skill-intensive good tends to be produced and exported by a relatively skill-abundant country, and as it becomes more labor-intensive a labor-abundant country will resume the production and exports.

Note that (5.5) can be rewritten as $\partial V_t/\partial t = R(\partial c_t/\partial t) < 0$, where R measures the ratio of the relative price of skills, or skill differential, in country j to that in country i, $R = \log[(w_s^j/w_l^j)(w_s^i/w_l^i)^{-1}]$. Since in (5.2) both w_s and w_l are positive, R must be positive as well. Given that, (5.5) implies that the magnitude of V_t will decrease faster the greater is the difference between i and j in terms of relative skilled labor wage rate. Assuming international identity of technology, then, between two "type-j" countries with initially identical value of V_t, the one with a higher relative skilled labor wage rate should be the first to acquire competitive advantage in the production of a good given up by the innovating economy i. Such an implication does not seem to square well with the evidence on international migration of the loci of production processes. As we empirically demonstrate in Chapter 8, relatively skill-scarce economies generally tend to be engaged in the final rather than the early stages of product cycle.

It appears, then, that with the postulated decrease in the good's skill intensity in the process of maturation, factor proportions alone may incorrectly predict the order in which consecutive "type-j" countries will resume production of the good. To see why relative factor prices may give incorrect predictions in this model, one has to recognize the possibility of inter-country differences in capability to acquire the commodity-specific technological knowledge. This implies that the assumption of internationally identical stocks of knowledge must now be relaxed, and the case has to be considered in which production functions are not completely uniform across countries.

5.1.3 Innovation and Imitation

It can be concluded from what has been laid out so far that the only way country i can continuously regenerate its eroding competitive advantage in this environment is through the accumulation of technological knowledge allowing cost reduction in the commodity already produced, and/or through perpetual development of new, skill-intensive products.[9] The latter way seems inevitable inasmuch as there is a lower limit to which the cost of producing the existing good(s) can be reduced.[10] Both ways require new knowledge, and that is most likely to be acquired through R&D activity. Country j is engaged in acquiring knowledge as well but the ability to do so differs between the two countries. Since we will have to deal with more than one commodity, it is appropriate to use a commodity index, n, which from now on will be attached to variables that differ across goods. Hence, the process of acquisition of the n'th-commodity-specific technological knowledge in the two countries is postulated to be described by:[11]

$$A^i_{tn} = A_0 e^{g(t-T_n)} \qquad \text{for } t \geq T_n \text{, and} \qquad (5.6)$$

$$A^j_{tn} = \begin{cases} 0 & \text{for } T_n \leq t < T_n + T_1 \\ A_0 e^{d(t-T_n-T_1)} & \text{for } T_n + T_1 \leq t < T_{sn} \\ A_0 e^{g(t-T_n)} & \text{for } t \geq T_{sn} \end{cases} \qquad (5.7)$$

The resulting time paths of knowledge parameters A_{tn} in countries i and j are sketched in Figure 5.1. Production of the commodity requires that a certain threshold of product-specific knowledge, A_0, be present. Given productivity of R&D, this means that a certain minimum investment in R&D needs to be made before a country is capable of successfully transforming inputs into a positive output according to the production function. Formally, $Y^i_{tn} = 0$ if $A^i_{tn} < A_0$, and the same is true for country j, A_{tn} being an increasing function of R&D expenditure in commodity n. The technology of producing good n is unknown until time T_n. At that point, country i is assumed to have accumulated the minimum necessary stock of knowledge, A_0, allowing it to initiate the production. The appearance of a positive output of commodity n in i's production is what I refer to as "innovation" and, consequently, country i will be viewed as an "innovator." Country i's technology is a sort of technological frontier, or the "best practice"[12] behind which country j lags, at time T_n, by T_1 years.[13]

Having reached A_0, the stocks of knowledge in countries i and j are growing at constant rates g and d, respectively. The "best practice" is subject to improvement over time. Also, the lag of the imitating

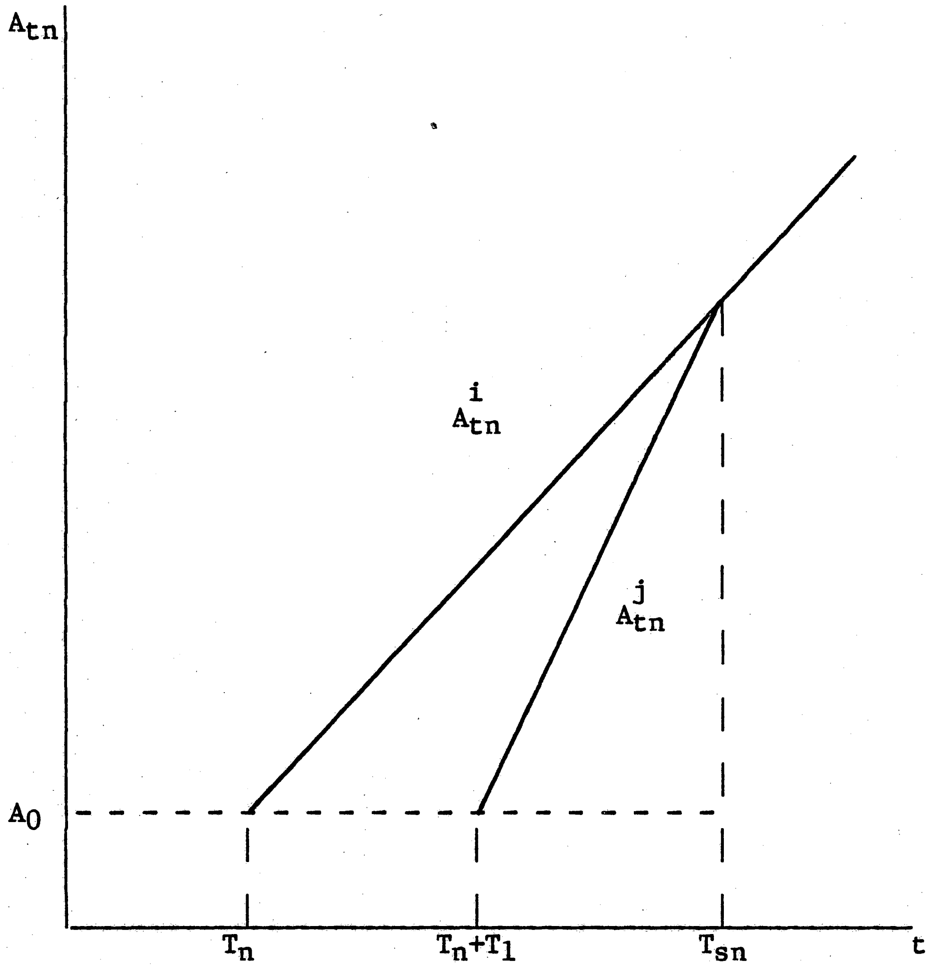

FIGURE 5.1

Acquisition of the Commodity-Specific Knowledge in Countries i and j country j is being shortened as time passes. This is because d is assumed to exceed g. It is easier to imitate the commodity than to maintain the lead.[14] The lag vanishes at time T_{sn}, when $A^i_{tn} = A^j_{tn}$. It is assumed for simplicity, however, that the lag never becomes negative. After T_{sn} the two countries acquire knowledge at the same rate. The imitator is not allowed to "know more" than country i on how to raise general productivity. He may, however, derive cost advantage from his relatively more labor-intensive technique of producing the commodity due to international differences in factor prices. As we have seen, this is the case if V_{tn} is negative.

We will say that good n is "new" if $A^i_{tn} > A^j_{tn}$, and that it is "mature" if $A^i_{tn} = A^j_{tn}$. Good n then is "new" until time T_{sn}, when it becomes "mature."

In order to separate the impact of differing stocks of knowledge on competitive advantage from that of relative factor prices, let us now consider for a while a situation in which no country enjoys a clear factor proportions advantage. For that, V_{tn} has to be zero. If V_{tn} is equal to zero, D^{ij}_{tn} collapses by (5.4) to $(\log A^i_{tn} - \log A^j_{tn})$, and by (5.6) and (5.7), it can be expressed as $(g-d)(t-T_n) + dT_1$ for $T_n + T_1 \leq t < T_{sn}$. After time T_{sn}, D^{ij}_{tn} equals zero. Competitive advantage is thus completely determined by the parameters of the knowledge acquisition process, D^{ij}_{tn} being a nonincreasing function of t.[15] It becomes clear at this point that, in general, competitive advantage is an outcome of two dynamic forces in this model. One originates from the changing difference in stocks of knowledge; the other from inter-country differences in factor prices, coupled with the continual change in product's factor intensities.

5.1.4 Overall Determination of Competitive Advantage

When both determinants of competitive advantage are accounted for, an interesting situation may arise, namely the factor prices may imply that the good should be produced by j, yet due to the difference in knowledge stocks the production is still located in i, even though j has reached the necessary knowledge threshold A_0. For such a situation to obtain, it must be true that $0 < -V_{tn} < gT_1$ at $t = T_n + T_1$. This condition means that country j enjoys factor-proportions advantage ($V_{tn} < 0$), but it is country i who has overall competitive advantage ($-V_{tn} < gT_1$ implies $D_{tn}^{ij} > 0$ at $t = T_n + T_1$) at the moment when j has just accumulated the necessary stock of knowledge A_0. It can be verified that, from that moment onwards, variable D_{tn}^{ij} will be given by:[16]

$$D_{tn}^{ij} = \begin{cases} (g - d)(t - T_n) + dT_1 + V_{tn} & \text{for } T_n + T_1 \leqslant t < T_{sn} \\ V_{tn} & \text{for } t \geqslant T_{sn} \end{cases} \tag{5.8}$$

This is graphed in Figure 5.2. Up to time T_{sn}, advantage in the "new" good is determined by both the interplay of factor prices with relative factor intensities in the production function, accounted for in the factor-proportions variable V_{tn}, and by the parameters of the knowledge acquisition process (g, d, T_n, T_1). The latter become irrelevant after T_{sn}; i.e., after the good has "matured" and its productive technology has become identical internationally. Once this has happened, the factor-proportions hypothesis resumes exclusive responsibility for determining the locus of production. Note that $\partial D_{tn}^{ij}/\partial t < 0$, country j's advantage

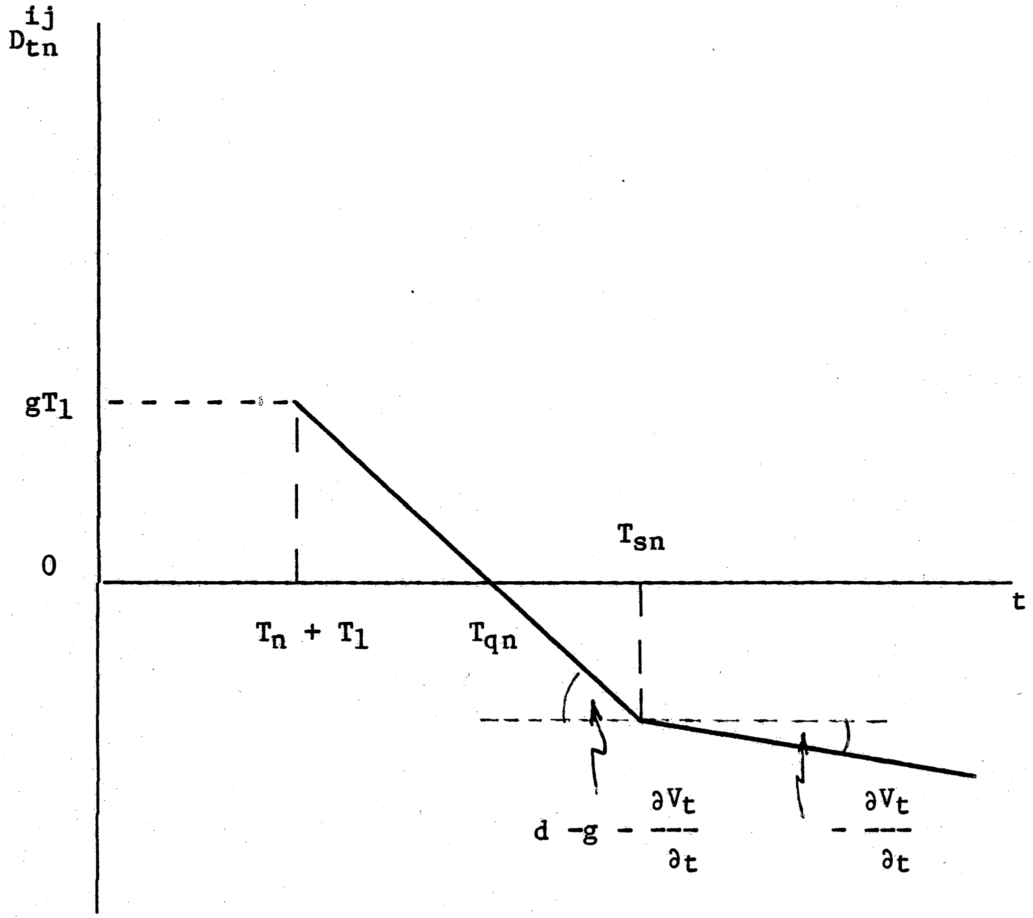

FIGURE 5.2

Competitive Advantage in Case $0 < -V_t < gT_1$

increases (disadvantage decreases) with time due to the change in factor intensity and/or due to the acquisition of knowledge by j's firms allowing them, before time T_{sn}, to reduce costs at the rate higher than that of i's firms. Note that until T_{qn} the good is produced and exported by firms in i. These exports can be referred to as "technology gap trade." At time T_{qn}, competitive advantage shifts to j whose firms become sole producers and exporters. "Low wage trade" is initiated.

5.1.5 The Case with Many Goods

At this point, the argument can be explicitly extended to a multi-commodity case.[17] It is convenient to think of a continuum of goods, indexed on a unit interval, [0,1]. Index n is assigned to commodities in such a way that $\partial c_{tn}/\partial n > 0$ and $\partial T_n/\partial n > 0$, for all t. In other words, goods are ranked by increasing skill intensity, and additionally, a higher-n (more skill-intensive) good is developed by i's firms after the immediately lower good in the continuum has been innovated. With g, d, T_1 and A_0 all being held fixed across goods, the latter condition implies that country i's superiority over j in terms of technological knowledge acquired is nondecreasing in the commodity index, $\partial(\log A^i_{tn} - \log A^j_{tn})/\partial n \geq 0$, for all t.[18] Furthermore, at the moment a given good $\hat{n}$ becomes "mature," all goods n such that $n < \hat{n}$ must be "mature" as well, and all goods n such that $n > \hat{n}$ are "new." With the additional assumption that $\partial c_{tn}/\partial t$ is the same for all n, it also follows that D^{ij}_{tn} in (5.8) is unambiguously increasing in n, for any given t.

This result allows one to determine which goods will be produced and exported by which country. Given time t, there will be some marginal good $\bar{n}$ with identical marginal costs in country i and in country j, $D^{ij}_{t\bar{n}} = 0$. Country i has a competitive advantage in all goods n such that $n > \bar{n}$, and country j in all goods n such that $n < \bar{n}$. This is because, with D^{ij}_{tn} being increasing in n, it is true for all t that

$$D^{ij}_{tn} > 0 \quad \text{for } n > \bar{n} \text{ and } D^{ij}_{tn} < 0 \text{ for } n < \bar{n}. \tag{5.9}$$

Good $\bar{n}$ can be conveniently looked at as a non-traded commodity.

Generally, the innovator's advantage will cover the upper portion of the commodity spectrum where "new" goods are located, while the imitator is assigned products from the lower part of the spectrum, largely "mature" goods. Let us notice, however, that formally there is no reason why the imitator should not have advantage in some "new" goods as well. This would be the case when the imitator's rate of knowledge acquisition d is high enough, or the initial imitation lag T_1 is small enough, to assure that some goods become marginal (D^{ij}_{tn} becomes zero) even before they have reached full maturity; i.e., before the inter-country difference in technological knowledge has vanished. Figure 5.2 shows such possibility. The good's exports from j start at T_{qn} even though the good is not "mature" until T_{sn}. As Marris (1979) points out, this type of "short-circuiting" of the traditional product cycle may be of special importance to the explanation of the export performance in relatively "new" products by the ANICs, as described in Section 3.2.[19] What it takes is the imitator's capacity for efficient acquisition of commodity-specific knowledge; e.g., through R&D effort and possibly other forms of knowledge search. To the extent such capacity is correlated with relative abundance of general labor skills,[20] this would explain why it is not necessarily the relatively most labor-rich imitators who will be the first to resume production of the good given up by firms in the innovating country.[21]

Finally, it has to be noticed that since D_{tn}^{ij} is increasing in n for any t and decreasing in t for any n, as time passes, increasingly higher-n (more skill-intensive, developed later) goods will be assuming the role of the marginal good:

$$\partial\bar{n}/\partial t > 0. \tag{5.10}$$

To see that, think of the competitive advantage variable as a function of continuous indices t and n, $D_{tn}^{ij} = f(t,n)$, such that $f_t < 0$, $f_n > 0$, and $f(t,\bar{n}) = 0$. The latter equation implicitly specifies the relationship between t and $\bar{n}$. Given the sign of partial derivatives of function f, total differentiation of this equation yields result (5.10). This result means that the domain of country j's competitive advantage progressively expands towards goods characterized by higher indices n. As we have seen, at any time, some of the goods newly included in the domain of j's competitive advantage may have not yet reached their maturity.

The dynamic nature of the specialization pattern implied by (5.10) makes it necessary for the innovator to take defensive steps against being left without any competitive advantage. In this model, the course of action i's firms adopt for that purpose is to develop new highly skill-intensive products, requiring also high R&D effort, and by introducing them into production, to expand the spectrum of goods. This is faciliated by i's superior innovative capability. However, it is important to recognize the role of relative factor prices in this process.

As we have seen, country i's relative skill abundance is instrumental in channelling the innovative effort toward new goods that are skill-intensive. Thus, advantage in "new" goods is an outcome of an interplay of the two factors which are conceptually separated in the model. One is the innovator's technological superiority demonstrated by a higher stock of knowledge, and resulting from R&D-related knowledge search. That, in turn, is induced by the erosion of the innovator's advantage in goods which gradually become less skill-intensive. The second factor, setting the innovation process in motion and directing it naturally towards skill-intensive goods, is thus the innovator's own high skill abundance (labor scarcity) itself. It becomes clear, then, that what is ultimately responsible for the emergence and direction of the innovative effort in this model is relative factor availability. By linking innovation to skill abundance we diverge from Vernon's original formulation of his product-cycle theory in which innovation is said to respond to relative labor scarcity, but above all, to high-income market needs.

5.2 Extension to a Multi-Country Case

It is fairly easy to envision how the argument, theoretically laid out in the two-country setting, could be extended to a multi-country case. We will now informally sketch one way in which a development of such multi-country model might go. Consider a ranking of potential traders such that, for each pair, a country ranked higher by innovative capability is also ranked higher by some measure of relative skill abundance. Consistency between these two types of rankings is in itself a testable hypothesis and is examined in Section 8.1. Also, consider a ranking of goods such that, as proposed in Section 5.1.5, for each pair a good ranked higher by "newness", measured by R&D-intensity or product age, is also ranked higher by skill intensity. Given such two rankings, and given other basic assumptions of the model, goods to be potentially exported by each country could be unambiguously identified at any moment in time.[22]

Following Krugman (1982) in using the informal jargon, each country will have a "niche" in the ranking of goods, and the higher the country is ranked, the higher in the commodity ranking its "niche" will be located. Simple conditions could be stipulated under which at least one commodity would be assigned to each country by this framework, at any point of time. It is important to recognize a dynamic aspect of this scenario. We will give more attention to it in Chapter 9. At this point, however, one should see that the corespondence between the country ranking and the commodity ranking will not be time invariant. Newly developed products build up on top of the ranking, all goods move down the ranking as they are subject to a continuous decrease in skill intensity, and the "mature" goods at the bottom of the ranking die out. One can see that a stable equilibrium in multilateral trade underlied by this scenario is possible, just as in two-way technology gap trade contemplated by Posner (1961).[23] As a result, each good, no matter what its skill intensity might intitially be, should eventually descend to the bottom of the ranking, passing on the way through domains of lower and lower ranked countries. Conversely, each country should eventually enjoy advantage in any given good, and when this will happen depends on the country's rank.

This way of looking at the scenario brings about the familiar "pecking order" result, typical to the product-cycle model.[24] In varying forms, the result is present, explicitly or implicitly, throughout the product-cycle literature. The specific position of a country in the "pecking order" is attributed to various factors, from relative skill abundance in Claudon (1977), through "innovativeness" and relative labor costs in Vernon (1966), to "ability to exploit new technology" in Krugman (1979b) or "technological level" in Krugman (1982). Krugman (1983) is more specific and suggests that a country's position in the ranking, and thus its position in a later competition in actual product markets, is linked to "the amount (its spends) on R&D."[25] Thus, two types of factors determining a country's position in the "pecking order" have been proposed in the literature. One is related to factor availability, and the other to the level of innovative capacity. The present model suggests that both these types of factors may simultaneously participate in determining the country ordering, and through that, the international pattern of exports.

The multi-country interpretation of the basic argument sketched above brings us a lot closer to being able to actually test the neo-factor and the neo-technology components of the model. It also suggests a convenient way of carrying out the tests, using cross-country and cross-commodity data. Before we move to the empirical part, however, the basic testable hypotheses suggested by the model need to be specified.

5.3 Testable Hypotheses

The two-country framework presented in Section 5.1 and amended by its multi-country interpretation in Section 5.2, generates three basic results of empirical interest. These are (5.8), (5.9) and (5.10). For the purpose of empirical testing, the three suggested hypotheses can be formulated, respectively, as follows:

Hypothesis 1: The neo-technology explanation of trade patterns applies primarily to trade in "new" goods, while the explanation based on factor proportions mainly to trade in "mature" products.

Hypothesis 2: (a) The higher the skill abundance rank of a country, the higher are likely to be the skill intensity ranks of the goods exported by this country; and (b) the higher a country's rank by innovative capability, the higher are likely to be the "youth" or R&D-intensity ranks of the goods exported by this country.

Hypothesis 3: Relative to lower ranked goods, a country's export performance in goods which at some given moment are ranked high both by "youth" or R&D intensity and by skill intensity is likely to be improved over time.

Thus, the first hypothesis deals with the suggested commodity specificity of the two explanations of trade patterns. The second addresses the problem of general validity of these explanations: relatively more skill abundant economies are expected to export more skill intensive goods, and more innovative economies should export younger, more R&D-intensive products. The third hypothesis captures the implied dynamism of international specialization: each country's domain of competitive advantage and along with it exports, are likely to be shifting with time toward relatively high-ranked "new" products. The three hypotheses are empirically examined in Part III.

FOOTNOTES

[1]Following Griliches (1979), it is convenient to think of the implied relationship as the knowledge parameter's being increasing in R&D expenditures. Ideally, to account for time lags, A_t^i would be viewed as linked to both present and past R&D effort (see p. 95). Implicitly ignoring the lags in the present analysis is of convenience rather than substance. Also, it needs to be noticed that it is applied research and experimental development, rather than fundamental research, what is of particular importance in acquiring knowledge aimed at installing new, low-cost processes, and as will be seen, developing new products. Apart from R&D, the two other possible sources of that type of knowledge are the learning-by-doing process and the diffusion of knowledge from abroad. It will be later assumed that the stocks of knowledge grow at constant rates. To the extent the latter two sources gain importance as product matures, such steady growth in knowledge stock may be obtained with progressively smaller increments in R&D expenditures. It is in this sense that the important stipulation typical for the product cycle hypothesis, namely that mature products are relatively less R&D-intensive, might be accommodated in this framework.

