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**THE PRODUCT LIFE CYCLE THEORY
AND
THE MANUFACTURED EXPORTS OF DEVELOPING COUNTRIES:
AN EMPIRICAL STUDY**

by

Yongming Feng, B.A. Economics

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of the requirements for
the degree of

Master in Management Studies

School of Business
Carleton University
Ottawa, Ontario

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**The Product Life Cycle Theory and
The Manufactured Exports of Developing Countries:
An Empirical Study**

submitted by Ycngming Feng, B.A. Economics
in partial fulfilment of the requirements for
the degree of Master of Management Studies

Thesis Supervisor

Director, School of Business

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Date

ABSTRACT

This study examines the international trade of manufactured goods from five developing countries (China, India, Indonesia, Malaysia and Mexico) in light of the international product life cycle theory. Two research problems are examined here. First, the trade balances of manufactured products for developing countries are predicted to be inversely correlated with the growth rates of world production of the corresponding products, an indication of product maturity. Second, the difference in the trade balances of comparable manufactured goods for developing countries are predicted to be a result of different levels of economic development. Trade statistics at the three digit SITC level covering a time span from 1982 to 1991 are used in the tests. The findings of the tests did not support the hypotheses of this thesis. Based on the results of the test, policy implications for economic development, foreign investment and industry support in developing countries are discussed.

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1. INTRODUCTION

International trade in manufactured goods has received increasing attention from government and academic circles in developing countries as the importance of exports has become more apparent in generating employment, income and economic growth. Numerous studies have been done to tackle issues in the development of manufacturing industries and to offer ways on how international trading in manufactured products can contribute to the national economy. The application of the product life cycle (PLC) theory is among those studies.

The PLC, one of the most important marketing concepts, was developed in the 1950s. Its application to international trade - the international PLC - was expanded in the late 1960s with the initial objective of explaining U.S. trade patterns and was later extended to other developed countries. The international PLC states that developed countries (DCs) are internationally competitive in growth products and developing countries are internationally competitive in mature products. This concept has proven to be very effective in understanding the trading patterns of the manufactured goods from developed countries. However, tests of the international PLC theory on less developed countries, e.g. De La Torre (1972), Kaynak (1987), are relatively scarce in the literature.

This thesis describes a study that attempted to address this deficiency by analyzing the trading behaviour of five developing countries - China, India, Indonesia, Malaysia and Mexico. Industrial and trade statistics from 1982 to 1991 for these countries (from 1987 to 1991 for China) were utilized to classify growth and mature products and to test the hypotheses. This study complements previous efforts and examines the applicability, if any, of the international PLC concept for developing countries. Findings from this study also have policy implications for developed countries and developing countries in particular as to where they should concentrate in their economic development in view of their respective competitive advantages. The findings also offer reflections on the PLC theory as well as alternative theories which may be applied to developing countries.

2. LITERATURE REVIEW

2.1 PRODUCT LIFE CYCLE

As introduced by Dean (1950, 1951), the product life cycle theory predicts that a product typically goes through four stages: introduction, growth, maturation, and decline. Thus, the product life cycle represents the unit sales curve for a certain product extending from the time it is first placed on the market until it is removed (Buzzell, 1966). A typical product life cycle curve is shown in Figure 1.

2.1.1 Introduction Stage

According to Onkvisit and Shaw (1989), the first stage, also called the "pioneering" stage, introduces a new product to satisfy a new or existing need. The high risk of new product development attracts few competitors. As stated by Onkvisit and Shaw (1989), even in a situation where competitors do exist, they are more likely to pose indirect competition (i.e. other product classes and/or forms) than direct competition (i.e. other brands).

Sales of a new product initially increase very slowly with higher income consumers being the target market since many new products are expensive and have a low price elasticity of demand. Market imperfections are usual. This situation results in frequent product modifications and a requirement for a high level of

Figure 1

Product Life Cycle and Profit Curves

Source: Sak Onkvisit and John J. Shaw, *Product Life Cycles and Product Management*. Englewood Cliffs, New Jersey: Quorum Books, 1989.

service. Combined with other factors such as low production volume and a lack of specialized equipment, new products are characterised by high marketing costs, inefficiency and diseconomies of scale.

Naturally, a loss is expected at this stage which makes it imperative to move the new product into the profitable growth stage as soon as possible.

2.1.2 Growth Stage

Market acceptance of the product is much better at this stage, leading to increased sales. Middle-income consumers are the marketing target. Onkvisit and Shaw (1989) divide this into two substages. In the first substage, sales grow at an increasing rate; while in the second substage, sales increase at a decreasing rate.

Mass production, mass distribution, and mass marketing contribute to the lower cost of production and marketing. On the other hand, competition increases, with opportunity-seeking firms lured by the product's profit potential and competing for market share. Still, profit is usually good for the industry and for individual firms. More precisely, it is improving profit margins that attract competitors.

As a result of product differentiation, product modification is widespread with competitors adding innovative features to the existing product technology. Brand loyalty starts to develop.

The fierce competition means survival of the fittest - a few strong companies which move the product into the third stage.

2.1.3 Maturation Stage

As the product reaches this stage, it is characterised by stability in industry sales volume, the number of competitors, production and marketing costs, profit, etc. Low-income consumers are the new target at this stage. Industry sales, however, are determined in part by economic conditions, because most consumers would have purchased the product and any replacement could be postponed should economic conditions not favour a replacement sale.

Product styles are changed often in order to encourage replacement demand. Automobiles are good examples.

Competition is stable with very few firms entering or leaving the industry. Therefore, large sales volumes, strong brand loyalty, an established distribution network, and a full product line are the main entry barriers at this stage.

2.1.4 Decline Stage

The final stage is also known as product obsolescence. At this stage, sales decrease, trade-in activity (the purchase of a new product with an old one), parts and service, purchasing and brand loyalty all decline. Markets tend to be small and specialized justifying only the existence of a few firms. Product modification activity declines, while production costs will increase because of the lack of volume and the loss of economies of scale. Marketing costs are likely to decline for the lack of competition and the unnecessary use of mass media. Profit is small and reasonable for the remaining firms resulting from a shallow product line, few parts and inventories, lack of competition, fewer retail outlets, brand loyalty in laggards, and inelastic demand.

2.1.5 Theoretical Support of the PLC Concept

Two underlying causes exist for the variations of product sales behaviour during the cycle, instability of demand and instability of supply (competitive position), which are explained by two important theories - the diffusion process of innovation theory and the theory of monopolistic competition which form the theoretical rationale for the PLC concept.

Diffusion theory (Rogers, 1962) explains the adoption of new products and services over time by consumers. At first, a few people (innovators) purchase the product. If the product is successful, more buyers (early adopters) will come into the market, causing a rapid growth in sales in the first half of the growth stage. A large number of buyers (early majority) will follow, explaining the increase in the second half of the same growth stage. Interaction and imitation among consumers cause more people to follow early buyers in purchasing the product. The sales in the maturation stage become relatively stable with the support of the next group (late majority) before declining and attracting the last group of buyers (laggards) in the decline stage.

The theory of monopolistic competition (Chamberlin, 1965) also contributes to the explanation for the behaviour of products in the product life cycle. Monopolistic competition is a market structure in which there are many firms selling products which are close, but

not perfect, substitutes for each other. Because of the lack of market entry barriers, market prosperity will quickly attract new competitors. To compete, both the established and the new firms tend to use product differentiation to gain strategic advantage. The product's psychological function is thus as important as its engineering aspects. But when the market declines, many competitors will hastily exit. Therefore, the theory of monopolistic competition provides a rationale for the variation in the number of firms and their behaviour in the different stages of the PLC.

There is also empirical evidence supporting the PLC theory. Thorelli and Burnett (1981) found in their study that the time span from rapid growth to maturity is more than 40 years for many industrial products. But for most product types, the duration of the life cycle is becoming shorter due to the increasing pace of technological innovation and the rapid rate of new product introduction (Qualls et al., 1981): Jensen (1982) studied products which were introduced in the early 1970s and were sold for at least five years. The PLC curves were drafted for more than 70 products in 20 categories and were found to exist for more than 80 per cent of the products investigated. Jensen did not indicate the duration of the life cycles for the products he studied.

2.2 THE PRODUCT LIFE CYCLE THEORY AND INTERNATIONAL TRADE

2.2.1 The International PLC and the Trading Behaviour of Developed Countries

2.2.1.1 An overview of international PLC model

There are a number of theories which attempt to explain international trade, such as Ricardo's comparative advantage, Heckscher-Ohlin's factor proportions theory, human skills models (Leontief, 1953), scale economy (Dreze, 1960), technological gap models (Kravis, 1956), and demand similarity models (Linder, 1961).

A major handicap of the neoclassical theories of international trade is the assumption that technology is unchanging and is equally available to all countries. To remedy this deficiency, the international PLC theory set out to explain trading behaviour in manufacturing industries where these assumptions are least applicable - industries in which technological innovation plays an important part in industrial competition and the location of comparative advantage.

Hirsch (1965) and Vernon (1966) incorporated and developed the international PLC theory to explain the international trading of manufactured goods. They argued that the location of production depended not so much on the extent to which competitors succeeded

in imitating a new product as on the characteristics of production associated with the product at the different stages of its "lifetime". At the stages of introduction and growth, new products typically require frequent or major changes in order to correct imperfections in technique, design, etc. Communication with consumers is extremely important. Therefore, production will be most efficient if it is located close to the market. While in the maturation and decline stage, product changes are much less frequent and production technique is standardized. Cost considerations are more important in determining the location of production. It does not have to be necessarily close to the market.

The international PLC model (see Figure 2, p. 12) as stated by Keegan (p. 266, 1980) suggests that "many products go through a cycle during which high-income mass-consumption countries are initially exporters, then lose their exporting markets, and finally become importers of the products. At the same time, other advanced countries shift from the position of importers to exporters later in time, and still later, developing countries shift from being importers to being exporters of a product. These shifts correspond to the three stages in the product life cycle - introduction, growth and maturity, and decline."

FIGURE 2 International trade and production in the product cycle

Source: Raymond Vernon and Louis T. Wells, Jr. *Manager in the International Economy*. Englewood Cliffs, New Jersey: Prentice-Hall, 1986.

There are several basic elements underlying the international PLC model, such as technology, income level, economies of scale, country market, etc. New and growth products are normally characterised as having high technology inputs, inelasticity of demand, closeness to a big market and a certain economy of scale. As products mature, production techniques become relatively stable, demand becomes more price-elastic, requirements for certain economies of scale may become less stringent as production costs go down, and the location of production may not be close to the market.

2.2.1.2 Technology inputs and income level

Firms in developed countries develop new products in order to meet domestic market characteristics: such as, the consumer's desire for convenience and the needs of a mass market with high income.

The international PLC theory was developed primarily with a view to explaining U.S. trading behaviour. According to Vernon (1979), the U.S. is a fertile land for innovations for two reasons: the high income level, which generates demand for a variety of sophisticated goods, and generates the probability of a market for certain new consumer goods; and the scarcity of labour and abundance of capital which creates a continuous demand for

innovations that substitute capital for labour. These conditions led to the introduction of a wide range of rather specialized products in the U.S. market, such as mass-produced automobiles and sewing machines 60 to 100 years ago, and in recent years, audio-visual equipment, automatic controls, and other products that appealed to high-income consumers or conserved labour.

