EXPORTS, IMPORTS, AND ECONOMIC GROWTH IN DEVELOPING COUNTRIES:

Multivariate Time-Series Evidence

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ABSTRACT

This dissertation investigates the Granger-causality between exports, imports, and economic growth in 32 developing countries. The role of the imports variable in the investigation of exports-output causality is emphasized, enabling one to test for the cases of direct causality, indirect causality, and spurious causality between export growth and output growth using the definitions provided by Hsiao (1982).

On the technical side, the Augmented-Dickey-Fuller and Phillips-Perron tests are used to test whether exports, imports and per capita real GDP are cointegrated. Furthermore, tests for breaking trends are carried out using a modified version of the procedure advanced by Perron (1989) and Zivot and Andrews (1992). Depending on the results from these tests, vector autoregressive or vector error correction models are specified for each country. The selection of lag lengths is done by using the Schwarz criterion. Following Poskitt and Tremayne (1987) a procedure for testing the decisiveness (strength) of (Granger-) causal findings is developed. Finally, the results are compared to those from a benchmark model, that is, a bivariate VAR model of export growth and output growth.

The empirical results indicate the following. First, breaking trends occur frequently in macroeconomic time series. Failure to test for breaking trends may lead to the possibility of spuriously cointegrating relationships. Second, exports and per capita output were not found to be cointegrated in most cases. Third, there is only weak evidence for a positive Granger-causal relationship from

export growth to output growth - the only two cases being Thailand and Pakistan. Fourth, the findings may lack decisiveness, and additional data may prove useful to draw more conclusive inferences. Fifth, results from the benchmark bivariate VARs indicate additional cases of positive causality from export growth to output growth. However, these cases should be regarded as spurious since the findings have not been confirmed when the real imports are included. Finally, there is no evidence of indirect causality from exports to output growth via the real imports variable. Thus, no causal evidence was found for the "exports as a foreign exchange source" hypothesis.

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CHAPTER I.

EXPORTS AND ECONOMIC GROWTH IN DEVELOPING COUNTRIES: Hypotheses and Definitions

1.0 AN OVERVIEW

The empirics of economic growth have received much attention from academics and policy makers. One particular line of research focuses on the relationship between openness and economic growth in developing countries. Researchers have used rank correlations, cross-country production functions, causality, and cointegration techniques to investigate whether those countries with outward-looking trade regimes grow faster than the others. Studies that have used rank correlation techniques and production function estimates provide support for a positive relationship between openness and economic growth. More recently, causality tests have led researchers to question the sign and the direction of the relationship between exports and economic growth. Causality tests indicate that there is only a weak causal relationship from openness (proxied by real export growth) to economic growth (proxied by per capita real output growth). This apparent reversal in the empirical evidence has been called by some authors a counter-revolution in the literature.

This dissertation makes contributions to the empirics of economic growth by undertaking a modern multivariate time series analysis of the relationship between exports and economic growth in 32 developing countries. In most cases, the time frame covers the period 1960-1988, and incorporates the effects of exports and imports on economic growth into the analysis. This study uses techniques of cointegration, vector error correction, and vector autoregressive modelling to examine the relationship between exports and economic growth. This study also evaluates the robustness of Granger-causality tests between exports and economic growth with respect to the filters and time-series techniques used. An important feature of the study is that testing for Granger-causality in a trivariate model enables one to identify any indirect and spurious causal relationships. These types of causality are tested using the methodology of Hsiao (1982) with extensions.

It is well-known that Granger-causality tests are sensitive to the filters used. This study uses tests for unit roots and breaking trends in the series to identify the appropriate filters. This approach and tests for breaking trends in the macroeconomic variables in developing countries are original contributions.

Seemingly nonstationary time series (i.e., time series that are stationary around breaking trends) raise the issue of spurious cointegration. The filters used for causality tests in this study take breaking trends into account, where applicable, thus, the empirical results should not suffer from possible spurious cointegrating relationships.

Another methodological point addressed by this dissertation is the question of inherent correlation between output growth and export growth. While this issue does not arise in the production function literature, no author has demonstrated whether Granger-causality tests suffer from an inherent relationship between the two variables. It is shown in this dissertation that this is not the case.