[2]The assumptions and structure of this part of the model follow those proposed by Claudon (1977). The model as a whole suggests some results concerning the timing of competitive advantage which generalize Claudon's findings.

[3]Homogeneity of degree one of the production function means that $\bar{a} + b_t + c_t = 1$, for all t. Differentiation with respect to t yields the result.

[4]This implies that, though production of any specific good at time t is more skill-intensive in i than in j, distributive shares of skills and labor are the same in both countries. The optimization problem implies that: $(S_t^{*i} w_s^i)/(L_t^{*i} w_l^i) = c_t/b_t = (S_t^{*j} w_s^j)/(L_t^{*j} w_l^j)$, where S_t^* and L_t^* are conditional input demands for skills and labor, respectively.

[5]For instance, in the case of country i the expression for marginal cost at period t is: $MC_t^i = (A_t^i)^{-1}[(\bar{a})^{\bar{a}}(b_t)^{b_t}(c_t)^{c_t}]^{-1}[(w_k)^{\bar{a}}(w_l^i)^{b_t}(w_s^i)^{c_t}]$. This makes use of the fact that, in the constrained cost minimization problem: $\min w_k K + w_l^i L + w_s^i S$ subject to $Y_t^i - A_t^i K^{\bar{a}} L^{b_t} S^{c_t} = 0$, the marginal cost at optimality is given by the Lagrange multiplier. In the case of country j, the expression is identical, except that superscripts i are switched into j.

[6]By definition, $D_t^{ij} = \log MC_t^j - \log MC_t^i$. With both b_t and c_t being identical between countries, substituting the expressions from footnote 5 for the marginal costs yields relationship (5.4). Note that by (5.2) relationship (5.4) becomes $D_t^{ij} = \log A_t^i - \log A_t^j + c_t w_s - b_t w_l$.

[7]We deliberately use the notion of competitive rather than comparative advantage because the latter would not make sense in the analysis involving one good. See Majumdar (1982), p. 2.

[8]Strictly speaking, for this to be true, we additionally need to assume the that V_t will not asymptotically approach some value greater or equal to zero.

[9]As a skill-abundant country, i is naturally more predisposed to doing that than country j is. Note that i's relative skill-abundance alone is perhaps a necessary but not a sufficient conditon for this country to develop new products or to promote Hicks-neutral technical progress. Accordingly, the conventional, static three-factor model in which the only difference between countries is in factor proportions deals with the fixed number of goods whose producive technology is stable. Within such a model, what country i is expected to do is to produce and export the relatively skill-intensive goods belonging to the fixed commodity set. It seems clear then that the observable phenomena such as development of new products and shifts in the production schedule do not follow from the conventional setting of the three-factor model, nor can they be accounted for by that static framework. But in reality new goods do appear as time passes, and production costs are subject to reduction following product's inception. So if country i's firms do, in fact, develop new, skill-intensive goods and promote the continual Hicks-improvement in the goods already produced, an incentive to do that must have come from something more than just i's relative skill-abundance. A dynamic nature of competitive advantage, as outlined in (5.5), is where such an incentive comes from in the present model.

[10]See Goodman and Ceyhun (1976), p. 533.

[11]A similar representation of the index of technological efficiency, A, is assumed in Findlay (1978), p. 3.

[12]The notion of the lag behind the "best practice" has been used in similar context in Findlay (1978) and Krugman (1982).

[13]The existence of the lag may reflect a differential between the cost of communication among the national firms and that among firms from different countries. See Arrow (1969), p. 33.

[14] I will not go into a deep question of why, in reality, this sort of imitation lag would tend to decline, and perhaps, eventually disappear. There are a number of ways though one could think of that. Unintended diffusion of knowledge due to ineffectiveness or expiration of patent protection and technological theft are frequent reasons. Then, the transfer of the kind of knowledge which is relativley obsolete by innovator's standards usually follows. A good deal of R&D effort by an innovating country is always centered around developing a new good rather than devising more efficient production techniques in the one already developed. Given that there is an upper limit to product-specific knowledge that can be acquired, a likelihood of such behavior on the part of an innovator increases as productive process of the existing commodity approaches the point of "technological saturation." That would tend to make it easier for the imitator to "catch-up" in the good that is already being produced by the innovator.

[15] For $T_n + T_1 \leq t < T_{sn}$, D_{tn}^{ij} is decreasing in t. This is because $\partial[(g - d)(t - T_n) + dT_1]/\partial t = g - d < 0$. For $t \geq T_{sn}$, D_{tn}^{ij} is fixed at the zero level.

[16] This follows directly from (5.4), (5.6), (5.7), and a definition of V_t.

[17] A one-factor, multicommodity "technology gap" model with similar features has been developed by Krugman (1982).

[18] This can be verified by using (5.6) and (5.7).

[19] Marris (1979), p. 30.

[20] In fact there seems to be such correlation. See Section 8.1.

[21] See discussion in Section 5.1.2.

[22] See Krugman (1982) for a similar setup.

[23] See pp. 336-337.

[24] For instance, see Claudon (1977), pp. 39sqq.

[25] Krugman (1983), p. 345.

PART III

TESTING THE HYPOTHESES

CHAPTER 6

COUNTRY AND COMMODITY SAMPLES, VARIABLES, AND DATA

6.1 Description of the Country and Commodity Samples

6.1.1 Country Sample

The present study covers 29 countries. The selection was guided by two requirements. One was that reliable and comparable data be available on the variables needed for at least one of the tests performed. In some cases, as warranted by especially serious gaps in available data, a country is dropped from the sample for the purpose of a specific test whose results might otherwise be distorted. On each such occasion the country not included in the analysis is explicitly indicated. The second requirement was that the country sample be a reasonable good representation of economies at various levels of industrial development. This requirement is met in a sense that, applying Balassa's classification criteria,[1] the sample includes 12 DCs (Australia, Austria, Belgium, Canada, France, Italy, Japan, Netherlands, Sweden, United Kingdom, United States and West Germany), 8 LDCs (Colombia, Egypt, India, Indonesia, Kenya, Philippines, Thailand and Tunisia), and 9 NICs (Argentina, Chile, Hong Kong, Israel, Korea, Mexico, Portugal, Singapore and Turkey).

Obviously, in the view of paucity of data and other limitations, some hard choices had to be made. For instance, Finland was left outside the sample as a country with an industry structure heavily based on wood related resources. Similarly, Indonesia is dropped from the sample on certain occasions due to its resource-based industry and due to substantial gaps in its trade data. Overall, however, it appears that, all compromises and restrictions notwithstanding, the two mentioned requirements regarding the composition of the country sample are adequately served.

6.1.2 Commodity Sample

The commodity sample is composed of 69 3-digit SITC commodity groups for which both trade data and data on basic commodity characteristics could be found. The complete listing and description of these commodity groups are provided in Table 6.1. The commodity set has been broken down into two subsets: the "high-technology" and the "low-technology" groups. The former are those with higher than average and the latter lower than average R&D intensity. R&D intensity is based on U.S. data and is measured for each commodity group after Aho and Rosen (1979) as the percentage of applied R&D expenditures in the value of product shipments.[2] R&D intensity measured this way varies from 0.22 for SITC groups 655 (special textile fabrics and related products) to 13.14 for SITC group 724 (telecommunications apparatus). The weighted average R&D intensity, used as a dividing line between the two subsets, is 2.19.

As it can be seen from Table 6.1, an attempt was made to assess the relationship between R&D intensity of commodity groups and their skill intensity. The dichotomous classification of 3-digit SITC groups with respect to skill intensity, reported in UNIDO (1981), was used for that purpose. Although the exact methodology underlying this typology is not totally clear,[3] given the lack of anything more quantitatively

Table 6.1

Commodity Groups Covered in the Test (Ranked by Decreasing R&D Intensity)

No	SITC Group	Skill Intensity*	Description of the Commodity Group
"High-Technology" Groups (Above-average R&D intensity):			
1	724	H	telecommunications apparatus
2	714	H	office machines
3	734	H	aircraft
4	541	H	medicinal and pharmaceutical products
5	726	H	electrical apparatus for medical purposes
6	711	H	power-generating machinery, excl. electrical
7	514	R	other inorganic chemicals
8	864	L	watches and clocks
9	513	R	inorganic chemicals: elem., oxides, halides
10	862	H	photographic and cinematographic supplies
11	861	H	scientific, medical and optical measur. instr.
12	571	H	explosives and pyrotechnic products
13	581	L	plastic materials, regenerated cellulose, resins
14	722	H	electric power machinery, switchgear
15	725	H	domestic electrical equipment
16	723	H	equipment for distributing electricity
17	732	L	road motor vehicles
"Low-Technology" Groups (Below-average R&D intensity):			
18	561	R	fertilizers, manufactured
19	599	-	chemical materials and products n. e. s.
20	729	H	other electrical machinery and apparatus
21	533	H	pigments, paints, varnishes and related
22	735	H	ships and boats
23	696	L	cutlery
24	712	H	agricultural machinery and implements
25	679	L	iron steel castings, forgings unworked
26	718	H	machines for special industries
27	733	L	road vehicles other than motor vehicles
28	694	H	nails, screws, nuts, bolts, rivets etc.
29	691	H	finished structures and structure parts n. e. s.
30	695	L	tools for use in the hand or in machines
31	692	H	metal containers for storage and transport
32	812	L	sanitary, plumbing, heating and light fixtures
33	698	H	manufactures of metals n. e. s.
34	893	L	articles of artificial plastic materials n. e. s.
35	629	L	articles of rubber n. e. s.

(continued)

Table 6.1 (Continued)

No	SITC Group	Skill Intensity*	Description of the Commodity Group
36	554	H	soaps, cleansing and polishing preparations
37	512	R	organic chemicals
38	717	H	textile and leather machinery
39	531	H	synthetic organic dyestuffs
40	521	R	mineral tar and crude chemicals from coal, petr.
41	553	H	perfumery, cosmetics except soaps
42	719	H	machines, appliances (excl. electric), parts
43	666	L	pottery
44	715	H	metalworking machinery
45	693	H	wire products (excl. electric), fencing grills
46	661	L	lime, cement, building materials excl. glass, clay
47	662	L	clay, refractory construction materials
48	665	L	glassware
49	663	H	mineral manufactures n.e.s.
50	664	L	glass
51	684	R	aluminum
52	689	R	miscellaneous non-ferrous metals used in metalurgy
53	682	R	copper
54	686	R	zinc
55	681	R	silver, platinum and related metals
56	673	L	iron and steel bars, rods angles etc.
57	676	L	rails and railway track construction materials
58	677	L	iron and steel wire
59	672	L	ingots and forms of iron and steel
60	671	L	pig iron, spiegeleisen, sponge iron etc.
61	675	L	hoop and strip of iron and steel
62	674	L	universals, plates and sheets of iron and steel
63	654	L	tulle, lace, embroidery, ribbon etc.
64	678	L	tubes, pipes and fittings of iron and steel
65	652	L	cotton fabric, woven
66	651	L	textile yarn and thread
67	657	L	floor covering, tapestry
68	653	L	textile fabrics woven, other than cotton
69	655	L	special textile fabrics and related products

Notes: */ H - high, L - low, R - resource-based commodity group for which skill-intensity has not been assessed.

Sources: Ranking by R&D-intensity is based on C.M. Aho and H.F. Rosen (1979), pp. 51-52. Classification by skill-intensity originates from UNIDO (1981), pp. 103-108.

rigorous, the classification may be useful as a heuristic device for descriptive purposes. Keeping this reservation in mind, one can notice that the high-technology commodity set is composed largely of groups with high skill intensity (71%), while the low-technology set includes mostly groups with low skill-intensity and resource-based groups (67%). This is an important observation regarding the nature of the two commodity subsets studied. It squares well with the theoretical proposition suggested earlier, namely that "new" goods in which R&D content is likely to be substantial are also highly skill-intensive while "mature" less R&D intensive goods tend to exhibit lower skill-intensity.[4]

Unfortunately, a number of commodity groups, mostly consumer durables of high importance in international manufacturing trade, could not be included in the commodity sample due to missing data. These include, among others, synthetic fiber, leather and wood products, radioactive materials, food products, petrochemical products, travel goods, clothing, footwear, sound recorders, toys, sporting goods, office and stationery supplies, perambulators and materials of rubber. These omissions, necessitated by the contents of data sets available, undoubtedly affected the quality of the results.

6.2 Description of the Variables Used in the Test

6.2.1 Measures of Export Performance

The two export performance variables used in the test are the revealed comparative advantage index (RCA) developed by Balassa (1965, 1977b)[5] and the share in total export index (STE). Formally, the two indices are defined as RCA = $(x_{in}/x_{wn})/(x_{im}/x_{wm})$, and STE = $(x_{in}/x_{im})\cdot 100$ respectively, where x stands for the value of exports, m denotes total manufacturing, n is a commodity group index, i is a country index, and w is a subscript for world export totals. For each country in the sample, data on RCA and STE, reported by 3-digit SITC commodity groups, are used in a form of three-year arithmetical averages calculated for the two periods analyzed, Period I (1969-71) and Period II (1976-78). I or II may be attached to the name of a variable to indicate the period from which data is taken. Data on RCA and STE for all 29 countries studied originate from UNIDO (1982).[6]

It is important to notice that the relationship between RCA and STE. It can be easily verified that for country i, $RCA_{in} = STE_{in}/STE_{wn}$. Verbally, RCA is the export share of commodity group n in country i's manufacturing exports normalized by the export share of the same commodity group in the world's manufacturing exports. Put still differently, while data sets on STE convey information about national export patterns, data sets on RCA describe the patterns of "revealed" national advantages or disadvantages in exporting particular commodity groups.

It is believed that trade performance indices based exclusively on export data, like RCA and STE, are empirically more useful than measures based on both export and import data; e.g., net exports, for the latter may be strongly influenced by internationally varying import restrictions.

One important limitation of RCA and STE that needs to be mentioned is that concerning missing observations on particular commodity groups for a series of countries.[7] LDCs, and particularly Indonesia, are the most severely affected by this shortcoming. There are two possible ways the problem could be dealt with. One is to retain only the countries with complete data over a certain number of commodity groups, and second, to exclude the commodity groups with missing data for some countries. As it turned out, either approach would result in a drastic reduction in the number of observations in the cross-section data sets. It was therefore decided to proceed with the test with this obvious weakness inherent in the data.

6.2.2 Commodity Characteristics

The total of six commodity characteristics, as reported for the U.S. by 3-digit SITC commodity groups, are used at various phases of the test. Given that export data are reported by the Standard International Trade Classifiction (SITC) code, the choice of the commodity characteristics was determined by the requirement that they be compatible with export data; i.e., that they be arranged by SITC as well rather than by the International Standard Industry Classification (ISIC) which is normally used to report data on industry characteristics. This left a limited number of available variables from which I could choose and, for instance, prevented me from being able to apply any measure of skill intensity underlied by skill ratios.[8]

The variables selected for the test are defined as follows:[9]

<u>RD</u>: the R&D-intensity variable; applied R&D expenditures in a commodity group as a percentage of the value of product shipments; based on U.S. data.

<u>SE</u>: the scale economy variable; obtained as the estimate of the exponent a in the regression equation $V = kn^a$, where V is the ratio between value added in plants employing n persons and average value added, and k is a constant; based on U.S. data.

<u>FTD</u>: the first trade date variable or a proxy for the average age of goods in a commodity group; obtained by identifying the average date of first appearances of goods from a commodity group in U.S. export statistics, and subsequently subtracting this average date from 1978.

<u>PD</u>: the product differentiation variable; measured as a coefficient of variation in unit values of U.S. exports of goods belonging to a commodity group.

<u>WM</u>: the wage-per-man or skill intensity variable; the wage bill divided by the total number of employees immediately occupied in producing commodities in a commodity group; based on U.S. data; expressed in U.S. dollars.

<u>CM</u>: the capital-per-man or Heckscher-Ohlin variable; the value of fixed plant and equipment employed in producing goods in a commodity group divided by employment in the production of these goods; based on U.S. data; expressed in U.S. dollars.

The first four of these variables relate to various aspects of the product cycle hypothesis. Each of them has been previously used to test specific propositions of the neo-technology framework. Their empirical use is based on the stipulation that they capture the changing commodity characteristics in the process of product's maturation over the lifecycle, as posultated by Vernon (1966) and Hirsch (1967). A potential weakness of FTD as a measure of product age needs to be recognized inasmuch as exports of a product do not have to immediately follow its development. Furthermore, the lags between product's development and first export are likely to differ across commodity groups. The remaining three neo-technology variables may also incorrectly characterize specific commodity groups as "new" or "mature" in that some products are intrinsically R&D-intensive, highly differentiated and subject to certain scale economies, irrespective of the stage in their lifecycle. It should be noted that the scale economy and product differentiation variables SE and PD, have no immediate relevance to the formal model presented in Chapter 5, in which neither economies of scale are admitted nor is product differentiation explicitly considered. These two variables are included in some initial regression specifications, and are subsequently dropped in the critical part of the test.

The fifth of the variables listed, WM, is intended to reflect skill intensity of commodity groups. Thus, it represents the neo-factor approach, with human capital or skills assessed on a price definition. The wage-per-man variable has been used in such capacity by Morrall (1972)[10] and Hufbauer (1970).[11] The interpretation of the variable as a proxy for skill intensity is based on the human capital theory of Becker (1962) and Schultz (1962), and has been discussed, among others, by Lary (1968), and Weahrer (1968).[12]

The last, sixth variable, CM, is of relatively lesser importance to this test as it relates to the standard Heckscher-Ohlin hypothesis which has been suppressed in the model by assuming international mobility of physical capital. The capital-per-man variable is applied merely to examine the possibility that, like the neo-factor model, the traditional version of the factor proportions theory may be more relevant to "mature" rather than "new" manufactures.

Data on all variables except RD, reported for all the 69 commodity groups, were taken from Hufbauer (1970). Regrettably, no adequate commodity characteristic data for more recent periods are available. Data on RD come from Aho and Rosen (1979).

6.2.3 Country Characteristics

For the purpose of testing hypothesis 2, it was necessary to establish rankings of the countries in the sample by their relative skill abundance on the one hand, and by their innovativeness, or innovative capacity, on the other. Based on the assessment of the potential relevance of different variables, and of the availability of data, the total of four alternative skill abundance variables and three alternative variables related to innovativeness were finally selected.

6.2.3.1 Proxies for Skill Abundance

Among the four skill abundance proxies used, one is meant to capture skill abundance on a price definition, two others measure quantitative aspect of availability of skills, and the last one is a rank measure based on the other three.

Ideally, assessing countries' relative skill abundance on a price definition would require knowledge of skill differentials, or relative skilled labor wages. Given that such data is hard to find, a variable that can be conveniently used as a proxy is the coefficient of variation in inter-industry wage structure, CVW. Some cross-country data on this type of index have been previously created by Papola and Bharadwaj (1970) and used for measurement of skill abundance by Morrall (1972).

The use of CVW as a proxy for skill abundance on a price definition is justified by its link to skill differentials. Here is a simple framework demonstrating the underlying rationale, and also indicating possible weaknesses of CVW as a skill abundance variable. Consider country i, and industry n, n = 1,...,N, employing two classes of labor: skilled labor S and unskilled labor L. Let the wage rates be w_{sn}^{i} and w_{1n}^{i}, respectively, and such that $w_{1n}^{i} = 1 < w_{sn}^{i}$, that is, the unskilled labor wage rate is assumed to be lower, and is taken as a numeraire. Competitive conditions in the two separate labor markets within a country assure that $w_{1n}^{i} = w_{1}^{i} = 1$ and $w_{sn}^{i} = w_{s}^{i}$, for all n. Labor mix coefficients for all N industries are given by vector $q = [q_1,\ldots,q_N]$, where q_n is defined as ratio S/(S+L) in industry n.

Vector q is taken to be identical across countries. Other determinants of an industry wage rate are ignored. Given that, the industry n wage rate is a convex combination of wage rates for the two labor classes, $w_n^i = q_n w_s^i + (1-q_n)$. The coefficient of variation in inter-industry wage structure for country i, $(CVW)^i$, defined as

$$(CVW)^i = (\bar{w}^i)^{-1}\left[\frac{\sum_{n=1}^{n}(w_n^i - \bar{w}^i)^2}{N}\right]^{1/2} \tag{6.1}$$

where $\bar{w}^i$ is the cross-industry mean wage rate, can be verified[13] to be equal to $s_q[\bar{q} + (w_s^i - 1)^{-1}]^{-1}$, where s_q is a standard deviation in the labor mix coefficients, and $\bar{q}$ is the mean labor mix coefficient. As long as q is identical across countries, this implies that, for any pair of countries i and j,

$$(CVW)^i \gtrless (CVW)^j \text{ as } w_s^i \gtrless w_s^j \tag{6.2}$$

In other words, the ranking of countries by CVW is consistent with the ranking by relative skilled labor wage rates. Countries which are relatively skill-rich should exhibit low CVW, and vice versa.

CVW was calculated and ranks assigned for each of the 28 countries,[14] based on industry wage structure data reported in ILO (1983) and U.N. (1983). The results are presented in Table 6.2. It is surprising to find three NICs (Mexico, Israel and Turkey), and one LDC (Colombia), to have higher ranks than that of the U.S. It is worth

Table 6.2

Coefficients of Variation for Inter-industry Wage Structure (CVW) in Selected Countries, 1977.

Country	Number of ISIC 2, 3, or 4-digit categories covered	CVW	Rank by CVW
Sweden[a]	28	0.0836	1
U.Kingdom[b]	22	0.0840	2
Netherlands	26	0.1109	3
France	24	0.1287	4
West Germany	28	0.1443	5
Mexico	22	0.1483	6
Italy	27	0.1571	7
Australia[c]	36	0.1687	8
Singapore	14	0.1869	9
Israel	16	0.1917	10
Belgium	24	0.1922	11
Austria	17	0.1959	12
Canada	25	0.2104	13
Japan	20	0.2159	14
Turkey	20	0.2201	15
Colombia	20	0.2234	16
United States	25	0.2377	17
India	17	0.2416	18
Hong Kong	13	0.2422	19
Egypt	28	0.2546	20
Argentina[c]	19	0.2742	21
Portugal	28	0.3309	22
Chile	20	0.3900	23
Tunisia[c]	33	0.4022	24
Korea	26	0.4359	25
Philippines[c]	28	0.6049	26
Indonesia[c]	33	0.6626	27
Kenya	26	0.7337	28
Thailand	-	-	-

Notes: a/Evaluated for 1978. b/ Male employees only. c/ Inter-industry wage structure calculated from U.N. (1983), pp. 449 sqq.

Source: Unless stated otherwise, coefficients of variation have been computed using the inter-industry wage structure data reported in ILO (1983), pp. 519-54.

mentioning, however, that a paradoxically low rank for the U.S. had also been detected in Papola and Bharadwaj (1970).

There are a number of reasons why CVW might turn out to be a rather weak measure of skill abundance. One is that vectors q are not, in reality, equal across nations. Second, international differences in data reporting may adversely affect cross-country comparability.[15] Third, the sets of industries covered by data vary widely between some countries. Finally, there may be numerous other factors affecting national industry wage structures: unionization, work conditions, industry-specific tenure regulations, "demand-for-skill reversals"[16] and others.