Most authors (e.g., Hirsch, 1970, 1972; Wells, 1972) extend the argument of U.S. advantage beyond high income and labour-saving products to a claim that the U.S. will lead in a majority of new products for two reasons. One reason follows the assumption that new products appeal more to higher income customers initially than they will later. Thus, new products which might later have a market elsewhere will face a better chance of initial success in the U.S.. Another reason is that the majority of new products are products which are developed for high income buyers.

Empirical tests of the elements of this theory are abundant. Gruber and Vernon (1970) showed that the U.S. export strength is in industries which are associated with high research effort. These industries, they argued, are the ones with a high rate of new product development. Hirsch (1965) demonstrated for the electronics industry that the U.S. export advantages are in the growth sectors of the industry. Stobaugh (1972) demonstrated similar results for petrochemicals. Wells (1972) showed that U.S. exports have grown more rapidly in consumer durables that had a high income elasticity

of demand than in those which were less income-elastic. Hufbauer (1966) found that advanced countries specialized in the export of differentiated products. Consistent with these findings were those of Houthakker and Magee (1969) that the manufactured exports of the U.S. were less price-elastic than the imported manufactures.

Many researchers have found that the level of R & D expenditures has usually been highly correlated with strong export performance (Balassa, 1977; Baldwin, 1971). In some cases, R & D expenditures have been considered the most important variable in explaining the export performance of various industries (Lowinger, 1975; Stryker, 1968).

2.2.1.3 Economies of scale and country market

Hirsch (1967), in his pioneering work on the international PLC and international trade, examined the problem of producing a nonstandardized product far from the market. He found that marketing requirements were critical in determining why optical crystals were produced in the U.S., close to the market, rather than in Israel, where scientific personnel are relatively cheaper.

Hufbauer (1966) found that the size of home market and economies of scale correlate positively with the export of synthetic materials. Stobaugh (1972) concluded that production of

petrochemicals is first located in a country with a large domestic market for three reasons: close communication between the plant and customers is required; the producer does not want to depend on the export market for a large share of plant output; and the relatively low price elasticity of demand.

2.2.1.4 Tariffs and transportation cost

Tariffs and transportation costs are of great importance in exporting products. Wells (1972) demonstrated that the percentage of exports to shipments of total production is positively correlated with the value per unit weight, and transportation costs are significant in determining the export volume of U.S. consumer durables. He further claimed that foreign production of a product should start early if foreign tariffs and transport costs are high.

2.2.1.5 "Middle Countries"

In the third phase of the cycle, exports from the originating country to nonproducing countries begin to be replaced by exports from other advanced nations. Major markets overseas reach sufficient size that manufacturers do not suffer the high costs associated with small scale. The capital costs for such firms may be no more than those for innovating firms - in fact, the producing

unit may be a subsidiary of the innovating firm. Faced with lower labour costs, but the same transportation and tariff charges, these firms take away markets in third countries that were previously supplied from the originating nation.

The role of "middle countries" in the international product life cycle has been studied by Tsurumi (1972), Mousouris (1970), and Hirsch (1970), who looked at the trade patterns of Japan, Greece, and Israel. These countries typically export products that are in earlier stages of the international product life cycle to countries which are less developed and products which are later in the cycle to more advanced countries.

2.2.1.6 The international PLC: a dynamic process

For developed countries, when their markets are lost in some areas, new ones are being established. Either the innovating country will build on its early lead in a product line by bringing out second or third generation products and related items, or continuing research and development will lead to new products and export possibilities in an unrelated area (Lipsey, 1972; Walker, 1979). The export mix of developed countries will thus consist of declining shares in old product markets and expanding new markets for products with high technology inputs (Adler, 1970; Ozawa, 1968).

2.2.1.7 Recent empirical tests

Hoy and Shaw (1981) attributed the decline of the U.S. share of world trade from 1960 to 1975 to the de-emphasis and decline of research and development. At the same time Japan and Germany increased R & D expenditures and consequently increased or maintained their share in both high technology manufactured exports and world trade. They further claim that new products and technology in pioneering R & D can contribute substantially to a positive balance of trade. Their findings support one aspect of the international PLC theory as new and growth products normally have high R & D contents. The U.S. can no longer dominate as the new product initiator. Other developed countries, such as Japan and Germany, are also becoming important innovators. Therefore, the original international PLC model needs to be modified.

Mullor-Sebastian (1983) empirically tested the PLC theory based on U.S. trade data from 1970 to 1974. With world production data from 1965 to 1973, products belonging in six industrial groups (chemicals; metal products, machinery & equipment; iron and steel industries; wood and cork products; manufacture of non-metallic mineral products; and textiles) were classified into growth and mature categories. Mullor-Sebastian (1983) then did three tests to measure the correlation between growth rates of production and trade balances of the six industrial groups and the competitiveness

of the industries. Her findings strongly indicate that industrial groups behave in the manner predicted by the international PLC theory on the world market. In the case of individual products, her results provided less support for the theory. The findings also offered the policy implication that economic development should target industrial sectors rather than individual commodities.

Lutz and Green (1983) analyzed the performance of manufactured trade for the U.S., Japan, West Germany and the UK with export data for 73 technology-intensive manufacturing goods and 83 nontechnology-intensive ones from 1963 to 1974 and found that the international PLC theory has at least explanatory relevance for three out of the four countries.

However, marked deviations from international PLC predictions were found by Ayal (1981). He collected trade statistics for 65 industries of manufactured goods for 1971 and 1975 for Israel, the U.S., the European Community, and other regions of the world. According to the international PLC model, a country like Israel can achieve export success only after the U.S. initial advantage has eroded. However, he found that successful Israel export performance frequently coincided with successful U.S. export and a narrow range of specialization is an important determinant of such success.

2.2.2 The International PLC and the Trading Behaviour of Developing Countries

A further phase of the international PLC has been hypothesized in which developing countries become exporters of mature products (De La Torre, 1972; Wortzel, 1981; Kaynak and Gurol, 1987).

In the original international PLC model, at the stage of introduction, all the activities involving the development, manufacture and marketing of a new product occur in developed countries. As production grows, the financially privileged class in developing countries may demand the product thus inducing imports from DCs. The technology of the product will gradually become mature, the product will become more standardised, mass production and distribution will considerably lower the costs of the product and make it more affordable. When the markets in developing countries are big enough, local manufacturing will come into place. Coupled with the low cost of labour, at the mature stage, developing countries will export the mature product to developed countries.

Lary (1968) contended that developing countries have little accumulated capital or technical skill and their competitive advantages in manufacturing exports are likely to be in industries of mature products which are more intensive in labour and less in capital.

As identified by Wortzel (1981), the manufactured exports from developing countries and newly industrialized countries (NICs) are mature products such as industrial electronic products and mature consumer products, which is in line with the prediction of the international PLC theory.

Applying the international PLC concept to the manufactured exports of Mexico, Colombia and Nicaragua, De La Torre (1972) showed that these developing countries tend to export products which were late in the international product life cycle. Where marketing expertise was required, the exports usually involved a foreign firm; where marketing techniques were less important, local firms could manage their exports without resorting to multinational corporations.

De La Torre (1973) studied the international PLC to anticipate trends in international competitiveness necessitating strategic adjustment in marketing and logistics. He proposed a framework as an aid to international executives in evaluating a product's performance over time. Having some concept of future trends in relative competitiveness, the firm can anticipate any changes in strategy necessary to reduce its exposure to changing trade patterns.

The movement of the international product cycle is characterised by various changes, such as, marketing conditions, changes in product and process technology, production processes, relative capital and labour intensity, industrial structure, etc. It is of vital importance for developing countries to recognize these changes and make full use of them in the process of economic development (Kaynak and Gurol, 1987).

Kaynak and Gurol (1987) explored the prospect of planning Turkish export marketing according to the international PLC and the Japanese experience in exporting, and developed an export marketing model for Turkey. In doing so, they suggested that Turkey could use its cheap labour as a competitive advantage and become a producer of many of the mature products in the European Community.

According to Vernon (1979), most developing countries are still in the process of absorbing the innovations of other countries introduced earlier, following patterns predicted by the international PLC theory. However, the performance of firms in some developing countries follows the product cycle in a very different sense. Firms operating in the more rapidly industrializing countries - such as Mexico, India and Brazil - are demonstrating a considerable capability for producing innovations that respond to the special conditions of their own economies. Once they have responded to those special conditions with a new product or process, firms of that sort are in a position to initiate their own

cycle of export and eventual direct investment. Their target will likely be the markets of the other developing countries that are lagging behind them in economic development (Vernon, 1979).

Since the 1970s, firms based in developing countries have been reported to be developing products and processes of special importance to other developing countries, to be followed eventually by the creation of producing subsidiaries in those countries. However, the foreign subsidiaries of these firms often maintain their position through oligopolistic strengths rather than a technological lead (Wells, 1977, 1978).

2.2.3 Technological Gap Theory and International PLC

Kravis (1956) and Williams (1954) put forth a number of the ideas that were later to appear in product life cycle explanations. These authors, and Posner (1961), Freeman (1963), and Hufbauer (1966), are often credited with the technological gap explanation of trade flows.

Kravis (1956) stressed the advantages to the innovating country which came from the possession of the newest products as opposed to advantages accruing from lower costs. The authors who stress a technological gap explanation assume that technology is not a free good and that a time period elapses before other countries obtain

good and that a time period elapses before other countries obtain the know-how. Kravis described something similar to the product cycle, where the U.S. may eventually become an importer.

Posner (1961) built on these early works and introduced explicitly the concept of "imitation lags". He divided the lag into two components - the demand lag and the reaction lag. The demand lag arises from the fact that new foreign goods may not be regarded as a perfect substitute for domestic goods. The reaction lag is the time between the production of a new product abroad and the time when a potential producer in the local market views the foreigner as a likely competitor to whom he should react with local production. The difference between these two lags gives rise to the possibility of international trade. The earlier manufacturer might export the product to the country in which the demand lag is shorter than the reaction lag.

The empirical findings of the proponents of the technological gap models are consistent with the PLC approach (Wells, 1972). Missing from the gap models is an explanation as to why certain countries will lead in specific technologies. Still, the empirical work of the gap proponents provides important support for the usefulness of the PLC in explaining international trade in manufactures (Wells, 1972). A country with innovative technology can produce the new product for its domestic market and then the world market. The imitation lag existing in other countries also

allows the originating country to export the new product. As time goes by, the technology will grow more stabilized and the markets overseas will become larger. The technological gap between the originating country and other countries will diminish and eventually disappear, local production will take place for domestic markets and then for export.

2.2.4 Criticism of the International PLC Model

Many researchers have challenged the relevance of the international PLC model as an explanation for changes in manufactured trade.

Leroy (1976) and Vernon (1971) suggested that a learning curve exists for U.S. multinationals, resulting in production decisions that bypass some or most steps in the cycle. Defining products based on technology using R & D content data in a product, rather than an industry definition as used in trade data, Leroy did not observe cases where a product initially exported from the U.S. was imported back by the same firm toward the end of its cycle. He suggests that the international PLC may be present in the aggregate without being observable for individual products. He concluded that the international PLC may have limited relevance for the description of innovation diffusion paths of products inside multinational firms.