On the econometric methodology side, the present study develops a sequential procedure to test for the strength of causality in Granger-causality tests. The procedure has Bayesian foundations. It is based on comparing the proximity of the posterior odds of a model which implies 'X causes Y' with another model which implies 'X does not cause Y'. Possible extensions of this procedure are also discussed.

The dissertation is organized as follows. Chapter I reviews arguments on the links between export growth and economic growth. The terminology is also discussed and differences between outward-oriented growth, export-led growth, and export promotion are emphasized.

Chapter II is a critical review of the literature on export growth and economic growth relationship. The role of the import variable in the relationship between exports and economic growth is emphasized in a separate section. It is also shown that Granger-causality tests do not suffer from an accounting identity effect between the variables of interest.

Chapter III studies the concept of and econometric tests for causality. Emphasis is given to the small sample properties, identification issues, and testing for Granger-causality in multivariate models. In the latter context, parametric tests for direct, indirect, and two types of spurious causality are derived, based on Hsiao's (1982) study. A major point in this chapter is the application of the model portfolio approach of Poskitt and Tremayne (1987) to multivariate time series modelling. An extension of this approach is used for testing the decisiveness (strength) of evidence from Granger-causality tests.

Chapter IV reviews the tests for unit roots, cointegration, and breaking trends with an emphasis on their implications for time-series modelling and testing for Granger-causality.

The empirical results of this dissertation are derived in Chapter V. After a discussion of sample selection and data quality, unit root tests and tests for breaking trends are applied to data on real exports, real imports, and per capita real GDP in 32 developing countries. This is followed by tests for cointegration and constructing vector error correction or vector autoregressive models for each of the 32 countries. In drawing the causal implications, the distinction is made between the cases of direct, indirect, and spurious causality.

Chapter VI presents and evaluates the empirical findings. This chapter also subjects the results to two types of sensitivity analysis. The first one involves a comparison of the results with a benchmark bivariate vector autoregressive model of export growth and per capita real income growth. The second one uses the model portfolio approach to evaluate the strength of the causal findings. The chapter concludes with a discussion of the results - no causality between exports and economic growth in many cases. In explaining this observed non-causality, a parallel is drawn with the trade liberalisation and economic growth literature, and the results are evaluated in the context of the effects of structural adjustment programs. The aggregate nature of the analysis and the need to conduct cointegration and causality tests at the disaggregate level are also examined.

Chapter VII concludes the dissertation and sets the directions for further research.

1.1. INTRODUCTION

There has been a great deal of theoretical and empirical research on the relationship between a country's trade orientation and the level of its economic development. The earliest work focused on the merits and drawbacks of outward- and inward-oriented development policies for growth and development in the less developed countries (LDCs). After World War II, many developing countries followed the inward-oriented strategy on the belief that it speeded up development by stimulating domestic industries, and by making countries less sensitive to external shocks and less dependent on the developed world.[1] During the 1960s, however, some East Asian countries, such as Hong Kong, Taiwan, South Korea, and Singapore took a different course and based their economic development on the growth of their tradable goods sectors.

The 1970s witnessed the successful growth performance of outward-oriented East Asian countries and the emergence of various

[1] See Bell, Ross-Larson and Westphal (1984) for an assessment of the infant industries argument.

problems with the inward-oriented strategies in Latin America and elsewhere. As more data have become available, empirical studies have supported the conclusion that countries that followed a relatively outward-oriented development strategy grew faster than those who did not.[2] The international debt crisis of the 1980s added another dimension to the arguments on trade policy. Under the International Monetary Fund (IMF) and the World Bank structural adjustment programs, a policy of outward-orientation and its associated activist export-promotion version were put forth as the dictum for the developing countries.

The 1980s also saw an increase in the number of studies investigating the empirical validity of the hypothesized links between exports and output growth. Until 1985, the empirical evidence was based on pooled cross-section data, using mainly simple rank correlation and cross-country production functions. Increasingly, however, longer data series and the availability of more country-specific data have allowed time-series investigations of the outward-orientation - economic growth relationship. Time-series estimation of production functions and tests of Granger-Sims causality have been extensively employed in the later studies. The findings, by and large, contradict the previous results of a positive relationship between export-growth and economic growth, and have cast doubt on the validity of the export-oriented growth

[2] Some of the influential studies in this area are: Maizels (1968), Little, Scitovsky, and Scott (1970), Chenery and Syrquin (1975), Bhagwati (1978), Krueger (1978) and Balassa (1978).

hypothesis. This apparent reversal in the empirical evidence has been called by Lal and Rajapatirana (1987, p. 195) a "counter-revolution" in the literature.