Overall, considering all these weaknesses, one needs to be extremely cautious while drawing conclusions from results generated with CVW data. The variable is clearly burdened with considerable shortcomings. If it is retained in this study, it is basically because it represents here the sole device allowing one to empirically get some feel of what the country ranking by skill differentials might be.

Two other skill abundance variables deal with skill abundance assessed on a quantity definition. The first of them is the human resource development index, HRD. Here is the procedure through which HRD was obtained. First, the gross enrollment ratio for the first and the second level of education, r_2, was determined for each country, and expressed in a percentage form. Second, the gross enrollment ratio for the third level of education, r_3, was found. Subsequently, HRD index was calculated as a combination of these two as follows: $HRD = r_2 + 3r_3$.

A higher weight attached to r_3 is meant to reflect special significance of the third level of education in determining skills. Thus constructed HRD resembles the Harbison-Myers index of human resource development used previously for similar purposes by Gruber and Vernon (1970) and Balassa (1977c). The Harbison-Myers index itself could not be calculated because the primary school enrollment ratio is not singled out in the data for most countries in the sample. Data used to calculate HRD were taken from UNESCO (1980). The results, and the ranking by HRD, are presented in Table 6.3. As it turns out, among the countries in the sample, the U.S. is the most skill abundant by HRD, the skill quantity variable. This may suggest that a surprisingly low rank detected for the U.S. with the use of CVW, the variable reflecting the price of skilled labor, might have obtained because of exceptionally high demand for skilled labor in the U.S. driving the relative skilled-labor wage rate up. It can also be seen from Table 6.3 that most other DCs are ranked, as expected, reasonably high.

The second variable of skill abundance based on a quantity definition is the percentage of professional, technical and related workers in total economically active population, PTR. Similar indices have been applied by Hufbauer (1970) and, for cross-industry studies, by Keesing (1968b), Weahrer (1968), and Goodman and Ceyhun (1976). Certain critical remarks related to using PTR for the assessment of skill availability have been proposed by Balassa (1977c). The basic objection against PTR is that is it includes various liberal occupations while excluding production supervisors, foremen, and skilled workers that are of considerable importance in DCs.[17] Nevertheless, PTR was retained in this test but the variable similar to the one proposed by Balassa as a substitute, HRD, is also being used. Values of PTR were derived for 25 countries[18] from ILO (1980) data, and they are reported together with the ranking by PTR in Table 6.3.

As is frequently the case with empirical work on trade models, no ideal proxies for relative skill abundance could be devised. Here, the problem is made even more difficult by the use of cross-country data. This is why efforts have been made to avoid disqualifying a priori any potentially useful variable. Each of the proxies may have its weaknesses, but all of them certainly do relate to some aspects of skill abundance. It is stipulated that if an independent application of individual variables generates results consistent with the expectations, it would be rather unlikely that this outcome is coincidental. It was also for the same reasons that the fourth skill abundance variable was constructed, namely the average rank by skill abundance measures, AVRS. AVRS was computed for each country by taking a simple average of the country's rank by CVW, HRD and PTR. The logic behind doing so relies on the expectation that if one of the three variables generates a paradoxical rank for a country; i.e., rank that does not seem to have much to do with country's true relative skill abundance, then such an aberration would be somewhat corrected by accounting for the other two variables. In other words, as long as the three variables are principally correct in their reflecting various demonstrations of relative skill abundance, AVRS will tend to reduce the impact of singular, variable-specific, biases on the

Table 6.3

Indicators of Skill Abundance: Human Resource Development Index (HRD) and Percentage of Professional, Technical and Related Workers in Economically Active Population (PTR), in Selected Countries.

Country	HRD[a]	Rank by HRD	PTR (year)	Rank by PTR
Sweden	185.5	3	25.1 (1975)	1
U.K.	151.5	14	-	-
Netherlands	180.5	5	16.2 (1977)	3
France	171.2	6	15.5 (1975)	4
West Germany	153.1	13	12.8 (1978)	7
Mexico	115.3	19	4.3 (1977)	19
Italy	165.5	7	5.9 (1971)	17
Australia	159.9	12	11.3 (1976)	8
Singapore	107.4	21	8.3 (1979)	10
Israel	162.2	9	21.5 (1979)	2
Belgium	163.2	8	-	-
Austria	143.8	15	3.7 (1979)	21
Canada	207.0	2	14.1 (1980)	6
Japan	181.7	4	8.2 (1975)	11
Turkey	95.0	24	-	-
Colombia	106.8	22	10.2 (1980)[b]	9
U.S.	268.1	1	14.7 (1979)	5
India	78.2[c]	25	4.2 (1971)	10
Hong Kong	109.0[c]	20	6.4 (1979)	15
Egypt	103.4	23	7.5 (1976)	12
Argentina	161.8	10	6.6 (1970)	14
Portugal	120.3	17	4.9 (1979)	18
Chile	135.4	16	7.2 (1980)[b]	13
Tunisia	75.9	27	2.2 (1980)[b]	23
Korea	116.9	18	3.1 (1975)	22
Philippines	160.1[c]	11	6.2 (1977)	16
Indonesia	64.4[c]	29	1.9 (1976)	25
Kenya	67.4	28	-	-
Thailand	77.9	26	2.2 (1978)	24

Notes: a/ Indices are calculated for 1977, unless stated otherwise. b/ Employed professional, technical and related workers as percentage of total employment. Source: ILO (1983), pp. 289-306. c/ Computed for 1976.

Sources: HRD indices have been computed from data reported in UNESCO (1980), pp. 153-215. Data on PTR comes from ILO (1980), pp. 90-134.

country ranking. It needs to be kept in mind that AVRS is a rank variable, so that it is only the country ordering, not the magnitudes of AVRS entries, that matters. The AVRS data are reported in the first column of Table 6.5.

One question that was addressed at the outset of the analysis was how the four different skill abundance measures are correlated with each other. Spearman rank correlation coefficients were calculated for all six pairs of variables, and they range from 0.52 (between CVW and HRD) to 0.89 (between PTR and AVRS). Table 8.1 shows that none of the coefficients exceeds the 1 percent significance level, and four coefficients are significant at 0.1 percent. The two variables of skill abundance on a quantity definition, HRD and PTR, are rather strongly (0.71) and significantly correlated with each other. Correlation of CVW with either of these two is lower, probably reflecting the fact that CVW is based on a price definition of skill abundance and as such, unlike HRD or PTR, it is meant to also account for demand for skills. Apart from that, especially severe problems with CVW mentioned earlier may be behind these low correlation coefficients as well.

6.2.3.2 <u>Proxies for Innovativeness</u>

The neo-technology or product-cycle component of the model is represented in the test by two basic country characteristics: the number of scientists and engineers engaged in R&D activities per million of population, SEP; and expenditures for R&D as percentage of GNP, PRD. They are both the input-type proxies for innovative capacity. Given the lack of reliable and internationally comparable data on output measures of technological innovativeness; e.g., patents,[19] these will have to do. Data on both these variables originate from UNESCO (1980) and they are given in Table 6.4. Also, the country rankings by SEP and PRD are reported there.

There are several indications that the R&D-based variables such as SEP and PRD should perform well as proxies for innovative capacity. Goodman and Ceyhun (1976)[20] point to their high correlation with innovative output. Also, Pavitt and Soete (1980)[21] report very high and significant correlation coefficients between selected R&D-related variables and characteristics based on U.S. patent data for ten DCs. Various R&D-related variables have been successfully applied as measures of innovative capacity in the empirical studies by, among others, Keesing (1968a), Walker (1979), and Holroyd (1983). Despite all that, certain skepticism is warranted in treating SEP and PRD as aggregate measures of a country's capability to develop and successfully market new products. The problem is best visualized by closely analyzing the cases of individual countries in the sample. For instance, as it can be seen from Table 6.4, Israel ranks higher than any DC in the sample and it is thus made to appear as the most innovative economy.[22] On the other hand, low ranks of France, Australia and Austria are somewhat surprising.

The two variables do not draw any distinction between the product innovation and the process innovation, they ignore the important problem of effectiveness of R&D effort, and they fail to capture the economies of scale in R&D, all these three factors being clearly determinants of how R&D input is translated into innovative output. Moreover, successful

Table 6.4

Proxies of Technological Innovativeness: Scientists and Engineers Engagaed in R&D per Million of Population (SEP) and Expenditure for R&D as Percentage of GNP (PRD), in Selected Countries.

Country	SEP (year)	Rank by SEP	PRD[a]	Rank by PRD
Sweden	1708 (1977)	6	2.0	5
U.K.	1417 (1975)	8	2.0	6[c]
Netherlands	1761 (1976)	5	2.1	4
France	1281 (1977)	10	1.8	8
West Germany	1807 (1977)	4	2.3	3
Mexico	101 (1974)	23	0.2	23
Italy	674 (1976)	12	0.8	15
Australia	1617 (1976)	7	1.0	11
Singapore	198 (1978)	19	0.2	24
Israel	3991 (1978)	1	4.2	1
Belgium	1412 (1977)	9	1.4	9
Austria	250 (1972)	17	0.4	19
Canada	1056 (1977)	11	1.1	10
Japan	3548 (1978)	2	1.9	7
Turkey	221 (1978)	18	0.9	14
Colombia	52 (1971)	26	0.1	26
U.S.	2685 (1978)	3	2.5	2
India	46 (1977)	27	0.5	18
Hong Kong	-	-	-	-
Egypt	299 (1973)	16	0.8	16
Argentina	313 (1978)	15	1.0	12
Portugal	181 (1976)	20	0.3[b]	20
Chile	580 (1975)	13	0.3[b]	21
Tunisia	153 (1974)	21	-	-
Korea	398 (1978)	14	1.0	13
Philippines	83 (1976)	24	0.3	22
Indonesia	57 (1976)	25	0.2	25
Kenya	27 (1975)	28	0.8	17
Thailand	149 (1975)	22	-	-

Notes: a/ 1977 data. b/ 1978. c/ In cases of identical PRD, a higher rank has been arbitrarily assigned to a country ranked higher by CVW, the index of skill abundance by price definition.

Source: UNESCO (1980), pp. 882-891.

Table 6.5

Average Ranks by Skill Abundance Measures (AVRS) and by Technological-Innovativeness Measures (AVRT), for Selected Countries.

Country	AVRS[a]	AVRT[b]
Sweden	1.67	5.5
U.K.	-	7.0
Netherlands	3.67	4.6
France	4.67	9.2
West Germany	8.33	3.5
Mexico	14.67	23.0
Italy	10.33	13.5
Australia	9.34	9.0
Singapore	13.33	21.5
Israel	7.01	1.0
Belgium	-	9.1
Austria	16.00	18.0
Canada	7.00	10.5
Japan	9.33	4.5
Turkey	-	16.1
Colombia	15.67	26.0
U.S.	7.67	2.5
India	21.00	22.5
Hong Kong	18.00	-
Egypt	18.33	16.0
Argentina	15.00	13.6
Portugal	19.00	20.0
Chile	17.33	17.0
Tunisia	24.67	-
Korea	21.67	13.7
Philippines	17.67	23.1
Indonesia	27.00	25.0
Kenya	-	22.6
Thailand	-	-

Notes: a/ For each country, AVRS was obtained as an arithmetical average of country's ranks by CVW, HRD and PTR. To obtain an unambiguous ranking, in cases of identical averages between two countries AVRS was arbitrarily raised by 0.01 for a country ranked higher by two out of the three skill-abundance indices. b/ AVRT is an arithmetical average of a country's ranks by SEP and PRD. In cases of identical average, AVRT was raised by 0.1 for a country with higher PRD (higher SEP, if PRD indices were equal).

innovations involve some inputs that are hard to quantify like organizational solutions, management of production processes, and marketing. Therefore, if R&D statistics have become widely accepted during the last 15 years or so for the purpose of measurement of innovative activities, it is merely because no better data on the output side were available in most studies. This is certainly the case with the present test as well.

The third variable of innovativeness used here is average rank by proxies of technological innovativeness, (AVRT), calculated as the arithmetical average of a country's ranks by SEP and PRD. The rationale behind devising AVRT is similar to that presented for AVRS. Both these rank variables are being used in the rank correlation test of hypothesis 2. AVRT data is given in the second column of Table 6.5

To examine the relationships among the three measures of innovativeness, Spearman correlation coefficients were calculated on the sample of 26 countries with no missing observations. The coefficients range from 0.87 to 0.97 and are all significant at 0.1 percent. The results are shown in Table 8.1.

FOOTNOTES

[1]The NICs are defined as those with "per capita incomes between $1100 and $3500 in 1978, and where the share of the manufacturing sector in the GDP was 20 percent or higher in 1977." Balassa (1981), p. XIX.

[2]For exact methodology, see Aho and Rosen (1979), p. 50.

[3]R. H. Ballance (1985) has pointed out to me that the general rule applied to obtain this classification was to calculate the simple average skill ratio for commodity groups, and use that as a dividing line between the two designations, high and low. However, a number of ad hoc assignments to high- or low-skill-intensity groups were also performed. Although somewhat arbitrary, this is, to my knowledge, the only attempt to assess relative skill intensity of 3-digit SITC commodity groups, based on the calculation of skill ratios.

[4]As it will be reported later, though, no statistically significant correlation has been detected in the overall commodity set between R&D intensity and skill intensity as measured by the wage-per-man.

[5]For a discussion of the RCA index, see also Hillman (1980).

[6]For methodological details, see UNIDO (1982), pp. 21-30.

[7]The SITC code commodity groups for which no comparable data on RCA and STE could be found are as follows: Isreal - 521, 671, 672, 675-677, 679; Austria - 561; Canada - 531, 664, 666, 675; Colombia - 671, 676, 679, 689, 726, 864; Turkey - 521, 531, 561, 571, 672, 674, 676, 677, 681, 682, 684, 686, 691, 693, 714, 726, 734, 735, 862, 864; India - 561, 681; Hong Kong - 521, 531, 571, 671, 672, 674-6, 679, 681, 686, 712, 726, 732, 734; Egypt - 521, 531, 581, 672, 675-7, 679, 681-2, 686, 689, 692-3, 712, 714, 726, 733-4, 864; Argentina - 671, 734; Chile - 521, 553-4, 652, 654, 662, 675-7, 681-2, 684, 686, 696, 712, 726; Tunisia - 521, 531, 571, 671-6, 681, 686, 689, 714-5, 726, 733, 862; Philippines - 521, 671-3, 675-7, 679, 682, 686, 689, 712, 714-5, 722-3, 725-6, 733-4, 862, 864; Kenya - 521, 531, 571, 662, 666, 671-2, 675-6, 679, 681-2, 686, 689, 711, 714, 722, 725-6, 734, 862, 864; Thailand - 521, 561, 571, 572, 675-7, 679, 681, 689, 726, 734. For Indonesia, data on the following commodity groups were available: 541, 553, 599, 629, 652, 653, 654, 655, 657, 682, 698, 735.

[8]Theoretically, better data on commodity characteristics could be obtained by converting statistics from ISIC to SITC, but that is a rather costly procedure in terms of computational time, and involves a substantial degree of arbitrariness.

[9]For details underlying the construction of the variables and for data listings, reader is referred to Aho and Rosen (1979), pp. 49-52, and Hufbauer (1970), pp. 212-223.

[10]See Morrall (1972), pp. 39, 76sqq.

[11]Hufbauer found that simple correlation between wage-per-man and skill ratio for the 24 countries studied was 0.911. See Hufbauer (1970), p. 195.

[12]Lary (1968), pp. 35sqq, Weahrer (1968), pp. 26, 37. Also, Hufbauer (1970) reviews some early work relying on inter-industry wage differentials as a reflection of skill differentials. See pp. 172-174.

[13]Given the assumptions, the mean industry wage rate in country i can be expresses as $\overline{w}^i = w_s^i \sum_{n=1}^{N} q_n/N + \sum_{n=1}^{N} (1-q_n)/N$. Therefore $w_n^i - \overline{w}^i = (w_s^i - 1)[q_n - \sum_{n=1}^{N} \frac{q_n}{N}]$. Substituting these two into equation (6.1) and rearranging terms yields the result.

[14]No data could be found for Thailand.

[15]Various countries report industry wages on different bases: hourly, weekly, monthly, or yearly. Since $(CVW)^i$ is not affected by multiplying w_n^i and $\overline{w}^i$ by a constant, these differences in data reporting will pose no serious problems with cross-country comparability of index CVW as long as the patterns of working hours are similar across countries.

[16]For a discussion of this, and other factors that may induce certain biases in CVW, see Fortune (1976), Morrall (1972), and Lutz (1976).

[17]Balassa (1977c), p. 14.

[18]The countries not covered are: United Kingdom, Belgium, Turkey, and Kenya.

[19]Pavitt and Soete (1980) have managed to come up with some comparable patent data for a narrow group of DCs by using the Department of Commerce statistics on U.S. patents which indicate the country of origin. They successfully link certain export characteristics to patent data, the latter being interpreted as an output measure of innovative capability.

[20] Pp. 356-7. Also, see Lowinger (1976), p. 226.

[21] See pp. 40-41.

[22] Note that Israel also ranks unexpectedly high by the skill abundance measures. Similarly high skill abundance indices for Israel were obtained by Balassa (1977c), p. 13.

CHAPTER 7

TEST OF HYPOTHESIS 1: EXAMINING COMMODITY SPECIFICITY OF THE FACTOR PROPORTIONS AND THE NEO-TECHNOLOGY THEORIES OF TRADE

In this, and the next two chapters, we describe the design and report the results of a broad-based empirical work covering 29 countries, 69 commodity groups, two time periods (1969-71, 1976-78), and the total of 15 variables used in the regression and/or correlation analyses: 2 export performance variables (RCA, STE), 6 commodity characteristics (RD, SE, FTD, PD, WM, CM), and 7 country characteristics of which 4 are proxies for skill abundance (CVW, HRD, PTR, AVRS) and 3 others are measures of innovativeness (PRD, SEP, AVRT).

The test addresses the three major hypotheses formulated in Section 5.3 on the basis of the results produced by the framework which combines the neo-factor (labor skills or human capital) explanation, and the neo-technology (product cycle) explanation of international trade in manufactures. As in the theoretical framework, the coexistence of the neo-factor and the neo-technology explanations is allowed for in this empirical analysis.

To my knowledge, the test provides the first attempt to test certain implications of an integrated multi-factor model of this type for an extensive sample of countries including not only DCs, customarily covered in related analyses, but also a series of other countries, notably NICs, with growing importance to manufacturing trade. The choice to include these in the country sample was not without costs. It resulted in certain problems with data availability and comparability discussed earlier. The decision to have those "new industrial exporters" in the sample was taken nevertheless because of the belief that they no longer can be ignored in assessing validity and generality of basic trade theory.

7.1 Regressing Export Performance on Commodity Characteristics for the Overall Set of 69 Commodity Groups

Important to the present test is the assertion that an individual country's pattern of export performance, as measured by variable STE or by the revealed comparative advantage index RCA, may be related in the cross-commodity data to more than one commodity characteristic. More precisely, six such characteristics are examined. Four of them represent different categories essential to the product cycle concept (R&D intensity RD, scale economy variable SE, product age FTD, and product differentiation PD). The fifth one, wage-per-man WM, represents the skill or human capital approach, and it stands for skill intensity. The sixth variable, capital-per-man CM allows for the possibility that the standard Heckscher-Ohlin result could manifest itself as well.

It is possible that some of these variables may be irrelevant to the explanation of cross-commodity export performance by particular countries. The problem could result from the fact that the commodity characteristics are based on the U.S. data. If undetected, this could create potentially serious problems for the test itself. Such a possibility was closely examined and the findings will now be summarized before the design and the results of the tests of the separate three hypotheses are systematically presented.

For each of the countries in the sample, the stepwise regression procedure was applied, using export data from Period II, to regress export performance on commodity characteristics. The working of the procedure is as follows. First, the variable that has the largest F-statistic is selected from the set of potential regressors. Subsequently, at consecutive steps, variables are added one by one to the model, and the F-statistic for a variable to be added must be significant at some arbitrarily chosen critical level, in this case 15 percent. After a variable is added, the procedure looks at all the variables already included, and deletes any variable that does not produce an F-statistic significant at the 15 percent level. The procedure ends when, after the final step, no variable left outside the model has an F-statistic significant at the critical level.[1]

The set of potential regressors includes all six commodity characteristics described in Section 6.2.2. In each country case both RCA and STE were used as endogeneous variables. For each of these variables two different functional forms of the regression equation were checked, the linear form and the logarithmic-linear form, the latter being a linear equation with all variables, both endogeneous and exogeneous, entering in logs.[2] Thus, four distinct sets of estimates were obtained for each country, resulting from four separate applications of the procedure. Two estimated equations, one with RCA and one with STE as a dependent variable, were selected for reporting in each country case, the choice criterion being a higher coefficient of determination. The selected results are presented in Table 7.1.

Table 7.1

Results of Selected Stepwise Regressions Involving Export Performance Measures RCA and STE in the Entire Set of 69 SITC Commodity Groups Studied, for 29 Countries, 1976-78 (Period II).