The presence of international oligopolies or other barriers to entry created by existing firms can also limit the operation of the international PLC (Giddy, 1978). The international manufacturing and marketing of many products follows different patterns, particularly when large multinational firms with developed global scanning capacities for sourcing and marketing are involved. New products are sometimes introduced abroad almost at the same time as at home. While other products, such as processed foods and toiletries, continue to be in the domain of multinational firms' production and marketing around the world long after they have reached the maturity. Giddy claimed that a more general theory (the industrial organization approach) is needed to explain how large multinationals cope with barriers to entry in world markets.

The importance of raw material inputs can be a critical determinant in the international product cycle. Stobaugh (1972) indicated that for petrochemicals low-cost raw materials rather than low-cost labour will be an important factor affecting trade, and that countries with low-cost raw materials will become exporters of petrochemicals to countries with high-cost raw materials, regardless of the sizes of the respective markets of the two countries.

In the past, when most industries in a country were at the same production stage, government activities could more easily influence the impacts of the cycle by domestic actions. Today such government

activities are variable, depending upon the relative political strengths of the industries at various stages of the cycle, because those in the early stages will have distinctly different demands than those in the latter stages. The outcome of the resulting domestic political conflicts will determine to what extent government intervention such as tariffs, quotas, and subsidies will occur in attempts to retard the impacts of changing production patterns (Kurth, 1979).

The international product cycle is also determined by the marketing expertise and the willingness to pursue export markets aggressively which vary from country to country. Brand name preferences (e.g. Coca-Cola) will also have an impact on export shares (Lutz & Green, 1983).

As an alternative to the international PLC concept, some researchers (Shanklin & Ryans, 1987) have proposed the technological life cycle (TLC). The TLC focuses on the sale of technology rather than on the sale of the product. The TLC curve represents the product and/or process performance of some technologies extending from the time of their inception to the time of their removal.

For a graphic presentation, please refer to Figure 3 - Technology Life Cycles (p. 28). In this figure, the horizontal axis refers to the units of efforts that have been spent on a technology

Managing High-Tech Products

Figure 3 Technology Life Cycles

Source: William L. Shanklin and John K. Ryans, Jr.
Essentials of Marketing High Technology.
Lexington, Mass.: Lexington Books, 1984.

to date, such as the total R&D person-years or dollars spent. The vertical axis designates the most crucial measure of a product's performance. Technology A starts out slowly, then with more and more R&D efforts, it performs much better, and finally plateaus as the technology reaches its limit. Technology B starts out at a performance far above the Technology A's origin. The two technologies compete for a while (the overlapping part of their s-curves), until the superior Technology B finally succeeds and captures the market (Shanklin & Ryans, 1987). The TLC theory focuses on the life cycles of some technologies as measured by their products' performances, while PLC theory studies the life cycles of some products based on the sales volume.

Naturally, the TLC concept applies particularly well to the marketing of high-tech industries. Industry executives can make strategic management decisions with close monitoring of the technology life cycle. The deficiency with the TLC is its narrow focus on high-tech marketing. The TLC concept has not yet been extended to the explanation of international trading patterns.

Nevertheless, the TLC concept does not completely reject the validity of the PLC concept. The PLC concept can be of strategic value to high-tech executives. Products do experience life cycle evolution from introduction to obsolescence and managers need to be alert to the general signs. The product life cycle concept of

market evolution is fundamental to the formulation of sound marketing strategy.

From the above analysis, it can be seen that the international PLC model does not have full explanatory power for manufactured products in the export mix of all countries. However, the international PLC theory has had abundant empirical support from its inception to recent time. Even though there are alternative explanations for the international trade of manufactured goods, none of them have been tested for developing countries. Therefore, the international PLC theory, still a valid concept, may provide a partial explanation for shifting patterns of exports of manufactured goods for both developed and developing countries.

2.2.5 Summary

The international PLC theory has contributed to the international trade literature by facilitating the understanding of the trade patterns of manufactured goods. The competitiveness and commodity composition of international trade in the manufacturing sector can be better appreciated with the concept of the international product life cycle.

However, the international PLC was developed in the historical context of the late 1960s and 1970s. Dramatic changes in the

international economy, especially the phenomenon of multinational companies (MNCs), free trade zones in many countries and multinational free-trade agreements, e.g., the North American Free Trade Agreement (NAFTA) and the European Union (EU), have posed challenges for the international PLC theory. As a result, the enthusiasm for the international PLC has decreased steadily.

Despite this decline, the international PLC is a fundamental concept and is still frequently employed in various contexts. When viewed in terms of the initial price inelasticity of demand for a new product and the evolution of competition and barriers to entry that follow market growth, the PLC maintains its validity in domestic and international business. The PLC may also be regarded as a strategic business concept, a tendency of international business that can be anticipated and acted upon by alert international product managers.

To achieve better economic growth, developing countries must give relatively high priority to the development of manufactured exports. The disadvantages of dependency upon primary products for export earnings, the limitations of reliance on import substitution as the main vehicle for industrialization, and the constraints which inefficient foreign exchange impose on promoting viable economic growth are the most frequently cited evidence of this need (De La Torre, 1972).

As developing countries are most frequently characterised by an abundance of labour and a lack of capital and technology, the international PLC theory predicts that developing countries will be internationally competitive in the production and export of standardised products. Therefore, this theory suggests that if developing countries can concentrate on mature manufactured products, they may achieve better economic development. For that purpose, it is further inferred that developing countries should adopt policy reforms to diversify the composition of their export from mainly primary products and commodities to mature manufactured products.

3. RESEARCH PROBLEM

Two hypotheses are identified:

Ho.1.: The trade balance of manufactured products for developing countries is inversely correlated with the world growth rate of production of the corresponding products: i.e., the trade balance will be low or negative if the world growth rate of production of the products is high; and high or positive if the growth rate of the products is low or in decline.

This hypothesis is based on the PLC theory. As developing countries are abundant in labour, poor in capital, and low in income, they are unlikely to have a market for the high-priced, labour-saving products which are normally at the growth stage of the international PLC and feature a high growth rate of production. When the product reaches the mature stage and the growth rate of production becomes lower or even negative, it has become much more standardised making it feasible for developing countries to manufacture it for their domestic market and eventually to export the product to other countries. Therefore, the bulk of manufactured exports from developing countries will be standardised mature products which are internationally competitive. A positive trade balance should occur for mature products characterised by a low growth rate of production. However, when it comes to growth products, the international PLC predicts that developing countries

will lack the capability to manufacture them and will have to import them for consumption. Consequently, a negative trade balance is expected for growth products which have high growth rates of production.

Ho.2.: The difference in the trade balances of comparable manufactured goods for developing countries will be a result of different levels of economic development: i.e., relatively more industrialized developing countries will have a better performance in their trade balance as they command more and better manufacturing capacities and expertise and can move into the growth stage of the international PLC for certain products at an earlier time than would be predicted by the international PLC.

Domestic economic development and foreign direct investment (FDI) have become major issues for developing countries especially since the 1980s. Development and FDI have changed developing countries in fundamental ways. With the transfer of technology, know-how and capital goods, a few more advanced developing countries may speed up the product process to be in a position to manufacture and export products at growth stage. Again, according to the international PLC theory, technology, income level, scale economy, etc, determine what nature of products a country may manufacture. The differences in the level of development for developing countries are manifested in a number of ways. For the more developed developing countries, their higher income level,

better command of technology and more skillful labour will prompt the production of growth products at an earlier time than for less developed ones. As a result, the more developed developing countries may show a better trade balance in certain growth products than the less developed ones.

4. DATA COLLECTION AND TIME FRAME

4.1 DATA COLLECTION

Based on 6-digit SITC trade statistics for six industrial product groups for the U.S., Mullor-Sebastian (1983) conducted three empirical tests of the international PLC theory. Her findings were that industrial product groups, not individual products, behave as predicted by the international PLC theory.

The present test will simulate Mullor-Sebastian's for developing countries to see whether her findings can be validated in the different context.

Ideally, a test of the international PLC should examine international trade patterns for individual products. However, data at this level are generally not available. Therefore, the test was conducted at the industry level where Mullor-Sebastian (1983) found the most convincing and stable results in her study.

Statistics of international trade and world industrial production for the sample countries were collected for five manufacturing industries. The growth rate of world production for each industry from 1981 to 1990 was the basis for the maturity ranking of products, using data from the United Nation's

International Industrial Statistics Yearbook (1990). According to the maturity ranking and available statistics, a range of industrial product groups was selected as representative of mature and growth products. (Please refer to Table 1 "Index Numbers of Industrial Production" for details.) Trade statistics for products within the five industrial categories (Textiles; Chemicals, Petroleum and Plastic Products; Basic Metal Industries; Electrical Machinery; and Transport Equipment as listed in Table 2) were obtained from the UN's International Trade Statistics Yearbook (1991), using the 3-digit Standard International Trade Statistics Classification (SITC) categories which are the data available at the lowest level of aggregation.

Unfortunately, the tests for the selected developing countries can't be done with 6-digit SITC statistics which were used by Mullor-Sebastian (1983). There are simply not sufficient 6-digit trade data available for this kind of study on developing countries. On the other hand, Mullor-Sebastian (1983) did find that industrial groups behave more in line with the prediction of international PLC theory than individual products.

Most of the previous research has been conducted using 2- or 3-digit SITC categories, among them, Vernon et al. (1970) based their study of the R&D factor in U.S. trade and investment on 2- and 3-digit SITC data; Tsurumi (1972) studied the manufactured exports of Japan on 3-digit data.

Table 1

A. INDEX NUMBERS OF INDUSTRIAL PRODUCTION

WORLD ^{a/}

1980=100

ISIC	BRANCH OF ACTIVITY	% WEIGHT (1980)	1978	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Annual growth rate (78-90)
210	Coal mining.....	1.9	94	97	100	102	101	101	106	107	107	108	107	98	0.4
220	Crude petroleum and natural gas.....	11.3	104	108	89	81	80	83	80	83	83	88	93	93	-0.9
230	Metal ore mining.....	1.3	98	100	100	97	98	104	108	108	113	122	129	138	2.8
290	Other mining.....	1.2	96	100	100	93	96	103	104	107	113	121	126	126	2.3
2	Mining and quarrying.....	15.7	102	106	92	86	85	88	87	90	91	96	100	100	-0.2
31	Food, beverages and tobacco.....	10.7	95	98	102	104	106	110	111	113	116	120	124	127	2.4
321	Textiles.....	4.4	97	100	99	97	99	100	103	106	108	110	112	107	0.8
322-324	Wearing apparel, leather and footwear....	3.4	98	100	100	98	99	102	102	103	104	106	106	103	0.4
33	Wood products and furniture.....	3.2	101	104	98	94	99	104	104	108	114	118	122	120	1.4
34	Paper, printing and publishing.....	4.9	94	98	100	100	104	111	114	120	127	134	138	142	3.5
341	Paper and paper products.....	2.2	94	98	100	98	104	111	112	118	125	131	138	138	3.3
35	Chemical, petroleum, plastic products..	11.2	96	101	101	99	101	111	114	119	126	134	138	138	3.1
353-354	Petroleum and coal products.....	2.1	100	103	98	97	99	105	104	110	116	125	128	130	2.2
355-356	Rubber and plastic products.....	2.4	96	101	99	98	104	112	116	121	128	138	142	139	3.1
36	Non-metallic mineral products.....	3.5	97	100	98	94	97	101	102	105	108	114	118	118	1.6
37	Basic metal industries.....	6.0	100	104	99	89	92	99	100	99	103	111	113	112	1.0
38	Metal products, machinery and equipment	29.1	94	98	102	99	102	112	118	123	128	137	144	144	3.6
383	Electrical machinery.....	6.1	90	96	103	104	113	130	135	140	149	162	170	170	5.4
384	Transport equipment.....	6.8	99	102	102	99	102	108	114	119	122	130	136	137	2.6
31-33, 342 355-56, 39	Light manufacturing	28.2	96	100	100	99	102	106	108	111	115	119	123	122	2.0
341, 351-54 36-38	Heavy manufacturing.....	49.6	95	100	101	98	101	110	114	118	123	131	137	137	3.1
3	Manufacturing.....	77.8	96	100	101	98	102	108	112	115	120	127	132	132	2.7
4	Electricity, gas and water	6.5	93	97	102	103	108	113	118	120	125	130	135	139	3.4
2-4	ALL INDUSTRY.....	100.0	96	100	99	97	99	105	108	112	116	122	127	127	2.4

^{a/} Excluding Albania, China, Democratic People's Republic of Korea and Viet Nam

Source: Department of economic and social development, Statistics Office.
Industrial Statistics Yearbook. New York, United Nations. 641.
1991.