Some methodological deficiencies have also been found in the application of the tests of causality. These deficiencies have been well described by Sephton (1989) and Bahmani-Oskooee, Mohtadi, and Shabsigh (1991). This dissertation addresses the methodological problems and empirically examines the case for export-led economic growth. In particular, the dissertation critically evaluates the Granger-causal relationships between exports and economic growth using recent developments in time-series analysis.

1.2. EXPORTS AND ECONOMIC GROWTH: HYPOTHESES

There are several arguments in the literature in favour of an outward-oriented development strategy.[3]

1) Under a binding foreign exchange constraint, export revenue may play an important role in relaxing the constraint. This allows for capital and intermediate goods imports, thus leading to higher growth [Esfahani (1991)].

2) Because an outward-oriented strategy does not discriminate between the domestic and the export sector, there should be fewer distortions in an economy than if it were to use an import-substituting strategy. Thus an outward-oriented strategy results in

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[3] An earlier bibliography on the topic is given by Emery (1967) in footnotes 3 to 8, and will not be repeated here. Keesing (1967) and Kravis (1970) are two other influential articles.

an improved resource allocation through getting the prices right, and reduces the potential for welfare losses from rent-seeking or directly unproductive activities under an import-substitution regime [Emery (1967) and Bhagwati (1988)].

3) Exports generally originate from the most efficient sectors of the economy, i.e., where the country has a comparative advantage. Relocating the factors of production from the inefficient sectors to more efficient sectors increases factor productivity in the economy, thus, leading to higher economic growth [Emery (1967) and Ram (1987)].

4) There are gains from scale economies. The size of the domestic market may not be sufficient for a firm to produce at the minimum efficient scale. Thus, the international market added to the domestic market may permit more efficient modes of production, resulting in increased factor productivity [Emery (1967)]. Alternatively, producing for the international markets may lead to increases in capacity utilization rates, if the firms formerly operated with excess capacity [Bruton (1967)].

5) The firms in the export sector need to remain competitive in international markets. This induces the flow of new technologies through innovation or imitation, increases their adaptability, and leads to a more efficient management of firm resources, among other benefits [Emery (1967) and Feder (1983)].

6) The domestic sector benefits from a more efficient export sector through learning, increased competition, and mobility of labour between the two sectors [Emery (1967)]. These effects are

called intersectoral spillovers or externalities, where an increase in factor productivity in the export sector also leads to an improvement in the productivity of the domestic goods sector [Feder (1983)].

7) An outward-oriented economy, *ceteris paribus*, is likely to have a higher international creditworthiness. As a result, those LDCs which pursue outward-oriented development strategies may have easier access to international capital markets and enjoy a more relaxed foreign exchange constraint than those who do not. The effect on economic growth is similar to the case of "exports as a source of foreign exchange" [Feder and Uy (1984) and Borenzstein and Ghosh (1989)]. An outward-oriented trade policy may also attract more foreign investment into the tradable goods sector.

8) The new or endogenous growth theory brings a deeper perspective into the relationship between a country's openness and economic performance.[4] A major implication of the theory is that increasing returns to scale and endogenous human capital formation are fundamental to economic growth. Because human capital displays increasing marginal productivity, the production of goods from increased knowledge demonstrates increasing returns (Shaw, 1992, p. 615). Thus, countries with greater stocks of human capital experience a more rapid introduction of new goods and grow faster. International competition and the associated scale economies lead

[4] The literature on endogenous growth is vast. Romer (1986) is a seminal article. Surveys of endogenous growth theory include van de Klundert and Smulders (1992), Verspagen (1992), Hammond and Rodriguez-Clare (1993), Lucas (1993), Pio (1994), and Romer (1994). See also Pack (1994) for a critical evaluation.

to increased capacity utilization and reduced managerial slack, and further induce the introduction of new technologies through innovation and/or imitation. The learning externalities provided by international competition also help to increase the stock of human capital of a country. Consequently, LDCs potentially gain the most from opening up to international trade, because they can draw upon the stock of world knowledge. Furthermore, imitation can save on the costs associated with research and product development, allowing resources to be channelled to other activities. In addition, greater openness may permit better quality intermediate goods to be imported thereby allowing quality improvements in existing products [Nishimizu and Page (1991)].