Country	Endog. Variable, Model[a]	RD	CM	WM	SE[b]	FTD	PD	F Stat.	R^2
Sweden	RCA,lin			0.1929**				5.17**	0.0717
	STE,log			1.6288		-4.7748***		9.36***	0.2210
U.K.	RCA	-	-	-	-	-	-	-	-
	STE,log	0.3294***				-3.3342***		14.79***	0.3095
Netherlands	RCA	-	-	-	-	-	-	-	-
	STE,log	0.2929**				-4.0668***		11.71***	0.2620
France	RCA,lin	-0.0360			2.4065***		-0.2770	5.16***	0.1923
	STE,log	0.1558				-4.1917***		16.40***	0.3220
Germany	RCA,lin	-0.0321*			1.1820**	-0.1458	0.2517*	3.04**	0.1596
	STE,log	0.2374**				-4.0175***		13.22***	0.2861
Mexico	RCA,lin				-23.4121***		-1.8219	13.75***	0.2942
	STE,lin		0.0392***		-4.5274**	-0.4489		6.94***	0.2417
Italy	RCA,log			-1.1743***		-1.0685*		5.29***	0.1382
	STE,log					-4.8042***		13.07***	0.2562
Australia	RCA,log		0.4818**	1.5544*				9.34***	0.2205
	STE,log			3.2684***		-2.6619**		12.03***	0.2672
Singapore	RCA,log	0.2763**		-2.9325***			0.8576***	11.25***	0.3418
	STE,log	0.4777***		-3.1432***		-4.5919***	0.8855*	10.50***	0.3962
Israel	RCA,log	0.7398***	0.5939	-4.1029***				4.12**	0.1757
	STE,log	0.6025**				-3.7379**		6.48***	0.1802

(continued)

Table 7.1 (Continued)

Country	Endog. Variable, Model[a]	RD	CM	WM	SE[b]	FTD	PD	F Stat.	R^2
Belgium	RCA,log	-0.3232***	0.3830***					13.31***	0.2874
	STE,log		0.3445**			-2.8277***		5.30***	0.1384
Austria	RCA,log	-0.2941***						8.35***	0.1124
	STE,log					-4.4147***		17.37***	0.2084
Canada	RCA,log		0.4584**	2.6999***		1.3892*		14.62***	0.4182
	STE,log			4.1592***		-1.9690*		11.29***	0.2670
Japan	RCA	-	-	-	-	-	-	-	-
	STE,log					-4.8444***		15.37***	0.1866
Turkey	RCA,log		1.6164***	-6.0137***				8.05***	0.2592
	STE,log		1.5427***	-4.0173**				4.96**	0.1773
Colombia	RCA,log	0.4062**	0.9571***	-6.6617***				8.14***	0.2928
	STE,lin		0.0368***	-0.6332***		-0.7416***		8.02***	0.2897
U.S.	RCA,lin	0.1351***					0.2935	19.18***	0.3676
	STE,log	0.6470***				-4.1412***		24.45***	0.4256
India	RCA,log	-0.5060***		-2.0282*		2.8256**		8.36***	0.2848
	STE,lin		0.0204	-0.5002***				5.26***	0.1411
Hong Kong	RCA,log	0.6319***		-7.2794***				15.03***	0.3708
	STE,lin	0.3041***		-0.6116***				15.24***	0.3741
Egypt	RCA,log	-0.4684*					-2.1371***	11.83***	0.3397
	STE,log	-0.5229				-4.2623*	-2.4317***	7.43***	0.3312
Argentina	RCA,log					-2.3881**		5.71**	0.0808
	STE,log	0.3297*				-6.1886***		12.88***	0.2869
Portugal	RCA,log			-5.6767***			0.8163*	17.96***	0.3524
	STE,lin			-0.6452***		-0.7700**		13.11***	0.2843

(continued)

Table 7.1 (Continued)

Country	Endog. Variable, Model[a]	RD	CM	WM	SE[b]	FTD	PD	F Stat.	R^2
Chile	RCA,lin				-27.2609***	-0.3327**		23.10***	0.4802
	STE,lin		0.0084**		-3.5479***	-0.1650		11.63***	0.4160
Tunisia	RCA,log	0.4965*		-5.1255***		2.5169		3.95**	0.1981
	STE,log	0.7474**		-4.8908**				4.22**	0.1470
Korea	RCA,log	-0.2893*		-4.3383***			0.9532**	8.64***	0.2851
	STE,log			-4.3096***		-2.2466	0.9988*	5.88***	0.2136
Philippines	RCA,log	-0.4556**						4.79**	0.0981
	STE,log					-4.6178***		8.70***	0.1621
Indonesia	RCA,lin	0.1720***		-0.1111*		0.1747		12.15***	0.8200
	STE,lin	0.1876***		-0.0891*				42.74***	0.9047
Kenya	RCA,lin		0.0968***			0.9526*		7.79***	0.2615
	STE,lin	0.0377***						13.70***	0.2334
Thailand	RCA,lin		0.0134	-0.4607***	-2.8320*	-0.3018		7.00***	0.3499
	STE,lin			-0.3157***	-2.4447*	-0.4704**		7.62***	0.3014

Notes: a/ For each country and each of the two endogeneous variables, results of a linear (lin) or a logarithmic-linear (log) form of the model are reported whichever generated a higher coefficient of determination R^2 in the final equation resulting from the stepwise procedure.

b/ Variable SE was not included in regressions of the logarithmic-linear form due to negative values of many observations on SE.

A dash (-) was used in cases where no exogeneous variable had been found to meet a 15 percent significance level in a linear or logarithmic-linear regression.
Asterisks *, **, and *** denote significance at the 10, 5, and 1 percent level, respectively.
Estimates of intercepts have been omitted.

Three types of corrections performed on the data need to be mentioned. First, zero values of RCA and STE were arbitrarily changed into 0.001 for the logarithmic-linear regressions to avoid the loss of observations. Second, the scale economy variable SE was omitted in the logarithmic-linear regressions due to negative signs that SE carries for some commodity groups. Both these corrections were made because logarithmic function is defined for positive arguments only. Three, since the values of the capital intensity variable, CM, the skill intensity variable, WM, and the product age variable FTD are much higher than the values of the remaining regressors and of dependent variables, scaling down original observations on these three variables was necessary.[3] For logarithmic-linear regressions, this was done by expressing CM and WM in thousands of U.S. dollars rather than in U.S. dollars, and by expressing FTD in decades rather than in years. For linear regressions, the three variables were additionally centered by measuring them as deviations from their respective means. Such corrections on CM, WM and FTD do not affect the rankings of commodity groups by these characteristics, and for the sake of comparability of results they are applied throughout the entire regression analysis in this study.

Let us now have a closer look at the results compiled in Table 7.1. They reveal that in the entire set of 69 commodity groups, the stepwise procedure generates multiple regressions for most country cases. The three explanatory variables that meet the 15 percent significance level with especially high frequency are R&D intensity RD, product age FTD, and skill intensity WM. In fact, in most equations they are significant at 1 or 5 percent.

The remaining three explanatory variables (SE, PD and CM) show a rather poor performance, except for a few equations in the case of each variable. It needs to be remembered that SE was not used in the logarithmic-linear equations, and that may in part explain its failure to appear more frequently in the final equations of the stepwise procedure. Poor showing by PD may well have something to do with the nature of this variable. Cross-section data on PD were generated by Hufbauer by calculating the coefficients of variation in unit export values for separate commodity groups. Hufbauer, himself, admits that, in the product cycle, goods may never change their degree of differentiation as measured by this index. Some goods are intrinsically differentiated, whatever their age in a product cycle sense. There is a chance then that what PD really captures is that time-invariant aspect of differentiation, essentially immaterial to the notion of product cycle.[4] If so, then validity of the product cycle explanation would not suffer from low significance of PD coefficients in Table 7.1.

A more important finding, however, is a disappointing performance of the Heckscher-Ohlin variable, CM. It appears that when other factors such as skill intensity, R&D intensity and product age are allowed to play the role in the model, the basic factor-proportions variable tends not to be significant in the explanation of both export structure (STE) and the patterns of revealed comparative advantage (RCA) within the entire set of 69 commodity groups studied.[5] Criticisms of the two-factor model, both of theoretical and empirical nature, can be traced back to the Leontief paradox, and we gave some attention to them in the survey of the literature. The result that we now obtain may well be yet another corroboration of the thesis that the standard Heckscher-Ohlin model can no longer be viewed as a universally applicable explanation of trade in manufactures. An attempt is made later in this chapter to reexamine the relevance of the Heckscher-Ohlin variable for the two more narrowly defined commodity sets, the low-technology and the high-technology goods.

The picture emerging from these findings leads one to the conclusion that the combined multi-factor model tends to be superior to any elegant single-variable framework. In the majority of cases, more than one explanatory variable turn out to be significant in the final step regression equation. The two neo-technology variables, R&D intensity RD and product age FTD, as well as the skill intensity variable WM play the predominant role in characterizing patterns of export performance over all 69 commodity groups covered by the analysis. With a few exceptions,[6] the estimates of coefficients on these three variables, when highly significant, carry signs that could be expected. FTD contributes especially to the explanation of export structures (equations with endogeneous STE), while the other two variables perform about as well in the equations with the revealed comparative advantage variable RCA as they do in those with STE. It is these three commodity characteristics then that will be extensively used further in the test, notably in the verification of hypotheses 2 and 3.

The regression results discussed here may be subject to criticisms related to low coefficients of determination. In many country cases, the independent variables explain no more than a third of the variation of RCA or STE. Clearly, some important explanatory variables have been omitted; e.g., natural resources,[7] cross-country differences in quality of skilled labor, and factors determining demand for exports. Although leaving these potentially important factors out may be generally objectionable, it should be kept in mind that generating the "best" model is not what the stepwise procedure was meant to do. Instead, it was intended to indicate the most relevant regressors among the six commodity characteristics selected for the analysis.

Finally, let us look at the findings for some individual country cases among those reported in Table 7.1. For instance, consider the case of the U.S. The revealed comparative advantage for this country turns out to be significantly and positively related to R&D intensity of commodity groups. Also, export shares tend to be higher for commodity groups that are both R&D-intensive and "young" in terms of FTD. These findings square well with numerous earlier results linking the U.S. export performance to various "technology-intensity" variables, notably R&D intensity.[8] More specifically, as in Lowinger's (1975) study, based on commodity data arranged by the industry rather than trade classification, R&D intensity is the single most powerful variable in the explanation of the U.S. export performance. Interestingly, RD exhibits similarly high significance, and also carries positive signs, for such NICs as Israel, Singapore, and Hong Kong. On the other hand, for a series of NICs and LDCs (Turkey, South Korea, Portugal, Colombia, Tunisia, Thailand) one or both factor-proportions variables (WM, CM) pick up significance and dominate the models. These countries can be described as exporters of commodities with relatively low skill intensity; Turkey and Colombia being additionally exporters of capital-intensive goods. Two DCs, Australia and Canada, join the group of country cases with highly significant skill intensity variable WM, except that these two enjoy revealed comparative advantage in commodity groups that are both capital-intensive and skill-intensive. The only systematic pattern shared by other DCs is that the commodity group export shares are inversely and significantly related to age of products as measured by FTD.

Having established that R&D intensity, product age, and skill intensity are the most important regressors of export performance for the entire set of commodity groups, and that the other three variables, including the capital-per-man variable, turn out to be far less significant, we now turn to the verification of hypothesis 1.

7.2 Regressing Export Performance on Commodity Characteristics within the High-Technology and the Low-Technology Commodity Subsets

7.2.1 Empirical Representation of "New" and "Mature" Products

Hypothesis 1 deals with one aspect of the presumed complementarity between the neo-factor and the neo-technology approach to industrial trade, namely the one that has to do with their commodity specificity.[9] As suggested by relationship (5.8), hypothesis 1 postulates that export performance in "new" products is explainable largely by the neo-technology type of characteristics, while the factor proportions type of variables gain in importance as products become "mature." The presence of such property has been hinted upon by numerous authors,[10] yet the problem has never been satisfactorily examined.

One important conceptual problem posed by such formulation of the hypothesis is that regarding the empirical distinction between "new" and "mature" goods. In terms of our model, the distinction can be made without difficulty at any point in time. For instance, at time $T_{s\hat{n}}$, the "new" goods are all goods n such that $n > \hat{n}$, and the remaining goods in the continuum are "mature."[11] No such clear-cut distinction is possible in the real-life commodities for the purpose of empirical testing.

Instead, let us have a look at the matter from a somewhat different point of view. More important than establishing the exact composition of the two product classes is perhaps to clearly realize what the distinctive characteristics of the two classes are. By construction of the model, "new" goods are characterized by relatively high skill-intensity, and the stock of commodity-specific technological knowledge regarding their production varies internationally. On the other hand, the model implies that "mature" goods are those less skill-intensive, and whose production functions are internationally identical, the latter being a result of the inter-country identicity of the stocks of knowledge. In each of "new" goods, the cross-country gap in the producton function is ascribed to R&D expenditures in the innovating country, and it undergoes a gradual erosion due to acquisition of knowledge by the imitator, presumably also as a result of R&D activities conducted in the imitating country. Even if the imitator acquires knowledge through diffusion from abroad, some R&D outlays will still be essential to adapt it to domestic relative factor costs and demand patterns. Therefore, in addition to being skill-intensive, "new" goods are also likely to have relatively high R&D intensity. Conversely, technological knowledge pertaining to "mature" goods is equally available in both countries. In these goods, the international identity of production functions implies that marginal physical products, and also marginal cost, depend only on domestic relative factor prices. Productivity gains, measured by an increase in the stock of knowledge, are uniform between the two countries. They are more likely to arise from the learning-by-doing process rather than from R&D investment, and they are virtually costlessly transferable from country to country. Hence, comparing to "new" goods, "mature" goods emerge as not only less skill-intensive but also less R&D-intensive. It should be noted that, following Vernon's (1966) original contribution, classification of goods along similar lines were attempted by many other authors. Among others, Hirsch (1974b)[12] contemplated a typology of "Heckscher-Ohlin goods" and "product-cycle goods" within a two-factor model, and that led him to conclusions regarding goods' skill- and R&D-intensity that are basically identical to ours.

Having established the crucial differences between the theoretically conceived classes of "new" and "mature" goods, we will now attempt to classify the 69 SITC commodity groups covered in this study. We propose that "new" goods be represented for empirical purposes by the set of 17 high-technology groups; i.e., those with above-average R&D intensity. The 52 low-technology groups, with below-average R&D intensity, will be taken to stand for "mature" goods. The former are not only relatively more R&D intensive, but also include goods that are, on average, more skill-intensive than those contained in the low-technology groups. As we saw, almost three quarters of them were classified by UNIDO (1981) as high skill-intensity groups, while only less than a third of the low-technology groups turned out to belong to this category.[13] Also, the mean value of the wage-per-man variable WM, our measure of skill-intensity, is appreciably higher in the high-technology than in the low-technology groups. There is only one commodity group (SITC 864, watches and clocks) which, although classified as high-technology due to impressive RD value, exhibits low skill intensity by both measures, the UNIDO's and ours. On the other hand, out of the 52 low-technology groups, seven are portrayed in UNIDO (1981) as having high skill-intensity, and they also have WM values that are above the mean value for all 69 groups. These seven ill-behaved commodity groups are: SITC 533 (pigments, paints, varnishes, and related), SITC 735 (ships and boats), SITC 718 (machines for special industries), SITC 694 (nails, screws, nuts, bolts, rivets, etc.), SITC 554 (soaps, cleansing and polishing preparations), SITC 531 (synthetic organic dyestuffs), and SITC 715 (metal-working machinery).

To summarize, there is a certain amount of arbitrariness involved in drawing a dividing line between the groups representing "new" and "mature" goods. Certain groups, taken to stand for "mature" or for "new" products, would be hardly judged as such by common sense. One has to remember though that the commodity groups studied here are heterogeneous in their composition, and involve mixtures of goods with varying skill- and R&D-intensity. At least some of the seemingly paradoxical assignments can presumably be attributed to that. The proposed empirical representation of "new" and "mature" goods is not free from shortcomings, but it is believed that the limited number of possibly ill-assigned groups should not greatly affect the nature of results.

7.2.2 Examining the Significance of Differences between Regression Coefficients for the High-Technology and the Low-Technology Commodity Subsets

In this section we look at the problem of how export performance in the two commodity subsets, high-technology and low-technology, is related to various commodity characteristics. Specifically, we wish to see if the cofficient estimates from regressing the revealed comparative advantage index RCA on the set of commodity characteristics for the high-technology commodity subset significantly differ from the coefficient estimates obtained when the same regression is applied to the low-technology subset. This is accomplished by first estimating the unrestricted model, then the restricted one, and subsequently applying the proper F-statistics to see if the hypothesized restrictions on the estimated parameters can be rejected.

Considering that the scale economy variable SE and the product differentiation variable PD were found in Section 7.1 to have generally low significance levels in the entire set of commodity groups, these two are now dropped. Consequently, the unrestricted model, estimated in a log-linear form for each individual country in Period II (1976-78) is given by:

$$\log RCA = \alpha_H + \beta_{H1}\log RD + \beta_{H2}\log CM + \beta_{H3}\log WM + \beta_{H4}\log fFTD \qquad (7.1)$$

$$\log RCA = \alpha_L + \beta_{L1}\log RD + \alpha_{L2}\log CM + \beta_{L3}\log WM + \beta_{L4}\log FTD \qquad (7.2)$$

Regression equation 7.1 is applied to the set of 17 high-technology commodity groups, and equation 7.2 to the set of 52 low-technology groups. Since, in some country cases data on RCA for some commodity groups are missing, the number of observations in 7.1 is, in general, N ($N \leqslant 17$), and in 7.2 it is M ($M \leqslant 52$). No restrictions are placed on the parameters of the model at this point, so the unrestricted residual sum of squares can be calculated as a sum of the residual sums of squares of the two individual equations, $SSE_{UR} = SSE_H + SSE_L$.

Now we consider the null hypothesis H_o: $\alpha_H = \alpha_L$, $\beta_{H1} = \beta_{L1}$, $\beta_{H2} = \beta_{L2}$, $\beta_{H3} = \beta_{L3}$, $\beta_{H4} = \beta_{L4}$. The relevant regression model can then be written in a single equation as follows:

$$\log RCA = \alpha + \beta_1\log RD + \beta_2\log CM + \beta_3\log WM + \beta_4\log FTD \qquad (7.3)$$

For each individual country in Period II (1976-78) this model is estimated using ordinary least squares, for the entire set of commodity groups, high- and low-technology. The number of observations is N+M. The estimation yields the restricted residual sum of squares, SSE_R. Fisher (1970)[14] has shown that the appropriate F-statistic for examining the null hypothesis like ours is:

$$F_{k,N+M-2k} = \frac{(SSE_R - SSE_{UR})/k}{SSE_{UR}/(N + M - 2k)}, \tag{7.4}$$

where k is the number of estimated, and restricted parameters, in this case k = 5. If the F-statistic exceeds the critical value of the F-distribution with 5 and N+M-10 degrees of freedom, the null hypothesis that the cofficients are equal between the two subsets of commodity groups can be rejected.

The test described above was applied individually to each of the country cases in the sample. In 27 out of the 29 cases, the calculated F-statistics turn out to be lower than the critical values of the F-distribution at the 5 percent level. The only two exceptions are Israel and West Germany, but even in these cases the null hypothesis cannot be rejected at the 1 percent significance level. It can be concluded that the estimated regression coefficients do not significantly differ between the high-technology subset and the low-technology subset of commodity groups. It is correct to pool data from the two subsets and this will be utilized later as we move, in Chapter 8, to testing the skill theory and the product cycle theory against the data covering the entire set of commodity groups.

It should be noticed that, while providing useful information about the relationship between the export performance and the commodity characteristics in the two commodity subsets, the above result does not, in itself,disprove hypothesis 1. The hypothesis says nothing about whether or how the expected magnitudes of the estimated regression coefficients might differ between the two subsets of commodity groups. What it does specify is that there may be a certain measure of specialization, or commodity specificity, between the explanation of export performance based on factor proportions and that based on product cycle. More precisely, the former is likely to work better for the low-technology subset, while the latter is expected to be more applicable to the high-technology commodity groups. This is what we will now look at.

7.2.3 Description of the Stepwise Regression Testing Method

The first preliminary test of hypothesis 1 involves regressing, for each individual country in the sample, export performance measures RCA and STE on commodity characteristics, separately for the high-technology and the low-technology subset of commodity groups. The stepwise regression procedure described in Section 7.1 is used, but unlike the analysis in Section 7.1, the procedure is now applied independently to the two commodity subsets rather than to the entire set of 69 commodity groups. As before, the same six commodity characteristics are treated as potential regressors, and the same data transformation are performed on variables CM, WM, and FTD.

The regression equations generated at the final step of the procedure have the form $y = f(x_1, x_2, ..., x_n)$, where y = RCA, STE, and the x_i's are these of the six commodity characteristics which are significant at the 15 percent level in the final a step equation. Two functional forms are checked, linear and logarithmic-linear, and data from two periods, Period I (1969-71) and Period II (1976-78) are experimented with. Thus, for each country, and each of the two set of commodity groups, eight distinct regression equations are obtained and estimated, each resulting from one application of the stepwise procedure adopting a given endogeneous variable, a given functional form, and using data from a given time period. Each such equation, obtained at the final step of the stepwise procedure, will be referred to as a model.[15] Subsequently, each such model, estimated for the high-technology set of commodity groups is compared to its counterpart emerging from the estimation using the low-technology data set. Considering the two distinct data sets, and by the nature of the stepwise procedure, a model for the high-technology set and its low-technology counterpart may involve different explanatory variables.

By hypothesis 1 it is expected that the neo-technology explanatory variables (R&D intensity RD, product age FTD, scale economy SE, and product differentiation PD) should generally show higher significance in the high-technology models (i.e., those resulting from the application of the high-technology sets of data), as compared to the low-technology counterparts of these models, while the opposite is likely to be true about the factor-proportions explanatory variables (skill intensity WM, and capital intensity CM[16]).

Consequently, hypothesis 1 will be said to receive support if one or both of the following occur: (1) none of the neo-technology regressors is less significant, and at least one is more significant, in the high-technology final step estimation of a model as compared to this model's low-technology estimation, plus the same is not true about the factor proportions regressors; (2) none of the factor proportions variables is less significant, and at least one is more significant, in the low-technology final step estimation of a model as compared to this model's high-technology estimation, plus this does not hold for the neo-technology regressors. The four levels of significance used in these comparisons are 1, 5, 10 and 15 percent.

7.2.4 Results

7.2.4.1 An Overview of the Stepwise Regression Estimates

This admittedly strong requirement based on a significance criterion was met, for 26 of the 29 countries, in at least one of the models examined. Table 7.2 presents selected results for these 26 countries. Also, in a series of the unreported models, although usually not meeting the restrictive requirement formulated above, the neo-technology variables tend to perform somewhat better in the high-technology estimations while the factor-proportions variables appear with remarkable frequency and significance in the tries based on the low-technology set's data.

Since coefficient of determination is sensitive to the number of explanatory variables, the models in Table 7.2 cannot be judged against each other in terms of R^2. However, it is useful to perform a rudimentary assessment of goodness of fit by looking at the reported values of R^2. Coefficients of determination vary widely and range from 0.05 to 0.88. The low R^2 values may indicate weak or no relationship, or suggest that equations for some countries are misspecified. As it

Table 7.2

Results of Selected Stepwise Regressions Involving Export Performance Measures in the High-Technology and the Low-Technology Commodity Groups, for 26 Countries, 1969-71 (Period I) or 1976-78 (Period II).