Table 2 List of Industrial Categories and Products

SITC CODE	PRODUCT DISCRIPTION
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TEXTILE

651	Textile Yarn
652	Cotton fabrics, woven
653	Woven man-made fibre fabrics
655	Knitted, etc fabrics
657	Special textile fabric
659	Floor covering, etc

BASIC METAL INDUSTRY

671	Pig iron, etc
672	Iron, steel primary forms
673	Iron, steel shapes etc
674	Iron, steel, univ, plate, sheet
675	Iron, steel, hoop, strip
684	Aluminium

CHEMICAL, PETROLEUM, PLASTIC PRODUCTS

334	Petroleum products, refined
511	Hydrocarbons
512	Alcohols, phenols, etc
513	Carboxylic acids, etc
514	Nitrogen-functioned compounds
582	Products of condensation
598	Miscellaneous chemical products

ELECTRICAL MACHINERY

764	Telecom equipments, parts
771	Electric power machinery
772	Switchgear, etc
776	Transistors, valves, etc
778	Electrical machinery
898	Musical instruments, parts

TRANSPORT EQUIPMENT

781	Passenger motor vehicles (excluding buses)
784	Motor vehicle parts
785	Cycles, etc
791	Railway vehicles
792	Aircrafts, etc
793	Ships and boats

4.2 TIME FRAME

Trade and production statistics from 1982 to 1991 were used in the test. Ten years should be sufficient to observe the change in the pattern of international trade. Previous research has usually been conducted over a much shorter time span: for example, Hirsch (1972) examined only 5 years in his study of the trade performance of the American electronics industry. Mullor-Sebastian also used 5 year trade statistics (from 1970 to 1974) for her study.

5. COUNTRIES INCLUDED

China, India, Indonesia, Malaysia and Mexico are included in this study. All five of these countries have been vigorously pursuing economic development, adopting different industrial policies, and have achieved different results.

The five countries were selected for the following reasons: 1) they are developing countries located in two different continents with different levels of economic performance; 2) sufficient trade statistics are available, while for most other developing countries, trade statistics are unfortunately inadequate making their inclusion into the present study difficult.

These developing countries have gone through different paths of development. The import substitution theory, popular especially in the 1960s and the 1970s, greatly influenced the industrial policies of many developing countries. Most of the countries in this study adopted import substitution policies in the past.

India and Mexico have been among the most enthusiastic practitioners of import substitution until recently. High levels of protection for domestic industries have prompted the development of national economies at the cost of reduced competitiveness in international trade and investment. Recent economic liberalization in the two countries has indicated good prospects for their

economies. In the case of Mexico, the initiation of NAFTA will further open its economy.

Malaysia and Indonesia are resource-rich especially in oil, metals and timber. Following their independence after the Second World War, they developed their economies, relying heavily on the export of raw materials which are subject to unpredictable price fluctuations in the world market. Since the late 1970s, they have adopted an export-promotion regime emulating the success of the East Asian NICs.

China, a central-planning economy, isolated itself from the rest of the world and practised a self-sufficiency economy until the late 1970s. Since then, however, China has been actively pursuing economic reform, encouraging international trade and investment. The result has been spectacular with economic growth averaging more than 10% annually. It should be noted, however, that available trade data for China covers only five years from 1987 to 1991. As a result of internal political turmoil before the 1980s, different standards of statistics were used by China and the UN statistical office.

These countries have gone through a similar path of development in their adoption of an import-substitution regime and all have started policies of economic liberalization, though differences abound in terms of the magnitude of the changes, their timing and

the results achieved so far.

It is clear that differences in development exist for the five countries as evidenced in Table 3 - Country Profiles (p. 44), but all five countries exhibit growing importance in today's world economy. Studies of the international PLC incorporating countries with varied levels of economic development will make the findings more generalizeable. These factors make this study interesting and meaningful. However, because of these country-based differences, even though they are all developing countries, the predictions of the international PLC may not be consistent for all of them.

Table 3

Profiles: China, India, Indonesia, Malaysia and Mexico 1991

Country	Population (millions)	Area (1,000 km²)	GNP per capita (US Dollars)	Manufactured export as % of total export
China	1150	9561	370	85.4
India	866	3288	330	66.1
Indonesia	181	1905	610	51.7
Malaysia	18	330	2520	71.4
Mexico	83	1958	3030	54.1

**Source: Social Indicators of Development 1993
The World Bank. The Johns Hopkins University Press,
Baltimore, 1993.**

6. METHODOLOGY

With some modifications, the methods used in Mullor-Sebastian's (1983) study were employed in the present tests.

6.1 CORRELATION BETWEEN MATURITY AND TRADE BALANCE

A correlation between the growth rate of world production and the trade balance of the corresponding commodity in each industrial category was computed to measure the relationship between the product maturity of commodities and the strength of their trade balance for that country. This test was applied for each of the five countries which are at different levels of economic development. If Hypothesis #1 is right or fails to be rejected, then the growth rate of world production should be negatively correlated with average trade balance of the developing countries.

In her tests, Mullor-Sebastian (1983) used Spearman rank correlations to establish a possible linkage between growth and trade balance for the U.S.. However, she provided no rationale for using this statistic. Given the interval scale data, it seems more appropriate to use a conventional product-moment statistic.

6.2 COMPETITIVENESS MEASUREMENT

In order to examine the relationship between growth rate and trade balance from another perspective, the median trade balance for each industrial group was calculated as a percentage of exports as a measure of competitiveness. The trade balance was computed as a percentage of exports for each commodity for each country in order to measure competitiveness. This method was also used in Mullor-Sebastian's (1983) test. The median of those percentages was then computed for each industrial group in order to compare the competitive strength of the various industrial groups.

If developing countries are internationally competitive in mature products which are characterised by a low growth rate of production, they should show positive trade balances in mature products and negative balances in growth products. Therefore, the highest median trade balance should correspond to the industrial group with the lowest median growth rate indicating where their competitive strength is the strongest. However, it is also expected that there may be variations in the outcome as a result of the different level of economic sophistication of these five countries.

The Kruskal-Wallis one-way analysis of variance by ranks was also used to measure the industrial competitiveness of the five countries and to test the second hypothesis. Tests were run, one on the ranks of the countries in terms of the trade balance for each

industrial group, and another on the ranks of the countries in terms of the trade balance as a percentage of export for each industrial group. If there is little variance in these two tests, then it may not support the hypothesis.

7. DATA ANALYSIS AND RESULTS

7.1 WORLD PRODUCTION AND TRADE STATISTICS

Trade statistics - more specifically, data for six industrial categories at the 3-digit SITC level for four industrial group (textiles, basic metal industry, transport equipment and electrical machinery) and data for seven industrial categories for the chemical, petroleum and plastic products industry - for all five countries from UN International Trade Statistics Yearbook (1991) were collected to be used in the tests. The results are shown in Tables 4.1 - 4.5 (p. 49 - p. 53) on which the following tests are based. World production changes from 1981 to 1990 for commodities under the six industrial groups (textiles; basic metal industry; chemical, petroleum, plastic products; electrical machinery; transport equipment) are listed in column 1 of Tables 4.1 - 4.5. Column 2 of Tables 4.1 to 4.5 gives the average trade balance for China (from 1987 to 1991) India, Indonesia, Malaysia and Mexico (all from 1982 to 1991). The average trade balance as a percentage of exports for all five countries appears in column 3 of table 4.1 to 4.5.

TABLE 4.1
World Production and China Trade of Selected Commodities
(in thousands of U.S. Dollars)

	World Production Changes (in %) 1981-1990	China Average Trade Balance 1987-1991	China Average Trade Balance as % of Export
TEXTILES			
Cotton fabrics,woven	43	-1401817	-15.6%
Knitted,etc fabric	27	777939	58.5%
Woven man-made fibre fabrics	26	1202020	23.4%
Special textile fabric	22	-1782117	-418.4%
Floor covering,etc	17	2098703	94.4%
Textile yarn	-12	2457143	40.8%
BASIC METAL INDUSTRY			
Aluminium	23	-1180494	-156.2%
Iron,steel primary forms	17	13617	3.8%
Iron,steel,univ,plate,sheet	17	-10358032	-1937.0%
Pig iron,etc	11	1190521	63.0%
Iron,steel shapes etc	1	-2509958	-234.6%
Iron,steel,hoop,strip	-2	-426255	-650.6%
CHEMICAL, PETROLEUM, PLASTIC PRODUCTS			
Hydrocarbons	246	-942717	-403.8%
Carboxylic acids,etc	52	-1182762	-173.0%
Nitrogen-functioned compounds	44	-866882	-173.0%
Miscellaneous chemical products	36	-456474	-59.6%
Alcohols,phenols,etc	17	-542135	-85.8%
Products of condensation	15	-1817008	-2583.9%
Petroleum products,refined	9	554565	14.2%
ELECTRICAL MACHINERY			
Electric power machinery	128	-469642	-102.7%
Telecomequipments,parts	103	-5716131	-287.4%
Switchgear,etc	94	-761682	-115.4%
Transistors,valves,etc	59	-3826143	-855.9%
Electrical machinery	25	-350584	-24.8%
Musical instruments,parts	-22	28510	4.0%
TRANSPORT EQUIPMENT			
Motor vehicle parts	52	-1366144	-9.8%
Passenger motor vehicles	47	-2220074	-7748.7%
Cycles,etc	1	513427	52.2%
Railway vehicles	-5	-1647814	-2237.4%
Ships and boats	-34	-714881	-70.6%
Aircraft,etc	-76	-3750686	-4030.9%

Sources: International Trade Statistics Yearbook (New York: Statistical Office of the U.N. , 1991 and 1987) and International Industrial Statistics Yearbook (New York: Statistical Office of the U.N., 1991).