9) Endogenous growth theory suggests that exports can enhance economic growth by allowing for the importation of better quality intermediate and capital goods, and can increase factor productivity. Pio (1994) evaluates the consequences of economic integration in an endogenous growth framework. He argues that the gains from openness will be greater if economic integration leads to economies of scale, and the larger the differences in the stock of knowledge between the countries. If, on the other hand, a country cannot compete in terms of quality and marketing ability, then the country loses market share and diseconomies of scale may arise. Endogenous growth theory places great emphasis on the sectoral specialization of trading partners. The implication is that specialization in low human capital industries can place a country on a lower growth path [see Pio (1994) and Grossman and

Helpman (1991)]. These findings illustrate the potential benefits and hazards of an outward-oriented development strategy in an endogenous growth framework.

In summary, an outward-oriented strategy can lead to both static and dynamic benefits. The static benefits are due to improved technical and/or allocative efficiency. Increased foreign exchange inflow, a less distorted domestic resource allocation through getting the prices right, and lead to static efficiency gains. The dynamic efficiency gains come from increased factor productivity, an increased flow of technology and market innovations, foreign investment, economies of scale due to external markets, learning effects provided for the domestic industries, increased managerial skills and know-how, and increased product variety and quality, among others. The dynamic gains can be represented by an outward shift in the production possibilities frontier.[5]

Another important insight into the relationship between export growth and output growth comes from the new or strategic trade theory. Imperfect competition and increasing returns to scale are the cornerstone of this literature [see Helpman and Krugman (1989)]. An important implication of new trade theory is that free trade is not always the first best policy. In particular, market structure, barriers to entry, and whether there is Cournot or Bertrand competition can affect the nature of the gains from an outward-oriented trade strategy. For example, Marin (1992, pp. 678-

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[5] See Kirkpatrick (1995, pp. 25-27) for a similar discussion.

680) shows that whether a trade expansion enhances or retards productivity growth depends on the size of the country, competitive conditions in the economy, and whether there is frictionless entry in particular industries. Her conclusion is that (p. 680): "...[e]xports...cause productivity gains the smaller the country is and the less entry occurs."[6] Inefficient entry induced by an expansion of exports "...might crowd in too many firms producing at too low levels of output which might dampen or reverse the original export-induced productivity increase."[7] (p. 679) As a result, Marin concludes (p. 680) that "[w]hether exports will cause productivity gains or losses, can in the end, only be decided empirically."[8]

Given the growing literature on strategic trade theory (STT) and its possible implications for protectionist policies, it is important to question the applicability of the STT for developing countries. Studies by Havrylyshyn and Civan (1985) and Greenaway

[6] See Backus, Kehoe and Kehoe (1992) for an investigation of various "scale" effects in trade and growth in an endogenous growth framework.

[7] Interestingly, in the Taiwanese case, Chen and Tang (1990, p. 583) argue that export growth shows no significant impact on productivity. Their explanation is as follows (p. 583):

> ...exporting to foreign markets requires adjustments in the whole chain of the production process, from product design to aftersales service. This imposes an extra burden on production costs and is therefore detrimental to productivity growth. Therefore it is unclear that export expansion always enhances productivity.

[8] The relationship between trade policy and productivity gains is surveyed by Havrylyshyn (1990) and Tybout (1992). The general conclusion is that both outward- and inward-oriented regimes have theoretical reasons for enhancing factor productivity, and the relationship may be ambiguous in cross-section studies.

(1991) shed some light on this issue. Havrylyshyn and Civan (1985) find that the international trade patterns of developing countries can mostly be explained by the Hecksher-Ohlin model of factor endowments or the traditional Ricardian model. This leaves little room for the trade patterns (i.e., intra-industry trade (IIT)) implied by the strategic trade theory. Greenaway (1991) explores this question and argues that since imperfect competition, increasing returns to scale, and product differentiation imply intra-industry trade, it is appropriate to examine the intra-industry trade component of developing countries' trade to evaluate the applicability of the STT. Using data from Havrylyshyn and Civan (1985), Greenaway demonstrates that IIT is a function of the level of development. The highest levels of IIT are found between developed countries. The Newly Industrialising Countries (NICs) come next, and the non-NIC developing countries come last. In fact, most IIT in this last category is due to aggregation in the commodity classifications. As a result, one can argue that for non-NIC developing countries, the factor endowments or productivity differentials models of international trade are more applicable.