Country (Model reported)[a]	Commodity Set[b]	RD	CM	WM	SE	FTD	PD	F Stat.	R^2
Sweden	h-t	-	-	-	-	-	-	-	-
(RCAII, log-lin)	l-t		-0.5152*	2.5310**				3.16*	0.1144
U.K.	h-t	-	-	-	-	-	-	-	-
(RCAI, log-lin)	l-t		-0.2658**					5.02**	0.0929
Netherlands	h-t	0.1411***			-12.7726***	-4.5302***	-0.9067**	21.18***	0.8759
(STEII, lin)	l-t	0.8050***	0.0328*			-0.8922***		5.05***	0.2398
France	h-t					-7.9212***	-0.7944	10.97***	0.6105
(STEII, log-lin)	l-t					-3.3908***		13.92***	0.2177
West Germany	h-t	-0.4815*						4.03*	0.2119
(RCAI, log-lin)	l-t		-0.3831***	1.1681***				8.05***	0.2472
Mexico	h-t			6.4732			1.9348*	3.04*	0.3029
(RCAI, log-lin)	l-t		1.4340***	-4.0451**				5.71***	0.1889
Italy	h-t	-0.0740*					-0.5106	2.71	0.2790
(RCAII, lin)	l-t			-0.2166**				5.22**	0.0945
Australia	h-t	-0.0964						2.32	0.1342
(RCAI, log-lin)	l-t		0.4917*	1.7311*				8.68***	0.2617
Singapore	h-t					-5.1570*		3.64*	0.1951
(STEI, log-lin)	l-t		-0.8238***					7.58***	0.1316
Israel	h-t	0.3227***				-1.2711*		9.94***	0.5867
(STEII, lin)	l-t	1.2067*						3.61*	0.0715
Belgium	h-t					-3.6662		2.85	0.1598
(STEII, lin)	l-t		0.0408**		2.4856	-0.4172		3.02**	0.1587

(continued)

Table 7.2 (Continued)

Country (Model reported)[a]	Commodity Set[b]	RD	CM	WM	SE	FTD	PD	F Stat.	R^2
Austria	h-t				-4.3146**	-2.1764***		10.53***	0.6007
(STEI,lin)	l-t					-0.8759**		6.18**	0.1121
Canada	h-t			5.8125		-5.8016*	-1.4738	3.55**	0.4504
(STEII,log-lin)	l-t			3.6547***				13.54***	0.2274
Turkey	h-t				-4.0677	0.9841**		12.86***	0.7627
(RCAI,lin)	l-t		0.1274***	-0.9194***				17.30***	0.4971
Colombia	h-t				-2.4472			3.03	0.1891
(RCAII,lin)	l-t		0.1455***	-1.3101***				10.89***	0.3261
India	h-t					-7.1957		2.97	0.1651
(STEI,log-lin)	l-t			-2.9932**				4.30**	0.0822
Hong Kong	h-t	2.1782**		-17.3488***				11.88***	0.7038
(RCAII,log-lin)	l-t	0.6257*		-6.2405***				10.14***	0.3481
Egypt	h-t	-	-	-	-	-	-	-	-
(RCAI,lin)	l-t		0.1331***	-1.6018***		-1.0210		6.60***	0.3751
Argentina	h-t					-7.8009**		4.94**	0.2610
(STEI,log-lin)	l-t					-2.8556		2.65	0.0514
Portugal	h-t				-2.7979*			3.14*	0.1729
(RCAII,lin)	l-t			-0.6133***				17.17***	0.2556
Chile	h-t	-	-	-	-	-	-	-	-
(RCAII,log-lin)	l-t		1.0892***					8.39***	0.1934
Tunisia	h-t	1.1456**						7.60**	0.4088
(RCAI,log-lin)	l-t	0.9117*	1.9033***	-8.3332***				4.29**	0.2688
Korea	h-t	1.6780***		-3.1372*		-4.8024**	1.3760**	10.00***	0.7693
(RCAI,log-lin)	l-t		1.1712***	-7.6490***				16.76***	0.4062

(continued)

Table 7.2 (Continued)

Country (Model reported)[a]	Commodity Set[b]	RD	CM	WM	SE	FTD	PD	F Stat.	R^2
Philippines	h-t	-	-	-	-	-	-	-	-
(RCAI,lin)	l-t		0.0589***	-0.2289**				11.33***	0.3930
Kenya	h-t	-	-	-	-	-	-	-	-
(RCAII,lin)	l-t		0.1145***					10.03***	0.2133
Thailand	h-t					4.6714*	1.2158	2.88*	0.3440
(RCAI,log-lin)	l-t		1.2115***	-6.1770***				10.71***	0.3488

Notes: a/ In the parentheses, the endogenous variable and the period (I or II) selected for the analysis have been specified. It is also indicated whether a linear (lin) or a logarithmic-linear (log-lin) form of the model has been used. Intercepts have been omitted in the reported results.

b/ Regressions ran for the set of high-technology commodity groups are denoted by h-t. Regressions ran for the set of low-technology groups are marked l-t.

Asterisks *, **, and *** denote significance levels of 10, 5, and 1 percent, respectively. A dash (-) was used in cases where no variable had been found to meet a 15 percent significance level and, consequently, no regression coefficients had been estimated through the stepwise procedure.
The three countries (Japan, U.S., and Indonesia) for which no evidence has been generated in support of hypothesis 1 were skipped.

turns out, only a handful of models are affected by unreasonably low levels of R^2. These low R^2 levels should not greatly influence the validity of the conclusions we draw from this analysis.

Although the findings collected in Table 7.2 are supportive of hypothesis 1, the present analysis also generates some results that can be perceived as counter-evidence to that hypothesis. That is looked at in the next section, where some selected country cases are discussed.

7.2.4.2 Selected Country Cases

When the stepwise regression procedure is applied to the two subsets individually, the two commodity characteristics associated with the factor-proportions approach (the skill intensity variable WM, and the capital-per-man CM) turn out to carry coefficients which are more likely to be significant for the low-technology subset, representing mature products, than for the high-technology one. This turns out to be generally true both in the models selected for reporting in Table 7.2 and in those not reported.[17]

In the spirit of hypothesis 1, the opposite property would be expected to obtain for the product cycle variables, especially the R&D-intensity variable RD, and the product age variable FTD; i.e., the ones that were found in Section 7.1 to be potentially reliable regressors of export performance. Yet when all the models examined for each country case are accounted for, including the unreported ones, there does not seem to be much evidence that variables RD and FTD are generally more significant in the high-technology estimations. In fact, for countries like Egypt, India, Philippines, or Argentina, the product-cycle variables, RD and FTD, rather systematically show up with high significances in estimations involving the low-technology subset while they fail to do so where one would expect then, namely in the high-technology estimations.

One possible explanation of this is that, given a high level of aggregation and resulting heterogeneity within the 3-digit SITC commodity groups, the typology of high- and low-technology groups used here may fail to adequately reflect the distinction between "new" and "mature" products in exports of some countries.

For example, if a country's exports are heavily concentrated in relatively low R&D goods within some commodity groups classified as high-technology, treating such groups as representing "new" products in exports of this country might be inappropriate. Similarly, if a country's exports are biased toward relatively R&D-intensive goods within some low-technology groups, these groups may fail to accurately represent "mature" products in a country's exports. Given the lack of more disaggregated data on R&D-intensity, it is hard to verify in practice whether this is in fact the problem.

There are three countries for which no model could be found that would support hypothesis 1 in a strict sense of the significance criterion stated in Section 7.2.3. These countries are Japan, U.S., and Indonesia. Indonesia's export performance data suffer from severe gaps and the lack of any meaningful result for this country can be probably attributed to that.[18] It is far more intersting that hypothesis 1 gains no support whatsoever from the results of regressions using Japan's and the U.S.'s data. In the high-technology groups, Japan's revealed comparative advantage is associated only with the skill intensity variable WM, while in the low-technology groups the indices of export performance are negatively and significantly related to product age, FTD. The pattern revealed for the U.S. is similar but even more pronounced. In this case, also, the R&D intensity variable RD, while absent from the high-technology models, appears with substantial regularity, and carries positive and significant coefficients in the low-technology counterparts of these models. On the other hand, the skill intensity variable WM is significant, and it alone explains more than 50 percent of the variation of the revealed comparative advantage index over the high-technology groups.

These findings evidently contradict the prediction implied by hypothesis 1. The factor-proportions variables and the neo-technology variables fail to show up where they are supposed to; i.e., in the low-technology and the high-technology regressions, respectively. More than that, the two sets of explanatory variables behave in the way that is precisely opposite to what hypothesis 1 suggests. It is hard to come up with any convincing explanation of this puzzling result. Specifically, the question can be asked, why should such clear counterevidence to hypothesis 1 be generated in the case of the U.S., the country which is being systematically located close to the top of the rankings by almost all measures of innovativeness and skill-abundance.

Let us look at the problem in the context of the U.S. results obtained in Section 7.1. In that analysis, based on the investigation of all 69 commodity groups, the U.S. revealed comparative advantage was found to be heavily skewed towards groups with high R&D intensity. Also, the R&D intensity variable RD appeared to be the single most powerful explanatory variable. It was present and highly significant in all eight models estimated, reported and unreported. These U.S. results were untypical in that no other country showed such a heavy involvement of RD. Now we see that, again unlike in almost all other countries, variable RD continues to play a significant role in explaining the U.S. export performance in the low-technology groups, but it is replaced by the skill intensity variable WM in the high-technology estimations. While, generally, the U.S. excels in the R&D-intensive commodities, its comparative advantage over the high-technology set of groups is especially pronounced in those groups which, in addition to being by their nature R&D-intensive, are also exceptionally skill-intensive (have high WM); i.e., require substantial inputs of original thought and professional expertise. As far as the low-technology set is concerned, the U.S. revealed comparative advantage is strongly and positively related to groups' R&D intensity, and skill intensity is of no importance as an explanatory variable.[19] It appears that with R&D intensity and product age being overriding factors in the U.S. industrial export structure, there is not really much scope left for the skill intensity variable WM to manifest its impact on export performance, except in the commodity groups that are the most R&D-intensive. One reason why this is so might be that, in addition to being highly innovative by both absolute and relative R&D measures, and skill-rich, the U.S. is endowed with especially high quality skills, more innovation-oriented than skill endowments of other economies. If so, the U.S. skills are likely to be particularly amenable to applications in goods at the high-RD end of the commodity spectrum. Under such circumstances, the detected reversal of the prediction of hypothesis 1 would appear perhaps a little more understandable.

The association of the U.S. export performance with the human-capital or skill variables and with various product-cycle variables has been well documented in several empirical studies.[20] One weakness shared by these studies though is that they make little or no effort to more clearly determine the scope of validity of the neo-factor and the neo-technology approach. The present findings offer some insights into this problem as they suggest the way in which the technology-related variables on the one hand, and human capital or skills on the other, may actually support each other in explaining the U.S. export performance in manufactures.

One of the countries in which the results obtained do provide strong support for hypothesis 1 is Korea. The R&D intensity variable RD is by far the best performing regressor in the equations involving the high-technology commodity subset. In these regressions, RD systematically carries coefficients which are positive and never less significant than at the 5 percent level. The product age variable FTD also shows a farily high significance, and enters the estimated models with a negative coefficient.[21] Among the high-technology groups, Korea's export performance is then strongest in those most R&D-intensive and including relatively young products. In accordance with hypothesis 1, variables RD and FTD lose their explanatory power when the stepwise regression procedure is applied to the low-technology subset's data. In these estimations, RD is never significant at 15 percent, and FTD in only one of the eight alternative models examined. Instead, the skill intensity variable WM, accompanied by the capital intensity variable CM, shows a dramatic increase in significance, in most cases passing the significance test at the 1 percent level. With negative signs on WM, and positive on CM, Korea's exports within the low-technology groups are best characterized as skill-saving and, somewhat surprisingly, capital intensive.

7.2.4.3 Behavior of the Heckscher-Ohlin Variable CM

The last point that needs to be specifically addressed is the performance of the Heckscher-Ohlin variable, CM. In Section 7.1, we found this variable to be largely unimportant as far as the explanation of export performance over the entire set of 69 commodity groups is concerned.[22] Also, we established that the structure of trade, and of revealed comparative advantage, might be better explained by commodity characteristics other than physical capital intensity. By suggesting the empirical vulnerability of the standard two-factor model, such findings seems to draw one's attention toward the neo-factor and/or the neo-technology approach. Historically, these two new approaches originated, as we said, precisely from the failure of the conventional Heckscher-Ohlin model to satisfactorily perform in the empirical studies. Too frequently, that led to a complete abandonment of the Heckscher-Ohlin tradition in the theoretical and empirical research that followed. It seems the possibility has been overlooked that what is preceived as the crisis of the Heckscher-Ohlin orthodoxy may have resulted from repeated misapplications of the model rather than from the limitations inherent in it. By its nature, the standard two-factor model can hardly be expected to perform well in trade flows characterized by "new" differentiated products resulting from the ongoing innovative process and traded under imperfect competition. However, when applied to "mature" homogeneous goods the standard factor-proportions model is likely to demonstrate its power and perform well, possibly along with the neo-factor commodity characteristics like skill-intensity.

The results of the present analysis seem to indicate that this may in fact be so. In 17 out of the 26 country cases reported in Table 7.2, the Heckscher-Ohlin variable CM shows up in the models estimated on the low-technology data while it does not pass a 15 percent significance test in the corresponding models estimated on the high-technology data. In the remaining 9 cases, CM fails to meet the 15 percent significance level in both the high-technology and the low-technology estimation. There is no case in which CM would perform better for the high-technology groups than for the low-technology ones.

A similar pattern is also revealed by the results of the models that are not being reported here.[23]

The fingings regarding variable CM, reported in this section and Section 7.1, demonstrate that the general validity of the standard two-factor model may be problematic, but by no means can they be interpreted as a disproval of the Heckscher-Ohlin prediction. As it was earlier pointed out, numerous theoretical improvements have been made resulting in new versions of the Heckscher-Ohlin model, with its particular assumptions being relaxed, productive factors redefined, and implications generalized. The present results suggest that there may be some promise in a shift of the emphasis from enriching the model to more carefully determining that part of the empirical reality which can still be successfully explained by the original version of the model. Specifically, the model's potential is likely to be better exploited by relating it to a narrowly defined group of "mature" goods whose markets most closely meet the model's assumptions. Trade in other products would then have to be explained by some characteristics beyond the physical capital intensity.

7.2.5. Examining the Correlation between the Simple Regression Coefficients and the Relevant Country Characteristics for the High-Technology and the Low-Technology Commodity Subset

The approach based on the stepwise regression procedure used so far in this chapter concentrates on assessing the relevance of various commodity characteristics to the explanation of industrial export performance structure. It does not explicitly recognize the importance of the country characteristics. To the extent this approach fails to unequivocally substantiate or refute hypotheses 1, there is a need for some other testing method that would account for international differences in skill abundance and innovativeness.

In Chapter 8, the argument is outlined that if the product cycle explanation of export patterns is true, the relative export performance in R&D-intensive manufactures, and in those relatively newly developed, should be positively correlated, across countries, with innovative capability. Hypothesis 1 suggests that this correlation is likely to be stronger for the high-technology commodity groups than for the low-technology ones. On the other hand, if the skill explanation of trade holds, it should do so primarily for the low-technology subset of commodity groups, and it is in this subset that the relative export performance in skill-intensive products is expected to be especially strongly correlated with countries' skill abundance.

To examine the above, first the measures of relative export performance are computed as the estimates of coefficient β from the following regression equations run for each country in Period II (1976-78)

$$\log RCA = \alpha + \beta \log X, \tag{7.5}$$

where X = RD, FTD, WM. The elasticity estimates associated with the R&D-intensity variable RD are interpreted as a measure of relative export performance in R&D-intensive products. Those associated with the product-age variable FTD convey information about how particular countries are doing in exporting relatively newly developed goods.

Finally, those associated with the skill-intensity variable WM are taken to represent countries' relative export performance in skill-intensive manufactures. In every country case, each of the three simple regression equations of the type (7.5) is estimated twice, for the high-technology and for the low-technology commodity groups, generating two sets of elasticity estimates, $\hat{\beta}_H$ and $\hat{\beta}_L$, respectively.

According to hypothesis 1, estimates $\hat{\beta}_L$ associated with the skill intensity variable WM should be correlated with countries' skill abundance more strongly than estimates $\hat{\beta}_H$ associated with WM are. To examine that, Spearman correlation coefficients between estimates $\hat{\beta}_H$ and $\hat{\beta}_L$ on WM and the four alternative skill abundance measures have been calculated, and they are reported in the first four columns of Table 7.3. All these correlation coefficients carry the expected signs. The results show that, except in the case when PTR is used as a measure of skill abundance, the correlation coefficients, in fact, tend to be both higher and statistically more significant for the low-technology subset of commodity groups.

Hypothesis 1 also implies that estimates $\hat{\beta}_H$ associated with the R&D-intensity variable RD and with the product age variable FTD are more likely to be related to countries' technological innovativeness than estimates of $\hat{\beta}_L$ associated with RD and FTD are. The last three columns in Table 7.3 show the relevant rank correlation coefficients, all of which carry the signs consistent with the expectations. It can be seen that, no matter which one of the three alternative measures of innovativeness is used, the Spearman coefficients between $\hat{\beta}_H$ associated

Table 7.3

Spearman Rank Correlation Coefficients Between Relative Export Performance Measures and the Measures of Skill Abundance and Technological Innovativeness, High-Technology and Low-Technology Subset, 28 Countries, Period II (1976-78)[a]

	Skill Abundance Measures				Technological Innovativeness Measures		
	CVW	HRD	PTR	AVRS	PRD	SEP	AVRT
High-Technology Commodity Groups							
Coefficient $\hat{\beta}_H$ on WM	-0.2619 (0.1869)[b] (27)	0.2983 (0.1231) (28)	0.5445 (0.0060) (24)	-0.6700 (0.0005) (23)			
Coefficient $\hat{\beta}_H$ on RD					0.1921 (0.3577) (25)	0.0647 (0.7485) (27)	-0.1269 (0.5455) (25)
Coefficient $\hat{\beta}_H$ on FTD					-0.5499 (0.0044) (25)	0.5464 (0.0032) (27)	0.6054 (0.0014) (25)
Low-Technology Commodity Groups							
Coefficient $\hat{\beta}_L$ on WM	-0.3736 (0.0549) (27)	0.5408 (0.0030) (28)	0.5345 (0.0071) (24)	-0.6710 (0.0005) (23)			
Coefficient $\hat{\beta}_L$ on RD					0.2461 (0.2358) (25)	0.2705 (0.1724) (27)	-0.2477 (0.2326) (25)
Coefficient $\hat{\beta}_L$ on FTD					-0.2892 (0.1608) (25)	-0.3797 (0.0507) (27)	0.3715 (0.0674) (25)

[a]Due to missing observations, Indonesia is dropped from the sample.

[b]Significance levels and number of observations (countries) are reported in parentheses.

with FTD and innovativeness range from 0.55 to 0.61, and they are significant at 1 percent. Correlation coefficients in which $\hat{\beta}_L$ associated with FTD is involved are markedly lower and they are not significant at 5 percent. Put differently, the explanation of the product age structure of industrial exports by international differences in innovative capability applies primarily to the high-technology subset of commodity groups. Inasmuch as the product age variable FTD properly differentiates among the products at various stages of the product cycle, it can be concluded that while the skill approach remains a dominant explanation of trade in the low-technology groups, the product cycle approach appears to be more applicable to the high-technology subset of commodity groups.

Interestingly, as Table 7.3 shows, no similar conclusion can be drawn with regard to the case when the R&D intensity variable RD, rather than FTD, is being used for distinguishing goods at different stages of the product cycle. Correlation between both estimates of $\hat{\beta}_H$ and $\hat{\beta}_L$ associated with RD and the proxies for innovativeness is generally weak and statistically insignificant. In neither of the two commodity subsets can the relative export performance in R&D-intensive products be successfuly explained by inter-country differences in the extent of innovative effort. This might be due to the fact that individual 3-digit commodity groups have a heterogeneous composition in terms of R&D intensity, and the structure of exports within the groups varies widely from country to country. However, repeating the correlation analysis for the restricted sample of 12 developed countries, whose R&D-intensity structures of intra-group exports are likely to be rather similar, does not greatly improve the result. Another possibility then is that the implicit assumption of no R&D-intensity reversals does not hold in reality in which case "new" and "mature" products would be represented, for different countries, by different sets of 3-digit commodity groups, not necessarily consistent with the proposed distinction between the high-technology and the low-technology subset, based on U.S. R&D-intensities. A closer investigation of this problem is impossible due to the lack of sufficiently disaggregated international data on R&D intensities.

Overall, the results generated in this chapter seem to offer some qualified support for hypothesis 1. Trade in "new" products tends to be fairly well explained by certain characteristics associated with the product cycle approach, while export in "mature" manufactures, more consistent with the assumptions of the conventional trade theory, is governed largely by factor proportions in conjunction with factor intensities. Considering all the exceptions, and imperfections of data, this finding has to be viewed as tentative rather than conclusive. Further empirical work, preferably based on data for individual products, is needed to more precisely determine the scope of validity for each of the two approaches.

FOOTNOTES

[1]For details, see SAS (1985). Pindyck and Rubinfeld (1981) discuss applications of the procedure to selecting explanatory variables when there are many possible candidates. See pp. 93-94.

[2]The logarithmic-linear form was examined to allow for nonlinearity after it had been determined that the linear specification did not yield satisfactory results in many cases.

[3]It is these differences in scale that may have caused, before the corrections, matrix X to appear as if it was of less than full rank, thus producing somewhat suspect values for condition indices and variance proportions in the multicollinearity diagnostic test.

[4]This seems to be confirmed by low correlation between the product differentiation variable PD and the product age variable FTD. The correlation coefficient is close to zero and insignificant. Also see Hufbauer (1970), pp. 192-193. For further criticism of the product differentiation index PD, see Gray and Martin (1980), pp. 325-326.

[5]Out of the 29 countries in the sample, only in six is variable CM significant at 5 percent when RCA is used as a dependent variable. These exceptions are: Australia, Belgium, Canada, Turkey, Colombia, and Kenya.

[6]E.g., the negative signs on RD for Belgium and Austria, and the positive ones for Kenya or Indonesia.

[7]It should be recalled that 10 of the 69 commodity groups are classified as "resource-based." The present set of the explanatory variables may be less adequate for the cases of countries whose exports emphasize these groups.

[8]Some of them are Gruber, Metha and Vernon (1967), Baldwin (1971), Lowinger (1975), and Goodman and Ceyhun (1976).

[9]Another aspect of that complementarity is discussed in the next section, where the two components of the model are being separately tested against the cross-country data.

[10]E.g., Vernon (1966), Hirsch (1974b, 1975), Finger (1975), Walker (1979) and Krugman (1983).

[11]This can be seen from relationship (5.8) and the discussion that follows it. Note that the dividing line between "new" and "mature" goods changes with time. As time passes, higher ranked products will join the class of "mature" goods. Also, the exact composition of the two classes of goods is affected by the relative characteristics regarding the knowledge acquisition process and relative factor prices

in the two countries, i and j. Thus, the model is not referring to goods that are new or mature in some general, country- or time-invariant sense. This further complicates the task of actually identifying "new" and "mature" products within the real-life commodities or commodity groups.

[12]Hirch (1974b), pp. 66-69.

[13]See Table 6.1.

[14]Fisher (1970), p. 362.

[15]Thus, for instance, model RCAI-lin is a final step regression equation of a linear form, with dependent variable RCA, and estimated using Period I data.

[16]Note that variable CM does not have its equivalent in the theoretical model due to the assumption of international mobility of physical capital. As earlier noted, it is being retained here to examine possible commodity specificity of the standard Heckscher-Ohlin prediction.

[17]For instance, variable WM turned out to be a significant regressor in the final step equations for the total of 147 models estimated for various countries. In 114 of these cases, it proved more significant in a low-technology estimation than in its high-technology counterpart. Variable CM is discussed in Section 7.2.4.

[18]Gaps in data are also likely to be reponsible for the paradoxical signs of the coefficients, otherwise highly significant, on RD and WM obtained for Indonesia in Table 7.1.

[19]In both commodity sets, export shares measured by STE are associated positively with RD or WM, and negatively with the product age variable FTD. The Heckscher-Ohlin variable CM shows no or poor significance for the U.S. in the two commodity sets.

[20]See the survey of the literature, especially Sections 2.3.2 and 4.3.

[21]See the model reported for Korea in Table 7.2

[22]Incidentally, such finding seems to support one of the structural assumptions of the model presented in Chapter 5, namely that concerning international mobility of physical capital.

[23]Overall, variable CM shows up in 95 of the regression equations produced by the stepwise procedure for various countries in the sample. On 83 occasions, CM was found to be more significant in a low-technology estimation of a model, as compared to its high-technology counterpart. The opposite was true in the remaining 12 cases.