TABLE 4.2
World Production and India Trade of Selected Commodities
(in thousands of U.S. Dollars)

	World Production Changes (in %) 1981-1990	India Average Trade Balance 1982-1991	India Average Trade Balance as % of Export
TEXTILES			
Cotton fabrics,woven	43	3387660	94.1%
Knitted,etc fabric	27	89215	56.9%
Woven man-made fibre fabrics	26	603070	94.3%
Special textile fabric	22	-83275	-97.2%
Floor covering,etc	17	3493197	90.9%
Textile yarn	-12	1203285	56.9%
BASIC METAL INDUSTRY			
Aluminium	23	-174048	-47.1%
Iron,steel primary forms	17	-1046803	-1079.1%
Iron,steel,univ,plate,sheet	17	-5839533	-2879.8%
Pig iron,etc	11	-304274	-67.8%
Iron,steel shapes etc	1	-853377	-329.7%
Iron,steel,hoop,strip	-2	-155000	-3216.4%
CHEMICAL, PETROLEUM, PLASTIC PRODUCTS			
Hydrocarbons	246	-866291	-1014.1%
Carboxylic acids,etc	52	-662022	-841.8%
Nitrogen-functioned compounds	44	-364689	-69.1%
Miscellaneous chemical products	36	-1015055	-1231.8%
Products of condensation	15	-303384	-540.3%
Alcohols,phenols,etc	17	-652822	-512.6%
Petroleum products,refined	9	-6351999	-164.6%
ELECTRICAL MACHINERY			
Electric power machiner,	128	-288990	-347.5%
Telecomequipments,parts	103	-2265818	-2155.6%
Switchgear,etc	94	-1065611	-468.6%
Transistors,valves,etc	59	-1463328	-425.3%
Electrical machinery	25	- 64847	-151.2%
Musical instruments,parts	-22	-84175	-57.4%
TRANSPORT EQUIPMENT			
Motor vehicle parts	52	-703277	-104.9%
Passenger motor vehicles	47	-305706	-232.1%
Cycles,etc	1	252011	41.3%
Railway vehicles	-5	-581346	-1343.2%
Ships and boats	-34	-2815466	-473.5%
Aircraft,etc	-76	-2693445	-2951.4%

Sources: International Trade Statistics Yearbook (New York: Statistical Office of the U.N., 1991 and 1987) and International Industrial Statistics Yearbook (New York: Statistical Office of the U.N., 1991).

TABLE 4.3
World Production and Indonesia Trade of Selected Commodities
(in thousands of U.S. Dollars)

	World Production Changes (in %) 1981-1990	Indonesia Average Trade Balance 1982-1991	Indonesia Average Trade Balance as % of Export
TEXTILES			
Cotton fabrics,woven	43	797990	70.4%
Knitted,etc fabric	27	-187716	-285.7%
Woven man-made fibre fabrics	26	1790437	73.1%
Special textile fabric	22	-376223	-136.8%
Floor covering,etc	17	317761	93.5%
Textile yarn	-12	-698648	-103.5%
BASIC METAL INDUSTRY			
Aluminium	23	1155520	54.7%
Iron,steel primary forms	17	-627343	-97.5%
Iron,steel,univ,plate,sheet	17	-3879757	-1503.8%
Pig iron,etc	11	-214007	-109.1%
Iron,steel shapes etc	1	-675282	-183.5%
Iron,steel,hoop,strip	-2	-112314	-3379.5%
CHEMICAL, PETROLEUM, PLASTIC PRODUCTS			
Hydrocarbons	246	-1474254	-7263.1%
Carboxylic acids,etc	52	-1208088	-1456.3%
Nitrogen-functioned compounds	44	-712798	-338.2%
Miscellaneous chemical products	36	-2167611	-5267.5%
Alcohols,phenols,etc	17	-860141	-778.2%
Products of condensation	15	-1079011	-1129.3%
Petroleum products,refined	9	-1860749	-21.9%
ELECTRICAL MACHINERY			
Electric power machinery	128	-881761	-6052.9%
Telecomequipments,parts	103	-2530924	-1072.4%
Switchgear,etc	94	-1270828	-397.3%
Transistors,valves,etc	58	-315891	-63.0%
Musical instruments,parts	64	95172	35.4%
Electrical machinery	25	-1317336	-454.1%
TRANSPORT EQUIPMENT			
Motor vehicle parts	52	-3361581	-13105.1%
Passenger motor vehicles	47	-2128887	-9505.6%
Cycles,etc	1	-1066512	-1101.4%
Railway vehicles	-5	-381626	-44118.6%
Ships and boats	-34	-3312092	-1579.0%
Aircraft,etc	-76	-2194564	-3216.5%

Sources: International Trade Statistics Yearbook (New York: Statistical Office of the U.N., 1991 and 1987) and International Industrial Statistics Yearbook (New York: Statistical Office of the U.N., 1991).

TABLE 4.4
World Production and Malaysia Trade of Selected Commodities
(in thousands of U.S. Dollars)

	World Production Charges (in %) 1981-1990	Malaysia Average Trade Balance 1982-1991	Malaysia Average Trade Balance as % of Export
TEXTILES			
Cotton fabrics,woven	43	-522920	-82.3%
Knitted,etc fabric	27	-701947	-258.7%
Woven man-made fibre fabrics	26	-742838	-86.0%
Special textile fabric	22	-370015	-664.6%
Floor covering,etc	17	546058	79.2%
Textile yarn	-12	-155616	-22.7%
BASIC METAL INDUSTRY			
Aluminium	23	-841681	-290.2%
Iron,steel primary forms	17	-1480335	-2235.0%
Iron,steel,univ,plate,sheet	17	-3721245	-4589.9%
Pig iron,etc	11	172221	45.7%
Iron,steel shapes etc	1	-850958	-233.0%
Iron,steel,hoop,strip	-2	-58231	-3744.8%
CHEMICAL, PETROLEUM, PLASTIC PRODUCTS			
Hydrocarbons	246	-534953	-1240.1%
Carboxylic acids,etc	52	-529368	-641.9%
Nitrogen-functioned compounds	44	-268064	-613.7%
Miscellaneous chemical products	36	-774228	-137.9%
Alcohols,phenois,etc	17	143571	25.9%
Products of condensation	15	-900725	-1099.3%
Petroleum products,refined	9	-6237016	-190.6%
ELECTRICAL MACHINERY			
Electric power machinery	128	237924	17.1%
Telecomequipments,parts	103	-1346184	-27.8%
Switchgear,etc	94	-2705482	-164.3%
Transistors,valves,etc	59	3124714	11.2%
Electrical machinery	25	-1638624	-165.1%
Musical instruments,parts	-22	-381541	-195.7%
TRANSPORT EQUIPMENT			
Motor vehicle parts	52	-852189	-925.1%
Passenger motor vehicles	47	-4159933	-1581.2%
Cycles,etc	1	-577348	-777.7%
Railway vehicles	-5	-211902	-5443.2%
Ships and boats	-34	-1553337	-95.6%
Aircraft,etc	-76	-2037392	-146.2%

Sources: International Trade Statistics Yearbook (New York: Statistical Office of the U.N., 1991 and 1987) and International Industrial Statistics Yearbook (New York: Statistical Office of the U.N., 1991).

TABLE 4.5
World Production and Mexico Trade of Selected Commodities
(in thousands of U.S. Dollars)

	World Production Changes (in %) 1981-1990	Mexico Average Trade Balance 1982-1991	Mexico Average Trade Balance as % of Export
TEXTILES			
Cotton fabrics,woven	43	49642	21.7%
Knitted,etc fabric	27	-18497	-85.5%
Woven man-made fibre fabrics	26	-817698	-1040.3%
Special textile fabric	22	-60969	-24.2%
Floor covering,etc	17	70581	35.8%
Textile yarn	-12	-142904	-13.2%
BASIC METAL INDUSTRY			
Aluminium	23	-1260095	-1124.2%
Iron,steel primary forms	17	-417202	-95.1%
Iron,steel,univ,plate,sheet	17	-1517073	-143.3%
Pig iron,etc	11	95779	32.7%
Iron,steel shapes etc	1	-278930	-60.3%
Iron,steel,hoop,strip	-2	-181122	-1368.6%
CHEMICAL, PETROLEUM, PLASTIC PRODUCTS			
Hydrocarbons	246	-1809323	-301.2%
Carboxylic acids,etc	52	1020985	55.7%
Nitrogen-functioned compounds	44	-1192539	-214.3%
Products of condensation	36	-441036	-111.5%
Alcohols,phenols,etc	17	-288991	-62.5%
Miscellaneous chemical products	15	-909911	-179.8%
Petroleum products,refined	9	1419765	30.3%
ELECTRICAL MACHINERY			
Electric power machinery	128	375483	25.9%
Telecomequipments,parts	103	-2142007	-50.6%
Switchgear,etc	94	-1063712	-41.2%
Musical instruments,parts	64	-361759	-50.7%
Transistors,valves,etc	58	-1581922	-98.0%
Electrical machinery	25	-1987579	-145.7%
TRANSPORT EQUIPMENT			
Motor vehicle parts	52	-8979343	-184.7%
Passenger motor vehicles	47	6271513	85.6%
Cycles,etc	1	-343288	-391.0%
Railway vehicles	-5	-830212	-674.1%
Ships and boats	-34	-1361488	-606.0%
Aircraft,etc	-76	-2035771	-490.1%

Sources: International Trade Statistics Yearbook (New York: Statistical Office of the U.N., 1991 and 1987) and International Industrial Statistics Yearbook (New York: Statistical Office of the U.N., 1991).

It is of interest to note that in the first column there are large differences in the growth rate of world production of the composite products for quite a number of industrial groups. The biggest differences are found in the chemical, petroleum and plastics products group, ranging from 9% - the lowest rate of production for refined petroleum products to 246% - the highest rate of production for hydrocarbons. Products in the electrical machinery group also exhibit very large differences in the growth rate of production: ranging from -22% to 128%. Overall, the variances in growth rates of production for growth industrial groups - chemical, petroleum, plastics products; electrical machinery; and transport equipment - are much bigger than those for mature industrial groups - textiles and basic metal industry. This may suggest that, on the one hand, products in one industrial group have different maturity rankings: there could be mature products in a growth industry and growth products in a mature industry. On the other hand, the differences in the variances for different industries indicate maturity rankings for the industrial groups, e.g. bigger variances resulting in higher average growth rates are found in growth industries and vice versa.

Another interesting observation is that the growth rate of production does not always match the corresponding trade balance as is expected according to the international PLC. Theoretically, for developing countries, products with a higher growth rate of world

production should expect a lower trade balance than products with a lower growth rate, and vice versa. In fact, it is not necessarily so. For example, in Table 4.1 for China, products of condensation - with the second lowest growth rate of world production in chemical, petroleum, plastic products group - has the largest trade deficit; while hydrocarbons - with the highest growth rate - only has the third largest trade deficit in that group. In the basic metal industry, iron, steel, hoop and strip which has the lowest growth rate in that group, suffers a considerable trade deficit; while iron steel (primary forms) and pig iron which all show much higher growth rates enjoy nice trade surpluses. Similiar situations exist for the other four countries.