CHAPTER 8

TEST OF HYPOTHESIS 2: VERIFICATION OF THE SKILL AND THE PRODUCT CYCLE COMPONENTS OF THE MODEL FOR CROSS-COUNTRY DATA

8.1 Examining Correlations among the Country Characteristics and among the Commodity Characteristics

In this chapter, we address the problem of whether the neo-factor and the neo-technology explanations of industrial export patterns withstand empirical scrutiny against cross-country data covering all 69 commodity groups. Before this is done, the question needs to be resolved whether two independent tests are in fact needed. In Section 4.4, we gave some attention to the possibility that the product cycle type of characteristics might be strongly correlated, across both products and economies, with the characteristics that are associated with the neo-factor argument. Indeed, successful search for knowledge, based on R&D activities and leading to innovations, is likely to rely heavily on the abundance of pertinent skills in labor force. Thus, relatively innovative economies would be expected to be also relatively skill-rich. On the other hand, relatively newly developed goods whose production requires substantial R&D outlays might exhibit relatively high skill intensity. When correlations between innovativeness and skill abundance for countries, and between R&D intensity or product age and skill intensity for goods, are strong, then the neo-factor and the neo-technology models may be almost indistinguishable empirically. That would make the two models appear as substitutable explanations of trade and encourage a search for the one which is marginally "better."[1] From the theoretical point of view, one would not really have to resort to technological considerations in such case, and building the explanation of trade around some dynamized version of the factor proportions framework would probably suffice. Yet, if at least one of the two correlations fails to manifest itself, then the two models are to be more correctly viewed as complements since each of them will contribute a different explanation for trade performance.

The problem was examined by calculating Spearman rank correlation coefficients between the three innovativeness measures (PRD, SEP, AVTR) and the four skill abundance measures (CVW, HRD, PTR, AVRS), and by calculating rank correlation coefficients among the six selected commodity characteristics.[2]

The correlation results for the country characteristics are reported in Table 8.1. The coefficients range from 0.46 to 0.80, most of them exceed 0.70, and all except the lowest one (between CVW and PRD) are significant at 1 percent. It can be concluded that the country rankings by innovativeness and by skill abundance are in fact considerably interrelated. A highly innovative economy is likely to be skill-rich, while imitators from the bottom of the innovativeness ranking are relatively skill-poor.[3] As we have suggested at various points, there may be two explanations for that. First, a country which is relatively skill abundant (poor in unqualified labor) will suffer from the erosion of its advantage in the existing goods as these goods become relatively less skill-intensive, and more labor-intensive, in the process of maturation. It is in this sense that relative abundance of skills may force a country into a "defensive" R&D search for new

Table 8.1

Spearman Rank Correlation Coefficients between Various Skill Abundance Measures and Technological Innovativeness Measures in the Sample of 29 Countries.

	Skill Abundance Measures: CVW	HRD	PTR	AVRS	Tech. Innovativeness Measures: PRD	SEP	AVRT
Skill Abundance Measures:							
CVW	-	-0.5233 (0.0043)[a] (28)	-0.6165 (0.0014) (24)	0.8157 (0.0001) (24)	-0.4574 (0.0188) (26)	-0.5775 (0.0016) (27)	0.5392 (0.0045) (26)
HRD		-	0.7098 (0.0001) (25)	-0.8296 (0.0001) (24)	0.6888 (0.0001) (26)	0.8013 (0.0001) (28)	-0.7525 (0.0001) (26)
PTR			-	-0.8870 (0.0001) (24)	0.6705 (0.0006) (22)	0.7241 (0.0001) (24)	-0.7007 (0.0003) (22)
AVRS				-	-0.7022 (0.0003) (22)	-0.7727 (0.0001) (23)	0.7527 (0.0001) (22)
Tech. Innovativeness Measures:							
PRD					-	0.8740 (0.0001) (26)	-0.9477 (0.0001) (26)
SEP						-	-0.9713 (0.0001) (26)
AVRT							-

Note: a/ Significance levels and numbers of observations (countries) are reported in parentheses. Numbers of observations are less than 29 due to missing data.

products. The second explanation is that ample supply of skills may be an important precondition for successfully carrying out R&D activities and utilizing their effects because of complementarity between R&D outlays and skill endowments. Whatever the reason, the country ranking by innovativeness is found to be fairly well matched by the ranking by skill abundance, and the result holds virtually irrespective of which measure of innovativeness and skill abundance are used.

The results of the correlation analysis for the commodity characteristics are not nearly as good. Rank correlation coefficient between the skill-intensity variable WM and the R&D-intensity variable RD is 0.22, and it is not significant at 5 percent. Similarly, there is no evidence of correlation between WM and the remaining neo-technology commodity characteristics, the coefficients being 0.25 or less, none of them being significant at 1 percent, and only one (between WM and PD) at 5 percent.[4]

On the basis of the above findings, it can be concluded that, even though we have found R&D intensive goods (high-technology groups) to be on average more skill-intensive than those belonging to the low-technology groups, there is no evidence of correlation between skill intensity and R&D intensity or product age. The commodity ranking by skill intensity does not, in general, conform to the rankings by product-cycle type of characteristics. The neo-factor account based on skills and the neo-technology account, will therefore offer two different types of explanations as to what goods should be exported by particular countries. They should not be viewed as competing, for each of them adds something else to the characterization of goods that are likely to be exported by a given country. Contrary to what many authors have feared, it cannot be confirmed that the two accounts are substitutable in a sense that empirical corroboration of one of them would automatically mean that the other one is corroborated as well.

The correlation results presented above have some interesting implications with regard to how a country's position in the "pecking order" may be determined. Countries which are both relatively innovative and relatively skill-abundant should specialize in those goods which are both R&D-intensive and skill-intensive. Such countries; e.g., U.S., Sweden, Netherlands, France, West Germany or Japan will be unambiguously located close to the top of the "pecking order." This can be seen by looking at the ranks by AVRS and AVRT reported in Table 6.5. On the other hand, it is empirically plausible that a country's good position in "new" R&D-intensive products may still derive from its strong innovative or imitative capability as measured by the R&D effort, even though the availability of skills in the country is less impressive. A position in the "pecking order" may be improved through aggressive knowledge search, directed towards selected "new" goods whose skill intensity is not too high. Table 6.5 suggests that this is likely to be the case with countries like Korea and Israel, whose average ranks by measures of innovativeness are markedly higher than their ranks by skill abundance.

8.2 Tests with Relative Export Performance Measured by Regression Coefficients

8.2.1 Test of the Skill Prediction

8.2.1.1 Description of the Test

It follows from the discussion in the preceding section that separate tests for the two views of trade are called for. We will first examine the neo-factor prediction as formulated in part (a) of hypothesis 2. By that proposition, relatively skill-abundant countries are expected to export goods which are relatively skill intensive, and vice versa. This specifies a relationship among three types of variables: export performance, skill intensity and skill abundance. The empirical test, then, has to involve relating them to each other. This will be done in two steps.

In step one, we want to see how each country's export performance over the set of 69 commodity groups is linked to these groups' skill intensity. Specifically, for each country, an export performance measure is regressed across commodity groups on the skill intensity variable WM. The two alternative measures of export performance are used (RCA and STE), the regressions are run separately on Period I (1969-71) and Period II (1976-78) data, and two alternative functional forms of the regression equations are examined, linear and logarithmic-linear. Formally, eight regression equations are estimated for each country, each having one of the two following forms:

$$y = \alpha + \beta x \text{ or} \qquad (8.1)$$

$$\log y = \alpha + \beta \log x, \qquad (8.2)$$

where y = RCA, STE (in Period I and II), and x = WM. Coefficient estimates $\hat{\beta}$ thus obtained for individual countries are viewed as measures of these countries' relative export performance in skill-intensive products.

The estimated coefficients $\hat{\beta}$ are reported in the first two columns of Table 8.2 (for the equations with dependent variable RCA), and in the first two columns of Table 8.3 (for the equations with dependent variable STE). The results in Table 8.2 indicate how a country's revealed comparative advantage is related to skill intensity of the traded commodity groups, while the results in Table 8.3 show how the commodity groups' shares in a country's total manufactured exports are related to skill intensity. The magnitude of an estimated regression coefficient gives an idea of a country's relative export performance in skill-intensive commodity groups.

The indices of relative export performance in skill-intensive goods estimated for individual countries, are expected to be positively linked to countries' skill abundance. The second step of the analysis involves examining the correlation between these two types of indices. To do that, Spearman rank correlation coefficients are calculated between the estimated regression coefficients $\hat{\beta}$ and each of the four alternative measures of skill abundance (CVW, HRD, PTR, AVRS). Coefficient estimates from regression equations run on Period II data were chosen for the correlation analysis because data on skill abundance originates generally from that period. For the equations with endogeneous RCA, the results of logarithmic-linear regressions were used in reported correlation analyses, while for the equations with endogeneous STE, the results of

Table 8.2

Results of Simple Regressions with Endogeneous Variable RCA and Exogeneous Variables WM, RD and FTD, for 29 Countries, 1969-71 (Period I) and 1976-78 (Period II).

Country	Period	Coefficients on WM (lin)[a]	(log)[b]	Coefficients on RD (lin)	(log)	Coefficients on FTD (lin)	(log)
Sweden	I	0.1493*	1.0507	0.0055	0.0302	-0.2465	-1.1127
	II	0.1929**	1.2193*	-0.0044	0.0044	-0.1599	-1.0435
U.K.	I	-0.0497	-0.0317	0.0039	0.0549	0.0791	-0.3109
	II	1.2156	0.4894	-0.2499	0.0385	-1.6098	-0.2297
Netherlands	I	-0.0406	-0.4731	0.0191	0.0617	-0.0571	-0.9276
	II	0.0239	-0.2727	0.0155	0.0820	0.0362	-0.4970
France	I	-0.0773	-0.2775	-0.0374	-0.0726	-0.0181	-0.4009
	II	-0.0116	0.1515	-0.0326	-0.0526	-0.0606	-0.5502
West Germany	I	0.0580	0.1920	-0.0134	0.0171	-0.0988	-0.1401
	II	0.0669	0.3147	-0.0129	0.0257	-0.1561	-0.5543*
Mexico	I	0.1844	-0.1781	-0.0508	-0.0624	0.4666	-0.1221
	II	0.2716	0.2679	-0.1361	-0.0371	1.2569	1.7796
Italy	I	-0.1710*	-1.2486**	-0.0218	0.0736	-0.0187	-0.5959
	II	-0.2239***	-1.1277**	-0.0504	-0.0575	-0.1447	-0.9895*
Australia	I	0.2668	2.3670***	-0.0420	-0.1965	0.2754	0.4205
	II	0.4588	2.6070***	0.0233	-0.1074	0.3895	0.7354
Singapore	I	-0.1291	-2.2200***	-0.0301	0.1002	0.2366	1.0911
	II	-0.1466**	-1.9047***	0.0575**	0.2917**	-0.1136	-1.3839
Israel	I	-0.4102*	-3.2778***	-0.0280	0.0828	0.8290	0.1453
	II	-0.1428	-1.1567	0.0535	0.4207**	0.3489	-0.7822
Belgium	I	0.2120	0.6672	-0.1546***	-0.4507***	0.5547*	1.1112
	II	0.1260	0.4897	-0.1197**	-0.3774***	0.5673**	1.1984

(continued)

Table 8.2 (Continued)

Country	Period	Coefficients on WM (lin)[a]	(log)[b]	Coefficients on RD (lin)	(log)	Coefficients on FTD (lin)	(log)
Austria	I	-0.4731**	-1.8851**	-0.1657**	-0.4346***	0.2512	0.1011
	II	-0.4031**	-1.3191**	-0.1354*	-0.1941***	0.1590	-0.1949
Canada	I	0.2341**	2.6633***	-0.0025	0.0880	0.2683	0.6114
	II	0.3066**	3.5823***	-0.0295	0.0404	0.5576**	1.6764*
Japan	I	-0.1852*	-1.3832**	-0.0083	-0.1257	-0.2558	-1.2215*
	II	-0.0142	-0.3694	0.0046	-0.1356	-0.2776	-1.0220
Turkey	I	-0.2201	-2.3886	-0.0778	-0.5443*	0.5732	2.1948
	II	-0.8446***	-2.1894	-0.1813	-0.6788**	0.3129	1.9972
Colombia	I	-0.3274	-2.4954**	-0.0884	-0.0079	0.5796	1.1299
	II	-0.5334**	-3.8665***	-0.1101	-0.0463	0.4661	1.8345
U.S.	I	0.2447***	1.6900***	0.1275***	0.3370***	-0.2739	-1.1128*
	II	0.1758**	0.7304	0.1450***	0.4360***	-0.3132*	-0.9696
India	I	-0.5848**	-3.2686***	-0.2117**	-0.6386***	0.3979	3.7128**
	II	-0.5281**	-2.9471***	-0.2019**	-0.6435***	0.6050	3.4442**
Hong Kong	I	-0.6276***	-5.8018***	-0.0028	-0.1118	-0.4873	1.3038
	II	-0.6216***	-5.7952***	0.0959	0.1445	-0.3610	-0.3924
Egypt	I	-0.8812***	-4.2627***	-0.1795	-0.8781***	-0.2542	1.7303
	II	-1.1191***	-4.7806***	-0.2047	-0.8915***	-0.2652	0.8886
Argentina	I	0.0540	1.3374	0.0231*	0.1637	-0.0488	-1.0394
	II	0.0187	0.4613	0.0070	0.1353	-0.1300	-2.3881**
Portugal	I	-0.7396***	-5.1799***	-0.0850	-0.2408	0.1226	2.2633*
	II	-0.5890***	-5.1085***	-0.0608	-0.1189	0.1130	1.2555
Chile	I	0.0644	1.3273	-0.0096	0.0339	-0.0388	1.8282
	II	0.2802	2.0249	-0.0861	-0.2606	-0.5791	2.0894

(continued)

Table 8.2 (Continued)

Country	Period	Coefficients on WM (lin)[a]	(log)[b]	Coefficients on RD (lin)	(log)	Coefficinets on FTD (lin)	(log)
Tunisia	I	-0.9585	-3.3864**	-0.0994	-0.2867	3.8570***	4.0294**
	II	-0.4232	-3.8741**	0.1133	-0.0041	2.2326**	2.2476
Korea	I	-0.5986***	-4.7230***	-0.0751	-0.3880**	0.2283	-0.1157
	II	-0.7132***	-4.1260***	-0.0760	-0.3166*	0.6593*	1.5400
Philippines	I	0.0158	-0.7994	-0.0367	-0.5603**	0.3976**	3.5742**
	II	-0.0291	-1.6469	-0.0175	-0.4556**	0.3634*	-0.2719
Indonesia	I	-0.0334	-1.2841	0.0343	0.0487	-0.3092	-4.0854
	II	0.0723	0.0452	0.1195***	0.2733	-0.0796	-0.9363
Kenya	I	0.3901	0.2535	0.0877	0.1573	1.6003*	5.1922***
	II	0.2340	0.9886	-0.0105	-0.0374	1.3795**	2.7075
Thailand	I	-0.0905	-4.0939***	-0.0407	-0.5748***	0.5202**	2.0119
	II	-0.3849***	-4.9418***	-0.0589	-0.3989*	-0.1760	-0.2372

Notes: a/ Simple linear regressions are marked (lin) and simple logarithmic-linear regressions are denoted by (log).

b/ For the purpose of logarithmic-linear regressions, zero values of RCA that occur in particular commodity groups in cases of 14 countries have been changed to 0.01.

Asterisks *, **, *** denote significance at the 10, 5, and 1 percent level, respectively. Intercepts and coefficients of determination have been omitted in the table.

Table 8.3

Results of Simple Regressions with Endogeneous Variable STE and Exogeneous Variables WM, RD and FTD, for 29 Countries, 1969-71 (Period I) and 1976-78 (Period II).

Country	Period	Coefficients on WM[b] (lin)[a]	(log)	Coefficients on RD (lin)	(log)	Coefficients on FTD (lin)	(log)
Sweden	I	0.3213	1.5560	0.0744	0.2499	-1.2260***	-4.7210***
	II	0.3367	-0.1541	0.0926	0.2808	-1.3637***	-4.8844***
U.K.	I	0.2792	0.5535	0.1025	0.2628**	-1.2718***	-3.9448***
	II	0.2953	0.7193	0.1271*	0.3841***	-1.2394***	-3.6493***
Netherlands	I	0.0427	0.0838	0.0663	0.2790*	-0.9122***	-4.5596***
	II	0.1655	0.3291	0.0830*	0.3597**	-0.9057***	-4.3471***
France	I	0.2610	0.2553	0.0486	0.1462	-1.1703***	-3.9821***
	II	0.3202	0.7580	0.0600	0.2246*	-1.3355***	-4.3409***
West Germany	I	0.3440	0.7907	0.0417	0.2359*	-1.4240***	-3.6410***
	II	0.3819	1.0028	0.0616	0.3033**	-1.5499***	-4.2446***
Mexico	I	0.1057	0.3201	0.0893*	0.1706	-0.4620	-3.6245***
	II	0.1553	0.8186	0.0278	0.1733	-0.2420	-1.8492
Italy	I	0.0555	-0.6217	0.0462	0.3226**	-1.0981***	-4.2856***
	II	0.0958	-0.4837	0.0176	0.2332	-1.1448***	-4.8042***
Australia	I	0.2405**	2.6273***	0.0030	0.0333	-0.2030	-3.3059***
	II	0.3074*	3.3845***	0.0627	0.1866	-0.1298	-2.8817**
Singapore	I	-0.0802	-1.7427*	0.0219	0.3326**	-0.4055**	-2.5266**
	II	-0.0638	-1.5817	0.1405**	0.5643***	-0.6056	-5.1270***
Israel	I	-0.2879	-2.2409	0.0154	0.3071	0.0302	-3.2864*
	II	0.0927	-0.0579	0.1429	0.6693***	-0.4937	-4.3344**
Belgium	I	0.3526*	1.1779	-0.0647	-0.2342*	-0.5288	-2.3702**
	II	0.3850*	1.0376	-0.0082	-0.1022	-0.8695*	-2.4953**
Austria	I	-0.0687	-1.3780	-0.0527	-0.2171	-0.8598***	-3.7954***
	II	0.0052	-0.8237	-0.0157	-0.0703	-1.0901***	-4.4147***

(continued)

Table 8.3 (Continued)

Country	Period	Coefficients on WM (lin)[a]	(log)[b]	Coefficients on RD (lin)	(log)	Coefficients on FTD (lin)	(log)
Canada	I	0.7640*	3.2573***	0.0795	0.2898	-1.1543	-2.9201**
	II	0.7734*	4.2216***	0.0639	0.2985*	-1.1824	-2.1517*
Japan	I	0.1529	-0.8591	0.1092	0.0865	-1.4661***	-4.7570***
	II	0.4191	0.2353	0.1414	0.1443	-1.7548***	-4.8444***
Turkey	I	-0.7386***	-1.5792	-0.0982	-0.5274*	-0.2213	-0.2322
	II	-1.3029***	-0.3672	-0.1861	-0.3885	-0.7747	-1.7557
Colombia	I	-0.3125**	-1.4602	0.0085	0.2080	-0.4486	-2.6486
	II	-0.3992***	-2.8183**	-0.0386	0.2261	-0.5193*	-2.0553
U.S.	I	0.5185**	2.2432**	0.2812***	0.5530***	-1.5905***	-4.6738***
	II	0.4648*	1.3370	0.2645***	0.7149***	-1.6145***	-4.7603***
India	I	-0.8351***	-2.8319**	-0.1377	-0.4680**	-0.4152	0.0538
	II	-0.3866***	-2.2684*	-0.0911*	-0.4191**	-0.3365	-0.4532
Hong Kong	I	-0.4003**	-5.4506***	0.1126*	0.0067	-0.5160	-0.6974
	II	-0.3694*	-5.0109***	0.2383***	0.4455	-0.4783	-3.2132
Egypt	I	-2.4088***	-3.6707**	-0.3685	-0.9368***	-2.3422	-1.4844
	II	-1.6380***	-4.0033**	-0.2662	-0.9601***	-1.5579	-3.2389
Argentina	I	0.1163**	1.5643	0.0541***	0.0381*	-0.2190**	-4.2447***
	II	0.1434	1.0156	0.0217	0.3915*	-0.5361***	-6.3707***
Portugal	I	-0.5503***	-4.6350***	-0.0085	-0.0360	-0.4799*	-1.1918
	II	-0.6175***	-4.6921***	0.0183	0.1112	-0.6650*	-2.4105
Chile	I	0.0316	2.6713	0.0010	0.3162	-0.0070	-0.2856
	II	0.0861	3.3690**	-0.0064	-0.1144	-0.0583	-1.4281
Tunisia	I	-0.5336	-2.3537	-0.0269	0.0781	2.0858***	0.1822
	II	-0.2263	-2.7970	0.0801	0.3388	1.0702**	-1.7054

(continued)

Table 8.3 (Continued)

Country	Period	Coefficients on WM (lin)[a]	(log)[b]	Coefficients on RD (lin)	(log)	Coefficients on FTD (lin)	(log)
Korea	I	-0.4065***	-4.1472***	-0.0164	-0.1756	-0.2787	-4.0443**
	II	-0.3353**	-3.5164***	0.0519	-0.0327	-0.3956	-2.2832
Philippines	I	0.0280	-0.3899	-0.0111	-0.7561***	0.0453	1.1417
	II	0.0389	-0.0887	0.0063	-0.0996	-0.0406	-4.6178***
Indonesia	I	0.0334	0.7640	0.0759	0.3512	-0.3517	-7.7812*
	II	0.1222	0.8325	0.1594***	0.5585	-0.2112	-5.3806
Kenya	I	0.1276	1.0011	0.0462	0.1891	0.3880	2.5972
	II	0.1049	2.5550*	0.0169	0.0040	0.3061	-0.6985
Thailand	I	-0.0734**	-3.6958***	-0.0161	-0.5445**	0.0352	-0.8603
	II	-0.3100***	-3.6598***	-0.0300	-0.1228	-0.3872*	-4.0031**

Notes: a/ Linear regressions are marked (lin), and logarithmic-linear regressions - (log).

b/ To prevent a substantial loss in the number of observations, in the logarithmic-linear regressions, zero values of STE occuring in some commodity groups in cases of 12 countries have been changed to 0.001.

Asterisks *, **, *** denote significance at the 10, 5, and 1 percent level, respectively. Intercepts and coefficients of determination have been omitted in the table.

the linear regressions were applied. It has to be noted, however, that Spearman coefficients are not greatly affected by the choice of the functional form of equations underlying the regression coefficients used for correlating.

The rationale behind an empirical test like this; i.e., one that relates trade to factor intensity across goods and then links these two to factor abundance across countries, is discussed in Deardorff (1984).[5] Most of the empirical studies reviewed earlier in the survey of the literature are limited to regressing trade data on various factor intensities. Since they do not look at how the coefficients obtained from those regressions for individual countries relate to factor endowments, it is questionable if they really provide complete tests of the factor proportions theory. One study which does account for all three relevant kinds of data is that of Balassa (1977c).

8.2.1.2 <u>Results</u>

The calculated Spearman correlation coefficients between estimates $\hat{\beta}$ and various measures of skill abundance are shown in the first four columns of Table 8.4. They all carry correct signs and, depending on the choice of a skill abundance measure and of the type of regression equation from which $\hat{\beta}$ was taken, they range in absolute value from 0.35 to 0.82. All except the lowest (the one involving CVW and $\hat{\beta}$ from logarithmic-linear regressions with endogeneous RCA) pass the significance test at the 1 percent level. Interestingly, each of the skill abundance measures is better correlated with an estimate of β if the latter comes from the regression equations involving STE, rather

Table 8.4

Spearman Rank Correlation Coefficients between Simple Regression Coefficient Estimates (from Regressing RCA and STE on WM, RD and FTD) and Measures of Skill Abundance and Technological Innovativeness, 28 Countries, 1976-78 (Period II).[a]

	Skill Abundance Measures: CVW	HRD	PTR	AVRS	Tech. Innovativeness Measures: PRD	SEP	AVRT
<u>RCA endogeneous, logarithmic-linear model</u>:							
Coefficient on WM	-0.3535 (0.0705)[b] (27)	0.5681 (0.0016) (28)	0.5806 (0.0030) (24)	-0.7065 (0.0002) (23)			
Coefficient on RD					0.4343 (0.0301) (25)	0.4377 (0.0224) (27)	-0.4477 (0.0248) (25)
Coefficient on FTD					-0.4481 (0.0247) (25)	-0.5891 (0.0012) (27)	0.5600 (0.0036) (25)
<u>STE endogeneous, linear model</u>:							
Coefficient on WM	-0.4890 (0.0096) (27)	0.7800 (0.0001) (28)	0.5971 (0.0021) (24)	-0.8231 (0.0001) (23)			
Coefficient on RD					0.6209 (0.0009) (25)	0.6600 (0.0002) (27)	-0.6785 (0.0002) (25)
Coefficient on FTD					-0.5569 (0.0038) (25)	-0.6331 (0.0004) (27)	0.6192 (0.0010) (25)

Notes: a/ Due to a substantial number of missing observations on RCA and STE, Indonesia has been dropped from the country sample for the purpose of this analysis.

b/ Significance levels and numbers of observations (countries) are reported in parentheses.

than RCA, as a dependent variable. It can be concluded that the structure of exports over commodity groups with varying skill intensity reflects a country's relative skill abundance more accurately than the structure of revealed comparative advantage does.

On the other hand, wide differences in Spearman coefficients across the skill abundance measures have to be noticed. The lowest coefficients are, quite systematically, those in which CVW, the variable of skill abundance based on a price definition, is involved. Bad showing of CVW can probably be attributed to the shortcomings of this variable that we discussed earlier.[6] The highest Spearman coefficients are produced when AVRS is used to characterize countries with respect to skill abundance. By construction, AVRS is supposed to accommodate various aspects of skill endowment measurement. We argued earlier, that, among the four variables, it is AVRS that gives probably the most reliable account of the country ranking by skill abundance. If so, high correlation coefficients generated by AVRS might be indicative of a really substantial explanantory power of the skill account of trade.

In summary, the picture emerging from the findings reported in Table 8.4 is the following. The higher a country's rank by skill abundance, the higher its rank by $\hat{\beta}$, the measure of relative export performance in skill-intensive goods, is likely to be. Thus, Keesing's (1966, 1968b) basic neo-factor notion, initially meant to relate only to the U.S. exports, receives support from this multi-country study, as does part (a) of hypothesis 2. Also, the conclusions drawn by Balassa (1977c)[7] from a similar test are confirmed. The result remains strong no matter which skill abundance variable is selected, with the possible exception of CVW, and regardless of which of the two reported types of regression equations underlies the estimated $\hat{\beta}$ used.

8.2.2. Test of the Product Cycle Prediction

8.2.2.1 Description of the Test

We now move to testing part (b) of hypothesis 2, which states that countries which have relatively high innovative capability, as measured by the extent of R&D effort, are likely to export manufactures which are both relatively young and R&D-intensive. This suggests a link among export performance, age or R&D intensity of products, and innovative capability of countries. The type of test applied in preceding sections to the neo-factor account of trade may then also be an acceptable method of verification of the neo-technology prediction.

The procedure involves, as before, running for each country simple regressions as described in equations 8.1 and 8.2, except that this time x = RD, FTD. The magnitude of thus estimated regression coefficients $\hat{\beta}$ are taken to reflect relative export performance in R&D-intensive products (when the R&D intensity variable RD serves as a regressor), or in products developed in relatively distant periods (when the product age variable FTD is a regressor). The results from regressions with endogeneous RCA are reported in the last four columns of Table 8.2, and the results from regressions with endogeneous STE are given in the last four columns of Table 8.3.

Relative export performance in R&D-intensive goods, and in goods which are young in terms of the product age variable FTD, is expected to be positively correlated, across countries, with innovativeness.

Therefore, the second step of the analysis is to examine whether the estimated coefficients $\hat{\beta}$ are correlated across countries with the three proposed measures of technological innovativeness (PRD, SEP, AVRT). For this purpose, we use the estimates $\hat{\beta}$ from logarithmic-linear equations with endogeneous RCA, and from linear equations with endogeneous STE. The results are summarized in the next section.

Except for Hufbauer's (1970) empirical work, a complete multi-country test of the neo-technology hypothesis is hard to find. As we noticed earlier, most authors are preoccupied wih the U.S. case. This is understandable since the neo-technology concepts of technology gap and product cycle first came up because of problems with explaining the U.S. position in international trade in the 1960s. On the other hand, the studies that do extend beyond the U.S. data fail to systematically consider the three relevant factors that need to be considered: trade, commodity characteristics, and country characteristics.[8] It is in this sense that the present test attempts to fill in the gap in the existing empirical literature.

8.2.2.2 Results

The calculated Spearman rank correlation coefficients are reported in the last three columns of Table 8.4. All of them are based on Period II data. All the correlation coefficients carry the expected signs, and they range in absolute value from 0.43 to 0.68. None fails to meet the 5 percent significance level, and most of them are significant at 1 percent. As it was the case with the test of the skill account, here as well the structure of exports over commodity groups with varying R&D

intensity reflects the inter-country differences in innovativeness somewhat better than the structure of comparative advantage does. Spearman coefficients are generally higher when the estimates $\hat{\beta}$ used originate from the equations with STE as an endogeneous variable.

On the basis of the correlation results, it can be concluded that countries' innovativeness is in fact reflected fairly well by their relative export performance in highly R&D-intensive goods, or goods which are young in terms of FTD. More specifically, high percentage of R&D expenditures in a country's GNP, and high percentage of engineers and scientists engaged in R&D activities, will generally be translated into a country's strong position in exporting R&D-intensive and relatively newly developed products. Let us notice that the implications of this go farther than those which seem to follow from Vernon's (1966) original formulation of the neo-technology model. Vernon proposed a concept of trinagular trade involving the U.S., the "remaining developed countries," and the "group of less developed countries." The present results suggest that R&D data may provide a useful device to identify each individual country's relative position within the spectrum of commodities with varying age and R&D intensity.

The results presented so far in this chatper indicate that neither the skill approach nor the product cycle approach can be ruled out as potentially important and empirically viable explanations of modern multilateral trade in manufactured products. As hypothesized, inter-country differences in the structure of industrial exports seem to be rather well explained both by differences in endowments of labor skills and differences in innovative capability. The results show little sensitivity to the choice of particular proxies for skill abundance and innovativeness.

While the findings generally conform to the expectations, the analysis suffers from one important weakness. A country's relative export performance in skill-intensive, R&D-intensive, and relatively newely developed goods has been assumed here to be correctly measured by coefficient estimates $\hat{\beta}$ obtained from regressing variables RCA and STE on the relevant commodity characteristics, WM, RD, and FTD, respectively. As it can be seen in Tables 8.2 and 8.3, significance of these coefficients is rather low for many countries.[9] Hence, using them in a cross-country correlation analysis may be criticized on the grounds that some of them may fail to be a reliable reflection of countries' structure of export performance at the first place. Therefore in the next section, the skill prediction and the product cycle prediction are reexamined with the use of an alternative method for assessing how, relatively, a country performs in exporting skill-intensive, R&D-intensive and newly developed manufactures.

8.3 Test with Relative Export Performance Measured by Weighted Averages of Commodity Characteristics in Exports

8.3.1 Description of the Test

As before, the test is based on the notion that relative export performance in skill-intensive, and in relatively newly developed R&D intensive products is likely to be positively correlated, across countries, with skill abundance and innovativeness, respectively. Unlike the tests described in Sections 8.2.1 and 8.2.2, however, relative export performance is now evaluated not on the basis of the coefficient estimates from regressing RCA or STE on the relevant commodity characteristics, but instead by calculating the weighted averages of these charactetistics for each country's exports in all reported commodity groups. The weights are given by the share of particular commodity groups in the value of a country's total exports in all groups. For example, the weighted average magnitude of skill intensity in exports, denoted by AWM, is computed for country i as follows:

$$(AWM)^i = \sum_{n=1}^{N} [(STE)_n^i / \sum_{k=1}^{N} (STE)_k^i](WM)_n, \qquad (8.3)$$

where n and k are commodity group indices, and N is the number of 3-digit SITC commodity groups for which STE data for country i could be collected, $N \leq 69$. Weighted averages of R&D intensity and product age, denoted ARD and AFTD, are calculated analogously by replacing variable WM in (8.3) with RD and FTD, respectively. The computations are done separately for Period I and Period II data on STE. The results are reported in Table 8.5.

Since the same data on the skill intensity variable WM, the R&D intensity variable RD, and the product age variable FTD are used for all countries in the sample, the differences in the magnitudes of weighted averages, AWM, ARD, and AFTD reflect cross-country differences in the industrial export structures with respect to skill intensity, R&D intensity, and age of the products.[10] As hypothesis 2 suggests, the calculated averages AWM are expected to be positively correlated, across countries, with skill abundance. Correlation between innovativeness and

Table 8.5

Weighted Average Magnitudes of Selected Commodity Characteristics in Exports of 69 SITC Commodity Groups by 29 Countries, 1969-71 (Period I) and 1976-78 (Period II).

Country	Period	AWM[a]	Percentage change[b]	ARD	Percentage change	AFTD	Percentage change
Sweden	I	6600.81		2.7677		29.48	
	II	6605.55	+0.07	2.8828	+4.3	29.26	-0.75
U.K.	I	6508.81		2.8618		29.85	
	II	6536.60	+0.43	3.0672	+7.2	29.79	-0.20
Nehterlands	I	6307.01		2.7386		30.08	
	II	6451.12	+2.28	2.8962	+5.8	30.04	-0.13
France	I	6516.64		2.5356		29.82	
	II	6572.47	+0.86	2.6166	+3.2	29.47	-1.17
West Germany	I	6545.01		2.4382		29.75	
	II	6583.25	+0.58	2.5688	+5.4	29.46	-0.97
Mexico	I	6396.26		3.0431		31.04	
	II	6420.65	+0.38	2.3961	-21.3	31.82	+2.51
Italy	I	6317.48		2.5487		29.79	
	II	6361.08	+0.69	2.3205	-8.9	29.66	-0.44
Australia	I	6659.83		2.2180		31.62	
	II	6754.68	+1.42	2.9313	+32.2	31.91	+0.92
Singapore	I	6083.90		2.5347		30.42	
	II	6157.88	+1.21	3.8260	+50.9	30.25	-0.56
Israel	I	5833.72		2.4947		32.25	
	II	6224.40	+6.70	3.3900	+35.9	31.16	-3.38
Belgium	I	6581.40		1.7419		31.30	
	II	6620.42	+0.59	2.1241	+21.9	30.56	-2.36

(continued)

Table 8.5 (Continued)

Country	Period	AWM[a]	Percentage change[b]	ARD	Percentage change	AFTD	Percentage change
Austria	I	6204.87		1.7609		30.34	
	II	6282.63	+1.25	2.0608	+17.0	29.92	-1.38
Canada	I	6972.75		2.9198		29.59	
	II	6979.56	+0.09	2.7907	-4.4	29.53	-0.20
Japan	I	6390.01		2.8764		29.58	
	II	6589.29	+3.12	3.0075	+4.6	29.31	-0.91
Turkey	I	4942.67		1.1588		31.26	
	II	4642.04	-6.08	0.8840	-23.7	30.13	-3.61
Colombia	I	5715.87		2.2515		30.68	
	II	5616.61	-1.74	1.7360	-22.9	30.54	-0.46
U.S.	I	6719.12		4.0312		29.24	
	II	6669.28	-0.74	3.9125	-2.9	29.21	-0.10
India	I	5181.51		0.8491		31.02	
	II	5708.04	+10.16	1.2059	+42.0	31.12	+0.32
Hong Kong	I	5322.19		3.6580		30.30	
	II	5483.46	+3.03	4.7740	+30.5	30.78	+1.58
Egypt	I	4172.37		0.4955		28.46	
	II	4318.84	+3.51	0.5265	+6.3	28.86	+1.41
Argentina	I	6721.94		3.5539		30.35	
	II	6596.57	-1.87	2.4336	-31.5	29.36	-3.26
Portugal	I	5367.91		2.0786		30.65	
	II	5343.23	-0.46	2.3816	+14.6	30.19	-1.50
Chile	I	6683.77		2.6370		31.71	
	II	6644.84	-0.58	2.2613	-14.2	31.30	-1.29

(continued)

Table 8.5 (Continued)

Country	Period	AWM[a]	Percentage change[b]	ADR	Percentage change	AFTD	Percentage change
Tunisia	I	5091.66		1.8744		41.97	
	II	5669.67	+11.35	3.0536	+62.9	36.75	-12.44
Korea	I	5325.09		1.9026		30.96	
	II	5776.43	+8.84	2.7340	+43.7	31.11	+0.48
Philippines	I	6294.40		1.4014		33.65	
	II	6208.78	-1.36	2.0862	+48.9	32.21	-4.28
Indonesia	I	5585.73		2.4847		29.76	
	II	6424.68	+15.02	5.8992	+137.4	29.26	-1.68
Kenya	I	6502.85		2.6314		35.84	
	II	6363.39	-2.14	2.0613	-21.7	34.67	-3.24
Thailand	I	5457.09		1.1498		32.65	
	II	5135.19	-5.90	1.4895	+29.5	29.57	-9.43

[a]Values of AWM are calculated using equation (8.3). ARD and AFTD are found Analogously.

[b]The change in the weighted average from period I to period II, expressed in percent.

weighted averages ARD and AFTD should be, respectively, positive and negative. Hence, to complete the test, correlations between the calculated averages for Period II (1976-78) and the corresponding country characteristics are examined. This is done by computing Spearman rank correlation coefficients between AWM and each of the four alternative skill abundance measures, and between ARD and AFTD and each of the three alternative measures of technological innovativeness. The correlation results are given in Table 8.6.

8.3.2 Results

The coefficients related to the skill theory carry the expected signs, they range from 0.36 to 0.74 in absolute value, and all except one (involving CVW) are significant at 1 percent. Thus, CVW again fails to generate a significant result, but the other three measures of skill abundance remain quite good predictors of countries' relative export performance in skill-intensive products.

The correlation coefficients which are meant to reflect the neo-technology or the product cycle account also have correct signs, and range in absolute value from 0.47 to 0.67. Those involving ARD are significant at 1 percent, and those with AFTD are somewhat lower, while either meeting or marginally exceeding the 1 percent significance level. Highly innovative economies are thus also likely to show good export performance in relatively newly developed and R&D intensive manufactures. On the other hand, less innovative countries export, in general, older products with lower R&D requirements.

Table 8.6

Spearman Rank Correlation Coefficients between Average Magnitudes of Commodity Characteristics in Exports (AWM, ARD, AFTD) and Measures of Skill Abundance and Technological Innovativeness, 28 Countries, 1976-78 (Period II).[a]

	Skill Abundance Measures:				Tech. Innovativeness Measures:		
	CVW	HRD	PTR	AVRS	PRD	SEP	AVRT
AWM	-0.3626 (0.0630)[b] (27)	0.7373 (0.0001) (28)	0.5575 (0.0047) (24)	-0.6976 (0.0002) (23)			
ARD					0.5823 (0.0023) (25)	0.6337 (0.0004) (27)	-0.6685 (0.0003) (25)
AFTD					-0.4682 (0.0183) (25)	-0.4823 (0.0108) (27)	0.5200 (0.0077) (25)

Notes: a/ Due to a substantial number of missing observations on STE (used to calculate weighted averages), Indonesia has been dropped from the country sample.

b/ Significance levels and numbers of observations (countries) are reported in parentheses.

As a whole, the above results strikingly resemble those based on the regression coefficients, and reported in Table 8.4. This new evidence gathered in support of hypothesis 2 seems to reinforce the conclusions drawn earlier regarding the neo-factor and the neo-technology accounts of trade.

To complete the discussion in this section, it would be instructive to get some idea of how particular countries in the sample conform to the view of trade in manufactures as suggested by the skill account and the product cycle account. One way to go about it is by looking at scatter diagrams in which individual countries' weighted averages of particular commodity characteristics calculated for these countries' exports, are plotted against the relevant country characteristics. The diagrams are presented in Figures 8.1, 8.2, and 8.3. Diagrams such as these provide a useful supplement to the correlation analysis as they reveal information hidden behind the correlation coefficients, and allow one to identify the outliers.

In Figure 8.1, weighted average skill intensity in exports AWM is shown as it relates to countries' average ranks by the skill abundance measures, AVRS. Low values of AVRS denote high ranks by availability of skills. Therefore, the countries are expected to be positioned along some downsloping line as they generally are, perhaps with the exception of Egypt, whose index of relative export performance in skill-intensive products seems to be below what that country's average skill-abundance rank AVRS would suggest.

Figure 8.2 relates weighted averages of R&D intensity in exports ARD to countries' average ranks by the measures of innovativeness, AVRT.