It is also expected that the average trade balance as a percentage of exports should be higher for products with lower growth rates and lower for products with higher growth rates. Again, this is not necessarily the case. In Table 4.4 for Malaysia, in the electrical machinery industry, the musical instruments and parts category with the lowest growth rate in that group also fares the worst in terms of the average trade balance as a percentage of export, while electrical power machinery with the highest growth rate is the strongest by the same measurement. In the basic metal industry, iron, steel, hoop and strip with the lowest growth rate in that group also shows the lowest trade balance as a percentage of export, while aluminium with the highest growth rate exhibits a much better result.

7.2 STATISTICAL TESTS

7.2.1. Correlation Between Growth Rates of Production and Trade Balance.

The first test consisted of computing the Pearson r coefficient of correlation between the growth rate of world production and the average trade balance of the corresponding commodity as a measure of the relationship between the growth rate of commodities and the strength of their trade balance. The results appear in Table 5 (p. 57).

In this table, the values of the Pearson r coefficient are given for the five industrial groups for the five countries. Then the corresponding table values (significance level $\alpha=0.05$) are compared with the values of the Pearson r . Significant correlation, which is indicated by the letter x , exists for the industry whose Pearson coefficient r is greater than the table value; it is not significant if r is smaller than the table value.

According to the test results, no evidence was found indicating any significant negative correlation between growth rate of production and trade balance.

Table 5

Correlation Between Growth Rates of Production and Trade Balance
(Pearson Coefficient r)

Industrial Group	China	India	Indonesia	Malaysia	Mexico
Transport Equipment	0.39	-0.14	-0.25	-0.19	0.19
Electrical Machinery	0.47	0.47	0.05	0.52	0.11
Chemical, Petroleum, Plastic Products	-0.16	-0.19	0.14	-0.15	0.90 x
Basic Metal Industry	0.79 x	0.37	0.21	0.39	0.10
Textiles	0.51	0.40	0.73 x	0.31	0.96 x

Source: Computed from figures in Table 4.1 - 4.5.

Note : X indicates significant correlation.

N = 6 or 7.

The results for China are shown in column 1, Table 5. Of the five industrial categories, only the basic metal industry was found to have a Pearson r value greater than the table value indicating a significantly positive correlation between its growth rate of production and its trade balance. The values of the Pearson coefficient r are considerably smaller than the comparable table values for the other four industrial groups showing no significant correlation for them between growth rates of production and trade balances. No significant negative correlation was found for any of the five industries.

In column 2, Table 5, the values of Pearson r for all five industries for India are much smaller than the table values. It appears there is no significant negative correlation for any of the five industrial groups between growth rate of production and trade balance for India.

In the case of Indonesia (column 3, Table 5), the Pearson r value is larger than the table value for the textiles industry indicating that the growth rate of production correlates positively with trade balance for this industry. While the other four industries show no significant correlation between the growth rate of production and trade balance as their values of Pearson r are significantly smaller than the table values. Overall, no significant negative correlation was found for Indonesia.

For Malaysia (column 4, Table 5), the values for all industries are considerably smaller than the corresponding table values. No evidence was found for significant negative correlation for any industrial groups between growth rates of production and trade balance.

There is a slightly different result for Mexico (column 5, Table 5). Two industrial groups - chemical, petroleum, plastic products and textiles - have larger values of Pearson r than the table values indicating significant positive correlation between growth rates of production and trade balance. The significant correlations in chemical, petroleum and plastic products group which is classified as a growth industry may be attributed to the considerable oil resources in this country. However, no significant negative correlation was found for any industries.

The Pearson product-moment coefficient indicates that the first hypothesis - the trade balances of manufactured products for developing countries are inversely correlated with the world growth rate of production of the corresponding products - is not supported. In fact, an inspection of columns 1 and 2 in Tables 4.1 - 4.5 shows that positive trade balances or much lower trade deficits are sometimes associated with growth products and negative or higher trade deficits sometimes with mature products, as opposed to what was expected according to the international PLC theory.

In Mullor-Sebastian's study, she used the Spearman rank coefficient to measure the association between the growth rate of production and the average trade balance of the corresponding commodities. She, too, found that the correlations were not significant.

It seems, from this test, that the international PLC theory does not apply to some individual commodity groups. The maturity of individual commodities in each industrial group may vary significantly. It is not unusual to see mature products in a growth industry and growth products in a mature industry. The heterogeneous nature of the maturities of some products tends to complicate the correlation study and produce such results.

The second test, as exhibited in Tables 6.1 to 6.5 (p. 61 - p. 65) with five industrial groups ranked in descending order according to the median rates of production of the commodities included in each group, is done in three steps for all five countries separately. The first step was the computation of the median growth rate of production (Column 1, Tables 6.1 to 6.5) as an indicator of maturity ranking for each industrial group; the second was the computation of the percentage of commodities whose growth rates were above the median and had positive trade balances (Column 3, Tables 6.1 to 6.5); and the third was the computation of the percentage of commodities whose growth rates were below the

TABLE 6.1

Indicators of Positions in the Product Cycle and of Trade Balance
for Selected Industrial Groups for China

Industrial Group	Median growth rate of pro- duction 1981-1990	Products with positive trade balance as % of number of products within each group	Products with positive trade balance as % of number of products with growth rate above median	Products with positive trade balance as % of number of products with growth rate below median	Median of ratio of trade balance to exports x 100 for each indus- trial group
Electrical Machinery	79	17%	0%	33%	-109.1
Chemical, Petroleum, Plastic Products	44	14%	0%	25%	-173.0
Textiles	24	67%	67%	67%	32.1
Basic Metal Industry	13	33%	33%	33%	-195.4
Transport Equipment	-2	17%	33%	0%	-1154.0

Source: Computed from figures in Table 4.1.

TABLE 6.2

Indicators of Positions in the Product Cycle and of Competitiveness
for Selected Industrial Groups for India

Industrial Group	Median growth rate of pro- duction 1981-1990	Products with positive trade balance as % of number of products within each group	Products with positive trade balance as % of number of products with growth rate above median	Products with positive trade balance as % of number of products with growth rate below median	Median of ratio of trade balance to exports x 100 for each indus- trial group
Electrical Machinery	79	0%	0%	0%	-386.4
Chemical, Petroleum, Plastic Products	44	0%	0%	0%	-540.3
Textiles	24	83%	100%	67%	73.9
Basic Metal Industry	13	0%	0%	0%	-704.4
Transport Equipment	-2	17%	33%	0%	-352.8

Source: Computed from figures in Table 4.2.

TABLE 6.3

Indicators of Positions in the Product Cycle and of Competitiveness
for Selected Industrial Groups for Indonesia

Industrial Group	Median growth rate of pro- duction 1981-1990	Products with positive trade balance as % of number of products within each group	Products with positive trade balance as % of number of products with growth rate above median	Products with positive trade balance as % of number of products with growth rate below median	Median of ratio of trade balance to exports x 100 for each indus- trial group
Electrical Machinery	79	17%	0%	17%	-425.7
Chemical, Petroleum, Plastic Products	44	0%	0%	0%	-1129.3
Textiles	24	50%	67%	33%	-16.6
Basic Metal Industry	13	17%	17%	0%	-146.3
Transport Equipment	-2	0%	0%	0%	-6361.1

Source: Computed from figures in Table 4.3.

TABLE 6.4

Indicators of Positions in the Product Cycle and of Competitiveness
for Selected Industrial Groups for Malaysia

Industrial Group	Median growth rate of pro- duction 1981-1990	Products with positive trade balance as % of number of products within each group	Products with positive trade balance as % of number of products with growth rate above median	Products with positive trade balance as % of number of products with growth rate below median	Median of ratio of trade balance to exports x 100 for each indus- trial group
Electrical Machinery	79	33%	17%	17%	-96.1
Chemical, Petroleum, Plastic Products	44	14%	0%	14%	-613.7
Textiles	24	17%	0%	17%	-84.2
Basic Metal Industry	13	17%	0%	17%	-1262.6
Transport Equipment	-2	0%	0%	0%	-881.4

Source: Computed from figures in Table 4.4.

TABLE 6.5

Indicators of Positions in the Product Cycle and of Competitiveness
for Selected Industrial Groups for Mexico

Industrial Group	Median growth rate of pro- duction 1981-1990	Products with positive trade balance as % of number of products within each group	Products with positive trade balance as % of number of products with growth rate above median	Products with positive trade balance as % of number of products with growth rate below median	Median of ratio of trade balance to exports x 100 for each indus- trial group
Electrical Machinery	79	17%	33%	0%	-74.3
Chemical, Petroleum, Plastic Products	44	29%	33%	33%	-111.5
Textiles	24	33%	33%	33%	-18.7
Basic Metal Industry	13	17%	0%	17%	-119.2
Transport Equipment	-2	17%	33%	0%	-440.6

Source: Computed from figures in Table 4.5.

median and had positive trade balances (Column 4, Tables 6.1 to 6.5). According to the international PLC theory, developing countries have competitive advantages in mature products represented here by products with below-median growth rates and disadvantages in growth products represented here by products with above-median growth rates. Therefore, it is expected that in this test the percentage of commodities with below-median growth rates and positive trade balances should be more than the percentage of commodities with above-median growth rates and positive trade balances.

In Table 6.1 for China, two industrial groups - electrical machinery and chemical, petroleum, plastic products - have more products with positive trade balances and below-median growth rates than those with a positive balance and above-median growth rates, 33% vs 0 and 25% vs. 0 respectively; two other groups - textiles and the basic metal industry - have the same number of products with positive balances and above-median growth rates as the number of products with positive balances and below-median growth rates, 67% and 33% respectively; only one group - transport equipment - shows a different result: it has more products (33%) with positive trade balances and above-median growth rates than those (0) with positive trade balances and below-median growth rates.

For India, Table 6.2 shows that in two industrial groups, textiles and transport equipment, the percentages of commodities

with positive balances were 33% higher for those commodities with growth rates above the median. In the other three groups, electrical machinery; chemical, petroleum and plastic products; and basic metal industry, the percentages of products with positive balances and above-median growth rates were the same as those of products with positive balances and below-median growth rates.

In the case of Indonesia (Table 6.3), only one group - electrical machinery - has more products with positive balances and below-median growth rates than those with positive balances and above-median growth rates, 17% vs 0. Two groups, textiles and the basic metal industry, show the opposite result: they have more products with positive balances and above-median growth rates than those with positive balances and below-median growth rates, 67% vs 33% and 17% vs 0, respectively. Two groups, chemical, petroleum and plastic products and transport equipment, have the same number of products with positive balances and below-median growth rates and products with positive balances and above-median growth rates.

The results for Malaysia (Table 6.4) are most in line with the international PLC theory. In 3 of the 5 groups - textiles, basic metal industry and chemical, petroleum, plastic products -, the percentages of commodities with positive balances were higher for those with growth rates below the median, 17%, 17% and 15%, respectively. For the other two groups, electrical machinery and transport equipment, the percentages of commodities with positive

balances and below-median growth rates were the same as those of products with positive balances and above-median growth rates, 17% and 0, respectively.

For Mexico (Table 6.5), only the basic metal industry has more products with positive balances and below-median growth rates than those with positive balance and above-median growth rate, 17% vs 0. Two groups, textiles and chemical, petroleum, plastic products, have the same number of products with positive balances and below-median growth rates as that of products with positive balances and above-median growth rates, all 33%. Two other groups, electrical machinery and transport equipment, have more products with positive balances and above-median growth rates than those with positive balance and below-median growth rate, 33% vs 0.