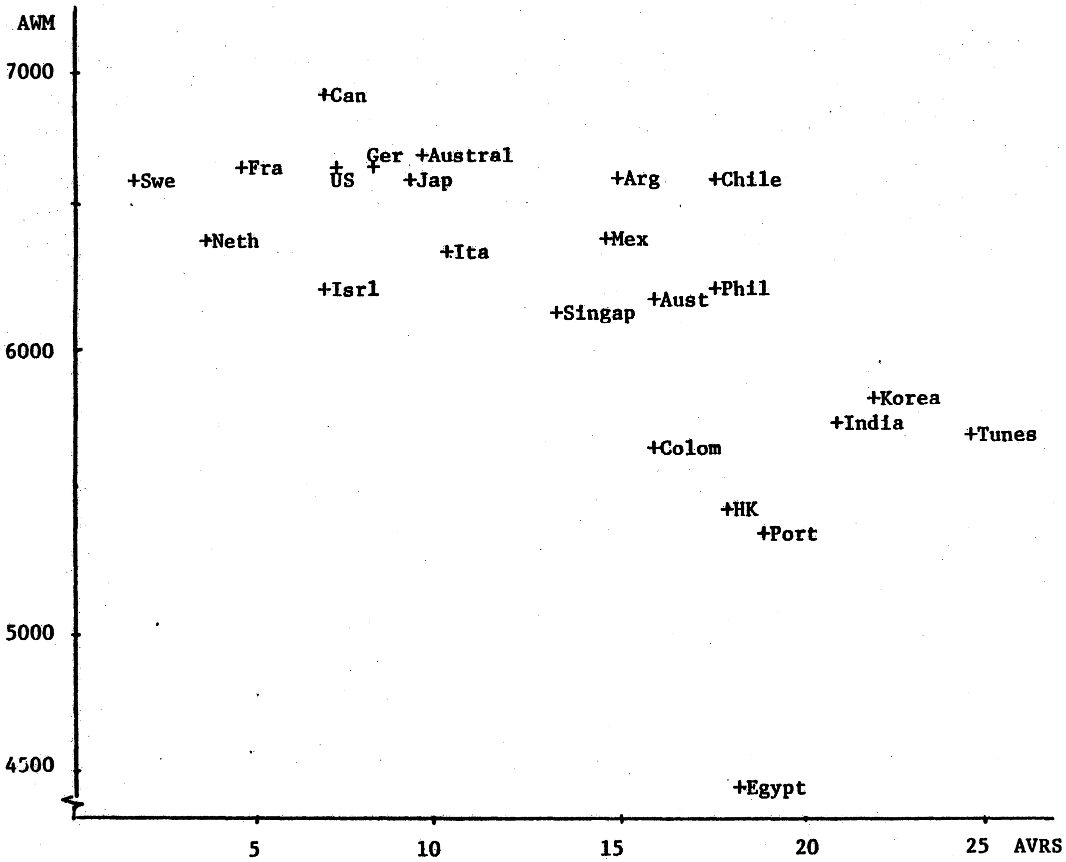

Figure 8.1: Scatter Diagram, AWM versus AVRS, 23 Countries, Period II

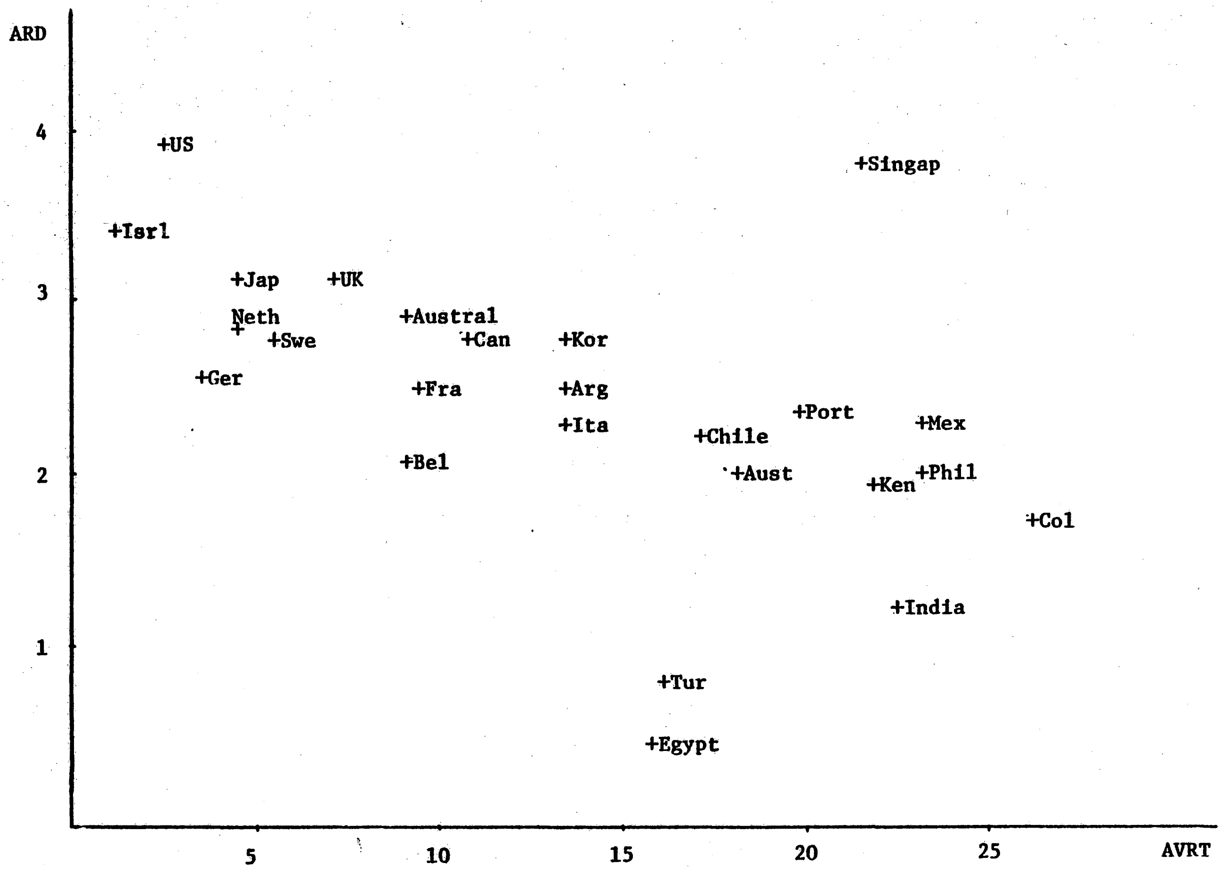

Figure 8.2: Scatter Diagram, ARD versus AVRT, 25 Countries, Period II

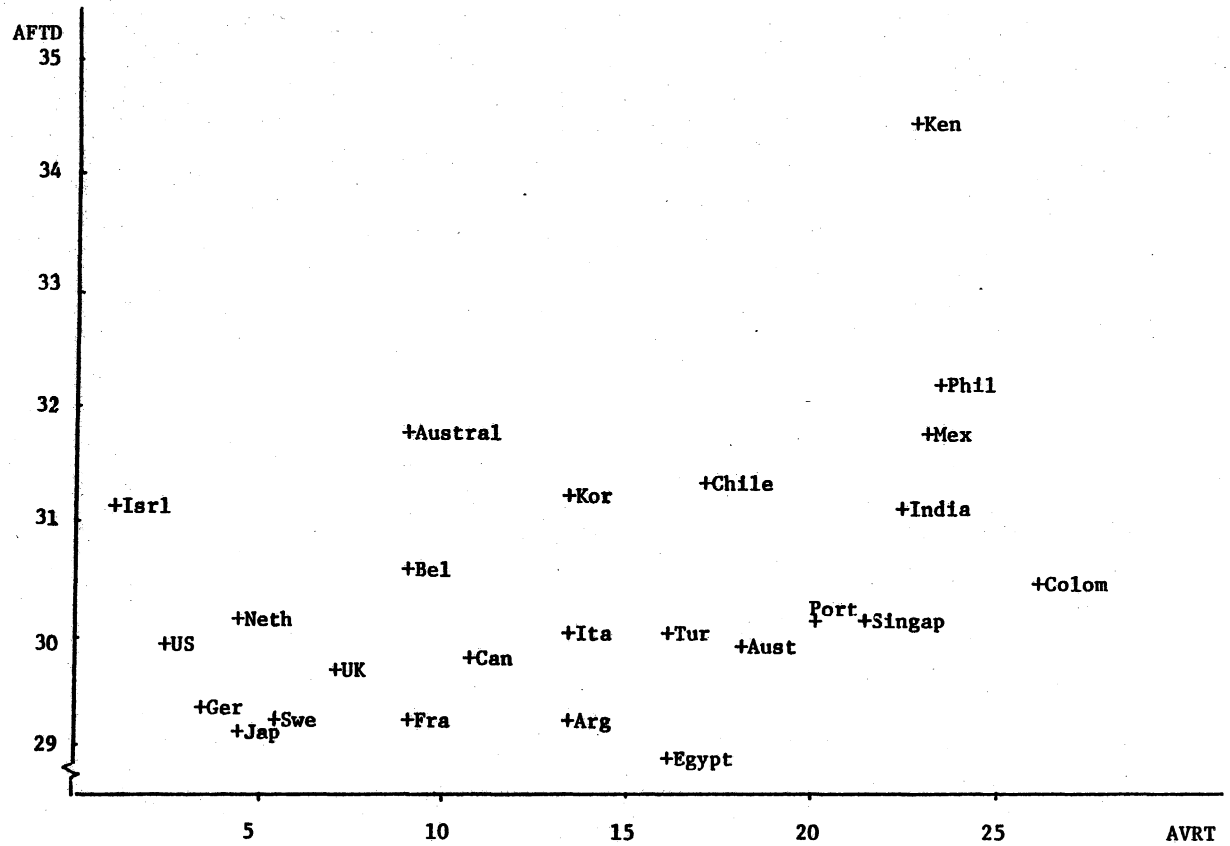

Figure 8.3: Scatter Diagram, AFTD versus AVRT, 25 Countries, Period II

Low AVRT values go with high innovative capability, so that we again expect to obtain a downsloping pattern of the plotted points. The revealed picture is consistent with part (b) of hypothesis 2, the most clear outliers being Egypt and Turkey whose ARD values are lower than their innovativeness ranks would indicate, and Singapore which is doing abnormally well in R&D-intensive goods. The image of the U.S. as a "technological leader," exporting heavily R&D-intensive products, seems to be confirmed. This is consistent with the U.S.'s role in Vernon's (1966) original formulation of the product cycle concept, and with the large body of the neo-technology literature dealing with the U.S. case. The position of Israel is also worth noticing, as are those of Singapore and Korea. These three NICs, although widely different from each other in terms of AVRT, show high indices of average R&D intensity in exports, in fact, higher than these of many advanced economies in the sample. In this context it needs to be noticed that, while products exported by these three NICs are R&D-intensive, they are not exceptionally skill-intensive, and generally consistent with these countries' ranks by skill abundance. This is seen from Figures 8.1 and 8.2. This may suggest that in NICs like these, the presence of economic systems which direct R&D efforts to most efficient uses, and are conducive to acquisition of technological knowledge from abroad, may be of critical importance in gaining competence needed for the production of goods that both are relatively R&D-intensive and at the same time conform to a country's relative availability of skills.

In general, Figure 2 shows that the group of NICs included in the sample, with the exception of Turkey, performs systematically better in

R&D-intensive goods than the countries classified as LDCs do. In this, the NICs resemble DCs rather than LDCs. Another feature distinguishing the NICs from the LDCs is visible, although perhaps not as clearly, in Figure 8.3, where weighted averages of FTD, the product age variable are related to countries' average ranks by innovativeness, AVRT. In that figure, the average age of industrial exports turns out to be unexpectedly low for Argentina and Egypt. The quality of STE data can probably be blamed for causing this paradoxical result.

Overall, it can be claimed that unlike LDCs, some NICs in the sample have secured a fairly good export position in "new" relatively R&D-intensive goods. This suggests a somewhat revised version of product cycle, in which some NICs, and especially the Asian NICs and Israel, play the type of role which in Vernon's original formulation of the model was reserved for DCs. Several studies, including Vernon's (1979)[11] critical review of his early work, and Balassa (1977c),[12] propose that some NICs would eventually replace the traditionally innovative economies like the U.S. or Japan in exporting certain "new," R&D-intensive manufactures, while being supplanted by other less developed economies in exporting "mature" products. The present findings show that such a process may already have been well under way by the late 1970s.

In summary, while the results of the analysis presented in this chapter are generally supportive of hypothesis 2, further empirical studies of the neo-factor and the neo-technology theories in a multi-country setup are needed. The work should emphasize the search for more refined country characteristics. The preferable way of measuring skill abundance would be that using some data more closely reflecting relative skilled labor wages, while innovativeness would be better assessed by the output rather than input-oriented statistics on innovations.

FOOTNOTES

[1]There are a lot of studies which seem to, more or less implicitly, adopt this line of reasoning. Some examples are Branson (1971), Katrak (1973), Lowinger (1975) and Helleiner (1976).

[2]See Sections 6.2.2 and 6.2.3 for definitions of all these variables.

[3]Although no drastic execeptions to this rule were found, it is worth mentioning that in countries like Sweden, France, Mexico, Canada and Colombia, the average skill ranks (AVRS) exceed the average innovativeness ranks (AVRT) by more than is the case in other countries. On the other hand, ranks by AVRT are most markedly above those by AVRS for West Germany, Israel, Japan, U.S., and Korea.

[4]Interestingly, the only commodity characteristics with which WM is correlated is the Heckscher-Ohlin variable CM. In that case, the coefficient in 0.48, which is close to what Hufbauer (1970, p. 164) found for skill ratio and capital-per-man, and it is significant at 0.1 percent. This suggests that physical capital may be complementary to labor skills in production.

[5]Deardorff (1984), pp. 473-475, 492-493.

[6]See Section 6.2.3.

[7]Balassa shows that endowments of human skills play an important role in explaining inter-country differences in the structure of exports. See Balassa (1977c), p. 14.

[8]Usually two of these are used as an empirical basis on which the third one is explicitly or implicitly inferred. The arguments against viewing such procedure as an acceptable method of verification of a trade model can be found in Deardorff (1984), p. 192, and Leamer (1984), pp. 49-50.

[9]Although Balassa's (1977c) study suffers from a similar shortcoming, the author does not seem to attach much importance to it as he uses insignificant coefficients for further cross-country regressions. See Balassa (1977c), p. 13a.

[10]There are two potential problems with this interpretation. First, while using the U.S. data on WM, RD, and FTD for all countries is justified by some evidence regarding factor intensity reversals, quoted in Section 4.4, and by the lack of comparable national data, the values of these variables for particular commodity groups are likly to differ internationally. Second, some countries suffer from gaps in data on variable STE which provides the weights for the calculation of AWM, ARD, and AFTD. The country most affected by that is Indonesia. It is therefore dropped from the sample when inter-country comparability of the computed averages is of importance.

[11]Vernon (1979), p. 226.

[12]See p. 26. Also, Hirsch (1974b) stresses the ability of some NICs to add less mature goods to the list of candidates for local manufacture. Many of these goods are at the earliest phases of product cycle. Israel, Hong Kong, Korea and other NICs are cited as examples. See p. 79. Further evidence can be found in Keesing (1979), Marris (1979), and Hsiao and Hsiao (1983).

CHAPTER 9

TEST OF HYPOTHESIS 3: INTERTEMPORAL CHANGES IN MANUFACTURING EXPORT STRUCTURES

9.1 Changes in Relative Export Performance Measured by Regression Coefficients

The conclusions from the preceding analysis suggest the view of an upgraded role played by the NICs in the international product cycle. Also, the analysis in Chapter 8 offers some interesting results with regard to LDCs. As indicated by the skill account and the neo-technology account, the range of products these countries can export competitively is not likley to be as wide as the standard Heckscher-Ohlin analysis would suggest. Relatively low skill intensity and low R&D intensity are the additional conditions that have to be met by the exported goods. However, we have argued that determination of competitive advantage has a dynamic character, and that should be reflected by intertemporal changes in export structures. In this chapter, we examine this dynamic aspect of industrial export performance.

According to hypothesis 3, the composition of a country's industrial exports is likely to be subject to a gradual shift toward commodity groups which are classified here as skill-intensive and R&D-intensive, and which are characterized by relatively low values of the product age variable FTD. In the model outlined in Chapter 5, the factors that set this process in motion are a continuous decrease in commodities' skill intensity and, on the other hand, the acquisition of relevent technological knowledge by the imitating countries, both resulting in recurrent decline of certain industries in the innovating economy, and inducing the emergence of new industries which are highly skill-intensive and require substantial R&D outlays.

Ideally, the test of hypothesis 3 would involve a systematic time-series analysis of each country's changing structure of industrial exports. However, the type of data available does not allow that. The data we have includes a "snapshot" of the 69 SITC commodity groups in terms of their characteristics (skill intensity, R&D intensity, and age), and two sets of data on the countries' export performance across these commodity groups, one regarding Period I (1969-71) and second from Period II (1976-78). By regressing export performance on commodity characteristics, these have been combined in Section 8.2 to obtain the indices of relative export performance in relatively newly developed R&D-intensive and skill-intensive products. Such indices are reported, both for Period I and for Period II, in Tables 8.2 and 8.3. Those calculated for Period II were used in the preceding section to test hypothesis 2. While more complete time-series data are lacking, results from Tables 8.2 and 8.3 can be helpful in examining hypothesis 3 as well.

The hypothesized dynamic process implies that the coefficient estimates $\hat{\beta}$ from regressing export performance (RCA and STE) on the skill intensity variable WM and the R&D intensity variable RD are expected to increase from Period I to Period II. On the other hand, the corresponding indices of relative export performance involving FTD, the product age variable, should be decreasing between Period I and Period II. The relevant evidence is summarized in the first four rows of Table 9.1, which reports the numbers of country cases within the 29-country sample confirming the hypothesized direction of the change in particular

Table 9.1

The Change in Relative Export Performance in "new" R&D-intensive, and Skill-intensive Commodity Groups from Period I (1969-71) to Period II (1976-78), 29 Countries.[a]

Index of relative export performance	WM	RD	FTD
Correlation coefficient (RCA endogeneous, logarithmic-linear)	21	17	16
Correlation coefficient (RCA endogeneous, linear)	17	15	19
Correlation coefficient (STE endogeneous, logarithmic-linear)	22	24	21
Correlation coefficient (STE endogeneous, linear)	23	19	21
Export embodiment (weighted average of a commodity characteristic)	20	20	23

Note: a/ The table reports the numbers of country cases in which the direction of the change in specific indices from period I to period II was found to be consistent with expectations. The hypothesized changes are: WM - increase, RD - increase, FTD - decrease.

indices of relative export performance. It shows that a majority of countries in the sample have indeed recorded a shift in their manufactured exports toward commodity groups including relatively newly developed, R&D-intensive and relatively skill-intensive products. Depending on the choice of endogeneous variable, and the functional form of the equation, coefficient estimates from regressing export performance on commodity characteristics change as anticipated in 15 to 24 out of the 29 countries analyzed.

What remains to be examined is whether the detected changes in the regression coefficient estimates between Periods I and II are statistically significant.

Doing that, we will concentrate on the coefficient estimates obtained from one specific model, namely the log-linear regression model with the share in total exports STE as a dependent variable. These estimates are reported in the second, fourth, and sixth columns of Table 8.3. We wish to see if the elasticity estimates produced by regressing STE individually on the three commodity characteristics (WM, RD and FTD) significantly change from Period I to Period II.

The test involves using, for each country, the residual sum of squares from the unrestricted model underlying the estimates listed in Table 8.3, and the residual sum of squares from the model in which a restriction is placed on the parameter estimates, and then applying the appropriate F-statistic to see if the hypothesized restriction can be rejected. The unrestricted model consists of two regression equations:

$$\log STEI = \alpha_I + \beta_I \log x \qquad (9.1)$$

$$\log STEII = \alpha_{II} + \beta_{II} \log x \qquad (9.2)$$

where x = WM, RD, FTD, and the symbols I and II attached to variable STE and to the estimated parameters stand for Period I and Period II. Equations 9.1 and 9.2 are estimated using data on STE from Period I and Period II, respectively, for all of the 69 commodity groups for which such data is reported. Due to missing observations in some country cases, the number of observations in each of the two regressions is in general equal to N, $N < 69$. The unrestricted residual sum of squares is obtained by adding the residual sum of squares of the two individual equations, $SSE_{UR} = SSE_{I} + SSE_{II}$.

Now we consider the null hypothesis $H_0 : \beta_I = \beta_{II}$, and the resulting restricted regression model can be written as follows:

$$\begin{bmatrix} \log STEI_1 \\ \vdots \\ \log STEI_N \\ \log STEII_1 \\ \vdots \\ \log STEII_N \end{bmatrix} = \begin{bmatrix} 1 & 0 & \log x_1 \\ \vdots & \vdots & \vdots \\ 1 & 0 & \log x_N \\ 0 & 1 & \log x_1 \\ \vdots & \vdots & \vdots \\ 0 & 1 & \log x_N \end{bmatrix} \begin{bmatrix} \alpha I \\ \alpha II \\ \beta \end{bmatrix} \qquad (9.3)$$

where x = WM, RD, FTD; I and II denote periods, as before. For each country, equation 9.3 is estimated using data from Period I and Period II. Intercepts are allowed to vary between periods, but parameter β is restricted by the null hypothesis. The number of observations is 2N. The estimation yields the restricted residual sum of squares, SSE_R.

Following Fisher (1970),[1] we examine the null hypothesis using the following F-statistic

$$F_{p,2N-2k} = \frac{(SSE_R - SSE_{UR})/p}{SSE_{UR}/(2N - 2k)} \qquad (9.4)$$

where k is the number of estimated parameters, and p is the number of restrictions. In this case, k = 2 and p = 1.

The test is applied individually to each country in the sample. In almost all cases the calculated F-statistics are lower than the critical values of the F-distribution at the 10 percent significance level. In these cases, the null hypothesis cannot be rejected. The differences in parameter estimates $\hat{\beta}$ between Periods I and II fail to pass a significance test. The only exception is the Philippines, where the difference between $\hat{\beta}_I$ and $\hat{\beta}_{II}$ on RD is significant at 10 percent, and the difference between $\hat{\beta}_I$ and $\hat{\beta}_{II}$ on FTD is significant at 5 percent.

The results of the tests described in this section can be then summarized as follows. Although for the majority of countries examined, the magnitudes of coefficient estimates $\hat{\beta}$ are shown to change in the hypothesized direction between Period I and Period II, these changes, generally, are not statistically significant. The time span of the analysis may be too short for the significance test to produce better results. It is also possible that in many countries, the shifts in export structures towards more skill-intensive, R&D-intensive and newly developed products may have been taking place within, rather than among, the 3-digit commodity groups. Due to aggregataion of data on exports and commodity characteristics, the results of such shifts could not be accounted for in this analysis.

9.2 Changes of Relative Export Performance Measured by Weighted Averages of Commodity Characteristics in Exports

An alternative method of measuring relative export performance in newly developed, R&D-intensive and skill-intensive goods, presented in Section 8.3, calls for computing weighted averages for each of the three commodity characteristics, FTD, RD, and WM. The averages, AFTD, ARD, and AWM computed for each country's exports in Periods I and II are shown in Table 8.5. Since the value of FTD, RD and WM are held constant, then AFTD, ARD and AWM will change from Period I to Period II only as a result of a change in the composition of exports. Hypothesis 3 suggests that ARD and AWM should be increasing, while AFTD should be decreasing over time, as the importance of newer, more R&D-intensive and skill-intensive manufactures in industrial exports increases.

The last row in Table 9.1 shows that ARD and AWM have changed in the hypothesized direction in 20 country cases. Twenty-three out of the 29 countries show, as expected, a decline in weighted average age of the exported manufactures.

By all measures, most countries in the sample seem to have participated in the dynamic changes in the international division of labor implied by the product cycle. The results indicate that Israel and the Asian Newly Industralizing Countries may have done so to a larger extent than others. On the other hand, Colombia and the Latin American Newly Industralizing Countries actually show some decline in the importance of R&D-intensive commodity groups in their exports.[2] These are also the countries that suffered some deterioration in the skill structure of industrial exports.

Therefore, while the picture emerging from these findings is generally consistent with the expectations, some important questions for future research impose themselves. One is why do some economies do far better than others in following what, by the product cycle logic, seems to be a natural path of industrial development? To what extent can this be rationalized simply on the basis of internationally varying rates at which availability of human skills and the R&D base have been changing? And, what is the relevance of the specific foreign trade regimes and industrial policies followed by particular countries in the late 1960s and the 1970s?

In the period covered by the analysis, the Latin American economies opted, unlike the Asian NICs, for inward-looking trade regimes based on import substitution and frequent distortion of incentives.[3] This may be helpful in explaining the lack of adequate mechanisms for acquisition of technological knowledge, that would also direct imitative effort to commodities indicated by these countries' relative factor abundance.[4] If this assertion is correct, then the adopted policies would be held at least partly responsible fo the failure of the Latin American economies to capitalize on the dynamic character of international division of labor in manufactured goods.

Another country showing no evidence of the hypothesized shift in the export structure toward R&D-intensive and skill-intensive products is the U.S. As Table 8.5 shows, the average R&D-intensity and skill-intensity in the U.S. industrial exports actually decreased between Period I and Period II. Also, the average age of the U.S. exports decreased only marginally. The U.S. results reported in Tables 8.2 and 8.3 are not much better.

It is common knowlege that, in the 1970s, the U.S. has suffered a decline of some more mature industries. This is a natural event, consistent with this model, and desirable from the point of view of world productive efficiency.[5] Yet the above findings suggest that the U.S. position in new, relatively R&D-intensive products may have been effectively challenged as well, the prime challengers being Japan, other DCs, and, increasingly, the Asian NICs.[6] It can be claimed that the dynamism implied by hypothesis 3 apparently results in some major shifts among the economies at the top of the "pecking order," and the U.S. seems to be one of the countries adversely affected by these shifts. As new countries graduate to high ranks in the "pecking order," the need grows stronger for more flexible accounts of manufactured trade that would accommodate these dynamic changes.

FOOTNOTES

[1]Fisher (1970), p. 364.

[2]See Table 8.5.

[3]Balassa (1977a), pp. 28-31.

[4]The problem of the impact of policy distortions on the LDCs' changing export structures in manufactured products in also discussed in Balassa (1977c), pp. 24-25.

[5]Some normative aspects of such dynamic processes are considered by Krugman (1979b), p. 265.

[6]The phenomenon is documented, among others, in Aho and Carney (1980), David (1982), Piekarz, Thomas and Jennings (1982), NYSE (1984), and PCIC (1985).

CHAPTER 10

SUMMARY

In this study, we have proposed and examined an integrated model of international trade which attempts to combine the neo-factor and the neo-technology explanations of industrial exports. The argument has been advanced that, while the traditional Ricardian and Heckscher-Ohlin theories are open to various types of criticisms with regard to how they explain modern trade in manufactures, such integrated model is both theoretically acceptable and empirically useful. Contrary to what some authors have suggested, the international differences in skill abundance, and differences in innovative capability are treated as complementary components of the framework, rather than as two competing explanations of cross-country differences in the patterns of export performance.

By and large, the empirical analysis confirms the hypotheses suggested by the model. First, the results show that the neo-factor or skill theory is applicable primarily to trade in "mature" products. Also, there is some qualified evidence that export performance in "new" products tends to be better explained by the variables associated with the neo-technology or product cycle theory. Trade in "new" goods appears then to be governed to a considerable extent by forces other than relative abundance of basic productive factors. In no way do these findings undermine the validity of the factor proportions theory. They do, however, suggest that in accordance with the character of the assumptions underlying it, the scope of its applicability may be confined to "mature" products. The low-technology set of commodity groups representing "mature" goods, turns out to be the one in which not only does the neo-factor theory perform well, but also in which the standard Heckscher-Ohlin model is likely to show some potential.

Second, both the neo-factor theory and the neo-technology theory gain support from a cross-country study covering a wide range of manufactures. In particular, relative export performance in skill-intensive goods is found to be strongly associated with avaiability of skills. On the other hand, relative export performance in newly developed R&D intensive goods turns out to be significantly correlated with the extent of innovative capability. The results exhibit little sensitivity to the choice of empirical proxies for export performance, skill availability, and innovativeness used in the verification.

Third, with regard to the dynamism of trade patterns, exports of manufactures included in the sample indeed show a tendency to shift, as implied by the notion of product cycle, towards products with high skill intensity, high R&D intensity, and low age. Some more spectacular exceptions to this rule are dealt with in the text.

Given a rather unimpressive quality of the data used, the findings should be viewed as suggestive rather than conclusive. As better statistics become available, further empirical research should concentrate on cross-country studies of determination of export patterns, as opposed to single country analyses, apply more disaggregated data, preferably on individual product basis, and look for more reliable proxies for relative availability of skills and for capability to develop new products. Theoretical work should take more interest in trying to devise dynamic models that would be both easily testable and, at the same time capable of accounting for the complexity of inter-country industrial competition. Such models are badly needed to explain the rapid changes in international division of labor in manufactured goods that have been taking place over the 1970s and early 1980s. Also, more work is needed to further investigate the presumed commodity specificity of the two explanations of trade, the factor proportions one and the one based on technological competition.

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