The result of the second test shows that only the findings for Malaysia lend marginal support to the international PLC, as it has, in three out of five industries, more products with positive balances and below-median growth rates than products with positive balances and above-median growth rates. For the other four countries, the results do not support the theory. It appears that there is sufficient evidence for rejecting the notion that the industrial groups behave as predicted by the international PLC theory.

7.2.2. Competitiveness Measurement

Trade balance was also computed as a percentage of exports for each commodity in order to measure competitiveness (column 3, Tables 4.1 to 4.5). This measurement is what Mullor-Sebastian (1983) used in her study of the U.S. trade performance. The median of those percentages was computed for each industrial group in order to compare the competitive strength of the various industrial groups. The results are in column 5, Tables 6.1 to 6.5. According to the international PLC theory, for developing countries, the highest median of trade balance as a percentage of exports should correspond to the industrial group with the lowest median growth rate, and the lowest median should correspond to the industrial group with the highest median growth rate. However, the actual results are mixed.

For China (Table 6.1), the highest median (32.1) corresponds to the industrial group, textiles, with an average median growth rate. And the lowest median (-1,154) corresponds to the industrial group with the lowest median growth rate.

The results for India (Table 6.2) are that the highest median (73.9) also corresponds to textiles, while the lowest median (-704.4) to basic metal industry which has a lower median growth rate of production.

Indonesia (Table 6.3) again has the highest median (-16.6) matching the textiles industry and the lowest median (-6,361.1) matching the transport equipment industry. This is exactly the same result as found for China.

For Malaysia (Table 6.4), the highest median (-84.2) was found for the textiles industry and lowest median (-1,262.6) for the basic metal industry. This result happens to be the same as that for India.

Mexico's result (Table 6.5) is the same as those for China and Indonesia, with the highest median (-18.7) corresponding to the same industrial group - textiles - and the lowest (-440.6) to transport equipment industry.

As classified by the growth rate of world production, the textiles industry is indeed a mature industry, and transport equipment a growth one. With all five countries having the highest median corresponding to the same mature textiles industry, and with three out of five countries having the lowest median corresponding to the growth industry - transport equipment, this test does indicate that these developing countries enjoy a competitive advantage in the mature industry - textiles - and a corresponding disadvantage in a growth industry - transport equipment.

The results of this test show some support for the international PLC theory. It indicates that the competitive strength for developing countries varies according to the maturity of the industry.

Using the same approach, Mullor-Sebastian (1983) found substantial evidence supporting the international PLC theory. She found that in five of the six industrial groups, the percentage of commodities with a positive trade balance was higher for those commodities with growth rates above the median. The median of trade balance as a percentage of exports for each industrial group declines from industries with the most vigorous growth rates to industries with the least vigorous growth rates.

One explanation for this result could be that the international PLC theory is more applicable to the trade performance of industrial groups despite the weak support in the previous test. Individual products may have heterogeneous life cycles, but the maturity ranking of an industry generally reflects the overall life cycle of the majority of the products inside the group. Therefore, the results for individual products may vary considerably; while the results for the industries may be more stable and consistent, and may reveal the general trend of an industrial group.

7.2.3 Kruskal-Wallis Test

In order to test the second hypothesis - the difference in the trade balances of comparable manufactured goods for developing countries will be a result of different levels of economic development, the Kruskal-Wallis test (Sharp, 1979) was employed. This test determines whether there is a difference in economic sophistication among the countries by finding out if the sums of the ranks, (as measured first by trade balance and second by trade balance as a percentage of exports), for each of the five countries differ significantly from each other. A significant value of H implies that the medians of the distribution are not the same.

The five countries were ranked first in terms of their trade balance and then in terms of their trade balance as a percentage of exports. The results appear in Table 7.1 (p. 74) and 7.2 (p. 75). In the rankings of five countries in terms of trade balance (table 7.1), the H value (2.92) is much smaller than the table value (9.49) with significance level at 0.05; and in the rankings of five countries in terms of trade balance as a percentage of exports (table 7.2), the H value (2.41) is again considerably smaller than the table value (9.49) also with significance level at 0.05. Therefore this test reveals no significant difference among the rankings of the five countries as measured by trade balance and by trade balance as a percentage of export. Even though the five

Table 7.1

**Rankings of Five Countries in Terms of Trade Balance
(Kruskal-Wallis Test)**

	China	India	Indonesia	Malaysia	Mexico
T.ansport Equipmen	6	9	2	21	12
Electrical Machinery	3	14	11	18	13
Chemical,Petroieum Plastic Products	15	4	5	7	19
Basic Metal Industry	1	8	16	10	17
Textiles	24	25	23	20	22
Total	49	60	57	76	83

H=2.92

Table Value=9.49 (at $\alpha=0.05$)

N = 6 or 7

Source: Computed from figures in Tables 6.1 - 6.5.

Table 7.2
Rankings of Five Countries in Terms of Trade Balance
as a Percentage of Export
(Kruskal-Wallis Test)

	China	India	Indonesia	Malaysia	Mexico
Transport Equipmen	1	7	20	3	14
Electrical Machinery	16	10	4	21	22
Chemical, Petroleum Plastic Products	11	8	15	9	19
Basic Metal Industry	12	5	6	2	13
Textiles	24	25	23	18	17
Total	64	55	68	53	85

H=2.41

Table Value=9.49 (at $\alpha=0.05$)

N = 6 or 7

Source: Computed from figures in Tables 6.1 - 6.5.

countries are indeed at different stages of economic development, which can be seen at their GNP per capita and the sums of their ranks in this test, this difference does not lead to significant differences in their trading performances as predicted by the international PLC. The second hypothesis also was not supported.

7.2 COMPARATIVE STUDIES

7.2.1 Country Comparison - China and Mexico

China and Mexico are at the two ends of the economic spectrum of the five countries selected as indicated in Table 3: Mexico has the highest GNP per capita, while China has the lowest. The difference in income also indicates the difference in the level of economic development with Mexico's economy being more developed than China's. In the period from 1982 to 1991, these two countries have gone through dramatic changes in their economies. China pursued vigorous economic reform instituting freer and more open market mechanisms and introducing foreign investment, management expertise and advanced technologies. On the other hand, Mexico gradually solved its foreign debt problems, undertook economic privatisation and continued to integrate its economy with the U.S. and Canada especially in the light of the North American Free Trade Agreement.

Despite all the differences, there are also similarities for these two countries. As shown in Table 6.1 and Table 6.5, China and Mexico have the same highest median trade balance as a percentage of exports corresponding to the same industry - textiles, and the lowest median to the same industry - transport equipment, indicating the similar structure of competitiveness of industries for the two countries, i.e., that they enjoy a competitive

advantage in a mature industry and a disadvantage in a growth industry.

In the study of correlations between growth rates of production and trade balance, both countries exhibit no significantly negative correlations in any of the five industries. The exception in Mexico is the positive correlation in chemical, petroleum and plastic products which is classified as a growth industry according to the growth rate of world production. Given the large oil resources of Mexico and relatively developed oil exploration and petrochemical industry there, this exception may well be understood.

Malaysia and Indonesia are also oil-rich countries like Mexico. But they are relatively less developed in their overall economies and in the petrochemical industry as well. They tend to export oil as a raw material to neighbouring countries, especially Japan, where oil is used as energy or processed into chemical products.

Mullor-Sebastian (1983) also found that a resource-specific industry may defy the international PLC theory. The strong performance of the wood and cork products industry of the U.S., a truly mature industry, was attributed to the abundant forestry resources and the highly-developed forestry industry there.

Even though the Kruskal-Wallis test indicates no significant

difference in the rankings of the five countries both in terms of the trade balance and trade balance as a percentage of export, it does show that Mexico, with the highest GNP per capita, has the highest rankings on both accounts (83 and 85); and China, with the lowest GNP per capita, has the lowest ranking (49) as measured by trade balance and the third lowest ranking (64) as measured by trade as a percentage of export. The difference in rankings may be attributed to the difference in the level of economic development for the two countries. Therefore, even though the Kruskal-Wallis test does not support the second hypothesis, the ordering of industry-based trade balances does suggest that the differences in economies exist and affect the production of mature goods. More developed developing countries tend to have a better command of production technology and superior economic infrastructure, and consequently will enjoy a stronger trade performance of manufactured goods compared to its less developed counterparts.

It appears from the comparison that developing countries, regardless of the different levels of economic development existing among them, indeed have competitive advantages in similar mature industries and disadvantages in growth industries. In the meantime, the differences may not be significantly visible in their trading performances.

7.2.2 Industry Comparison - Textiles and Transport Equipment.

According to the growth rate of world production, textiles and transport equipment are respectively the most mature industry and the #1 growth industry. In industry comparison, the tests also presented some interesting results.

The highest median of trade balance as a percentage of export for five countries corresponds to the textiles industry (column 5, Tables 6.1 to 6.5). In addition, 3 of the lowest and 1 of the second lowest medians correspond to transport equipment industry. This does, again, indicate competitive situations of industries that developing countries enjoy competitive advantage in mature industries but not in growth industries, exactly as predicted by the international PLC theory.

For the other three industries - electrical machinery, basic metal industry and chemical, petroleum and plastic products, the results are mixed. Next to the transport industry, basic metal is the least competitive industry for India and Malaysia and the second least competitive industry for Mexico. This may be attributed to the capital-intensive and resource-dependent nature of the industry and high domestic consumption. The only exception is China which enjoys considerable mineral resources and has invested heavily in this industry leading to a stronger performance.

There is no pattern found for electrical machinery and chemical, petroleum and plastic products. This may indicate that the international PLC theory has support for the least mature and most mature industries, with less support for industries between the two bands. One possible explanation is that industries at the two ends of the spectrum have a distinctive life cycle which holds for most of the products. While products in other groups may exhibit more varied life cycles, which affect their overall performance. Development strategies and the globalization of the world economies may also contribute to the result. Developing countries may prioritize certain industries, which results in the different performance of the relevant industries. The globalization of the world economies may shorten the technological gap of certain products for developing countries and affect the result.

However, the results of correlation studies do not support the hypothesis as no significantly negative correlation was found. It was not revealed that developing countries enjoy competitive advantages in mature industries and disadvantages in growth industries.

The Kruskal-Wallis test (Tables 7.1 to 7.2) reveals that in both measures the textiles industry receives the highest or higher rankings and the transport equipment industry the lowest or the lower rankings for all the countries studied. This result also

supports the international PLC theory in its prediction that developing countries are competitive in mature industries.

The industry comparison indicates for developing countries the competitive strength in mature industries, such as textiles and the basic metal industry, and the lack of competitiveness in growth industries, such as transport equipment industry.

7.3 DISCUSSION

The first test provided little evidence of a significant association between the growth rates of production, an indication of product maturity, and the trade balances of the 5 industrial groups. In fact, only four cases of significantly positive correlation were found for China, Indonesia and Mexico. Given the massive investment in the iron, steel and aluminium industry since the late 1970s, the positive significant correlation in basic metal for China is not surprising. The positive significant correlation in Mexico's textiles industry may be a result of industry relocation because of Mexico's advantage in this mature, labour-intensive and low-tech industry and its closeness to the huge American market. Spurred by the economic achievements of its neighbours, notably Singapore, Hong Kong and Taiwan, Indonesia has been taking measures to attract foreign investment. Following the fiscal incentives offered by the government, and also because of the cheaper labour, labour-intensive industries, like textiles, footwear and apparel, have relocated to Indonesia on a large scale. India has until recently been following the import-substitution regime. Its domestic industries were protected and insulated for some time from the world competition which resulted in a loss of industrial competitiveness. It is not surprising to see a lacklustre trade performance. The recent economic liberalization in India should change its outlook. Though Malaysia has been pursuing an outward-looking development strategy, its competitiveness lies

more in the electronics industry which attracted heavy investment from American and Japanese MNCs. Unfortunately, this industry is not covered in this study.

The second test did not show that commodities with below-median growth rates performed better than those with above-median growth rates. But the test did indicate that for these countries, the highest median of trade balance as a percentage of export corresponds to the same industry - textiles. For China, Indonesia and Mexico, the lowest median of trade balance as a percentage of export corresponds to transport industry; for India and Malaysia, the lowest median of trade balance corresponds to basic metal industry. This result reveals that developing countries have competitive advantage in mature labour-intensive, low-tech and low-capital industry such as textiles. While finding the lowest median in the transport industry is understandable given the growth nature of this industry, and the lowest median found in the basic metal industry can be explained by the fact that though basic metal is a mature industry, it requires abundant resources and large amounts of capital which is relatively scarce in developing countries.

The Kruskal-Wallis test did not support the second hypothesis that differences in economies will be evidenced in trade performance. Meanwhile, the ranks for each country clearly indicate that the five countries are at different stages on the economic ladder.

7.4 CONCLUSION

It seems from the statistical tests that the hypotheses, which are in line with the international PLC theory, were not supported. The trade balances of manufactured goods for developing countries are not inversely correlated with the growth rate of world production of the corresponding commodities; and the difference in the level of economic development in developing countries does not lead to the difference in the trade balances of comparable manufactured goods.

The lack of support for the hypotheses can be explained in the following ways. First, the problem of aggregation in world production statistics may distort the results. When products are lumped together, the maturity ranking may not be accurate because of the different maturities for the composite product and the bias caused by the heavily represented products. The second reason could be the globalization of MNCs. With the easy mobility of capital and technology, MNCs can move the production of commodities, be they mature or growing, from developed countries to developing countries to take advantage of cheaper labour and fiscal incentives offered there. This tends to speed up the production of the manufactured goods and accelerate the stages of the life cycle of products. The positive trade balances of some growth products in some developing countries can be a result of the globalization phenomenon. The third reason is the availability of specific natural resources. The

abundant oil resources in Mexico and the large metallurgical resources in China give the natural basis for the development of the relevant industries in the two countries.

A fourth reason could be the effect of different economic policies. Most of the countries have undertaken economic liberalization initiatives, notably China, Malaysia and Mexico. Developing countries have gradually realized the importance of export promotion vs. import substitution and the role of foreign investment, and consequently have taken steps in developing target industries and attracting foreign capital. These countries have adopted measures to build a better economic infrastructure, nourish appropriate industries, and offer fiscal incentives to attract foreign investment. As a result, especially mature industries, such as textiles, footwear and apparel, have been relatively developed, and the products become very competitive in the world market.

A fifth reason could be the nature of the mature industry. Both basic metal and textiles are mature industries, but basic metal requires the relevant resources and much larger capital outlays than textiles. The much better performance by the textiles industry in all five countries indicates that developing countries should target the right mature industry - labour-intensive, low-tech and low-capital. Industries such as basic metal, though in a mature stage, are capital-intensive, and may not be suitable candidates for developing countries.

Despite the lower SITC level statistics, it is unlikely that the rejection of the hypotheses was caused by the selection and availability of trade statistics for the five developing countries. Better statistics at higher SITC level may help to clarify the test results, but the results of previous studies (Vernon et al, 1970; Tsurumi, 1972; Mullor-Sebastian, 1983), which based their studies on trade statistics ranging from 2- and 3-digit SITC level to 6-digit level, are generally consistent in supporting the international PLC theory. In this light, it is unlikely to produce any significantly different results even if better statistics are available. Therefore, regardless of its shortcomings, the data still gave the general pattern of the trading behaviour and industrial competitiveness for these developing countries.

Clearly, this study did not find support for these specific hypotheses. Nonetheless, there is indeed some support for the broad concept of the international PLC theory. Specifically, the results from the least mature and most mature industries complied the most with the international PLC theory. Developing countries were found to have a competitive advantage in the most mature industry and a disadvantage in the least mature industry. For industries in between the two extremes, there are no clear patterns of competitive strength, except in the basic metal industry.

There may be other explanations for the trade performance of

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developing countries, such as the technology life cycle theory, export-promotion strategy, country-specific reasons, the internalization theory, etc.

The technology life cycle (TLC) theory attempted to address this issue. Unfortunately, the relevant statistics required for using TLC are barely available for developing countries. Also, the TLC concept has not yet been applied to the explanation of international trade. However, the good performance of some growth products in these countries may be attributed to the fast development in technological innovation and diffusion. New technology and process may replace the old ones, increase productivity and efficiency and move the products to a new stage. In this respect, the TLC approach may be more applicable.

The export-driven development strategy may offer the right explanation. The relatively better performance in some industries in China, Indonesia and Mexico is largely a result of governmental development strategies. They all have undertaken economic reforms to establish investor-friendly mechanisms and also to nourish domestic industries in the international market. As a result, foreign investments poured in not only with capital but also with technology, management expertise and marketing channels. Domestic industries are established and strengthened, and some of them become competitive in the world market.

Development strategy has been a constant focus for developing countries. There were considerable debates on the relative advantages of import-substitution policies and export-promotion policies among academics and policy makers. Based on economic statistics for Brazil, Hong Kong, Korea, Singapore and Taiwan from the 1960s to the late 1970s, Krueger (1985) found that export-promotion policies have achieved significantly better performances. She found three distinctions for countries on export-led growth. First, their high growth rates correlated with the rapid growth of exports; second, the growth rate was sharply higher after adoption of export-oriented policies; third, export-promotion policies also created dynamic effects in the economies and more productive allocation of resources.

The lack of specific data may also distort the results. At the 3-digit SITC level, maturity rankings of the industrial groups will be more weighted by the composite products most heavily represented in the groups. There will be mature products in growth industries and growth products in mature industries. For example, the transport equipment industry consists of products with a diverse maturity ranking - motor vehicles, bicycles and airplanes, while Mexico has vehicle production but no production for airplanes. The study of five diverse developing countries measured the same five industries at a high aggregation level of trade statistics. This proved to be problematic. The huge differences among these countries in terms of technological sophistication, resource

disposition, etc may have contributed to the results. Future studies based on lower-aggregation statistics and more comparable industries may be more effective.

The internalization theory (Dunning, 1987; Rugman, 1985) was developed to provide an economic rationale for the existence of MNCs. It could also offer some explanations for the results. Factor endowment differs dramatically in these five countries, which results in the different performances of the relevant industries. For example, Mexico has a developed petrochemical industry largely because of its abundant oil resources. The significant correlation in the basic metal industry for China is directly linked with the huge mineral resources in that country. Not surprisingly, countries appear to internalize their inherent advantages in their economic development.

8. LIMITATIONS AND BENEFITS

8.1 LIMITATIONS

Several limitations exist for this study:

1) Ranking of product maturity

A number of previous studies (Hirsch, 1967; Kuznets, 1953; Mullor-Sebastian, 1983) based the ranking of product maturity on the growth rate of production. Hirsch (1967) classified as growth industries (or products) those characterised by a significant increase in output (generally more than 10% annually) and classified as mature industries (or products) those characterised by sluggish or declining output (generally less than 10% annually).

This is a debatable method. Many researchers argued that the R & D content of a product should be used as the parameter to determine whether a product is at growth stage or mature stage (Balassa, 1977; Gruber and Vernon, 1970; Lutz and Green, 1983). However, it is very difficult to obtain reliable R & D statistics, especially for developing products from developing countries.

2) Level of aggregation

The study is done with trade statistics at the 3-digit SITC levels because of the limited availability of more detailed statistics for developing countries.

Problems may arise as products in the same group may have heterogeneous life cycles: the maturity ranking of the group can be different from the real but unknown ranking of each component; and the ranking of the group might be biased toward the ranking of the product most heavily represented.

3) Samples

The five countries may not be representative of developing countries as they are, more or less, relatively developed developing countries. The sizes of their economies are big. More developing countries of various differences should be included in future studies so that the results and the policy implications could be generalized.

8.2 BENEFITS

As stated before, there is a vacuum in the recent literature on the study of the international PLC theory in the explanation of international trade for various reasons. By testing the international PLC with relatively new data in the recent context, this study attempts to address this problem and to contribute to further study in this field.

There are few empirical tests in the literature to examine manufactured exports in light of the international PLC theory for developing countries. Therefore, another benefit is that the study might compliment previous research by expanding the study of the international PLC to developing countries. The results from this study also have policy implications for developing countries in their economic development.

This study rejected the hypotheses and showed that the international PLC theory may not be valid in today's context. The drastic changes and progress of technology and global economies have made the international PLC much less applicable. Other theories may be more appropriate, such as the technology life cycle theory, export-promotion strategy, the internalization theory, etc. The TLC theory may explain why certain growth products are better developed in developing countries. Export-development strategy enjoyed phenomenal success especially for countries in

South-East Asia, and was adopted by more and more developing countries. The internalization theory may also be applied to the economic development of these countries. In order to achieve better economic and social growth, developing countries should fully realize and take advantage of their existing advantages in manpower, natural resources, market and capital.

Though the hypotheses are not supported by the tests, the results do offer selectively weak support for the broad concept of the international PLC theory. There are the following implications for industry executives and executives in government organizations.

For industry executives in developed countries the models will provide a helpful framework in scanning for products that are likely candidates for exports. Products that are relatively new, have a high technological content, appeal to high income consumers, or are labour-saving are good prospects. On the other hand, executives can predict import competition for standardised products which foreign markets are large enough to provide opportunities for large scale production.

The implications for industry executives in developing countries will likely be the opposite of their counterparts in developed countries. The model will also help them to identify products with the best export potential: mature products that are characterised by standardised technology, intensive labour and low-capital input.

Firms there may manufacture the products independently or with the help of firms from developed countries.

For government policies, the models will give useful indications as to what kind of products might be at the threshold of being exportable from developing countries. Policies aimed at standardised products may be more likely to generate an increase in exports than would policies that are directed simply at labour-intensive products. More importantly, a better development strategy can be implemented which is outward-oriented. Governments in developing countries should adopt measures to boost foreign investment. Policies should focus on target industries which fit most suitably to the situations of developing countries. The initial target may be the most mature industry. As the economies grow, the target should also move upward along the maturity ranking of the industries. This simplistic approach is certainly not adequate. Developing countries should adjust their policies to their different economic conditions, locate their advantages - be it labour, resources, market proximity, etc. More importantly, a better understanding and internalization of the inherent advantages (locations, resources, etc.) should also help to achieve more desirable performance.

For advanced countries, the models indicate what effects the spread of multinational corporations might be. With efficient information networks among subsidiaries and the rapid technological

development, the gap between the introduction in the first market and a second market might be diminishing. The originating country of the new products will have a shorter period of exports as the cycle will be shortened.

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