An overlooked point in empirical testing of the exports-economic growth relationship is the commodity composition of trade. The endogenous growth theory draws attention to the sectoral specialization of the trading partners, and the implications of the commodity structure of trade. As outlined above, most arguments for export-led growth concentrate on the microeconomic effects of an export expansion on productivity growth elsewhere in the economy.

The implicit assumption in this argument is that the export expansion in question refers to manufactured or processed exports. It is otherwise difficult to see how exports of primary commodities and raw materials increase productivity elsewhere in the economy. The only argument in favour of an export expansion in this case would be the "exports as a source of foreign exchange" hypothesis.

1.3. TRADE ORIENTATION: DEFINITIONS AND MEASUREMENT ISSUES

This section examines the various approaches to identifying a country's overall trade orientation. The basic dichotomy in trade orientation is outward-orientation versus inward-orientation. Outward-orientation generally indicates that a country treats its domestic and external sectors equally. According to Bhagwati (1988), when the average effective exchange rate for the export sector is more or less equal to the domestic sector, a country has an "outward-orientation." In this sense, outward-orientation means the elimination of an anti-export bias.

Outward-orientation does not imply activist export promotion [Lal and Rajapatirana (1987), Bhagwati (1988), Helleiner (1990), and Liang (1992)]. Bhagwati (1988, p. 33) calls the case where the average effective exchange rate for the export sector is greater than that of the domestic sector as "ultra-export promotion". The effective exchange rate for the export sector includes not only the nominal exchange rate but also export subsidies, tax credits, and other special credits and allowances.[9]

Bhagwati (1988) notes that his approach identifies the *overall* trade orientation of a country. Thus, the presence of import-substituting industries in an outward-oriented economy is not excluded.

Liang (1992) summarizes the various approaches to classifying a country's trade strategy. He calls the coexistence of export-promotion and import-substitution policies as a *protected export promotion (PEP) strategy* (p. 455). In this case, "...domestic firms are protected in their home markets, but encouraged to export and compete internationally." (Liang, 1992, p. 455). He demonstrates that South Korea is an example of the PEP strategy.

Helleiner (1990) emphasizes the difficulties in identifying a country's trade orientation. The problem is not only distinguishing between export-promotion and ultra-export promotion but also the difficulty in distinguishing between inward- and outward-orientation in an unambiguous and consistent way.

Helleiner (1990) considers three main approaches to identifying the overall orientation of a trade strategy. These are: a revealed policy approach, an incentive structure approach, and a trade policy instruments approach.

The *revealed policy approach* includes several ratios, such as the share of exports in the GDP, the share of exports plus imports in GDP, or the incremental exports to output ratio, among others.

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[9] Keesing (1967, pp.304-305) gives a list of instruments that can be used to stimulate the exports sector.

A variant of this approach is the calculation of a trade orientation index, based on the deviations of a country's actual trade performance from a norm that would be achieved by another country of similar characteristics. Chenery (1960), Balassa (1985), Chenery, Robinson and Syrquin (1986), Leamer (1988) and Dollar (1992) followed this approach.[10] Constant market share analysis of export performance and intensity of intra-industry trade are the other measures offered under the revealed policy approach.[11]

The *incentive structure* approach is similar to that discussed by Bhagwati (1988). It has been used in the World Development Report 1987 (WDR'87) (p. 78) illustrates the argument as follows:

> For analytical convenience, trade strategies can be broadly divided into two groups, outward oriented and inward oriented. An outward oriented strategy is one in which trade and industrial policies do not discriminate between production for the domestic market and exports, nor between purchases of domestic goods and foreign goods. Because it does not discourage international trade, this nondiscriminatory strategy is often (somewhat inaptly) referred to as an export promotion strategy.

Liang's (1992) net effective subsidy rate concept is variation of the incentive structure approach. Liang (1992) obtained trade orientation five categories. The first three are the conventional classifications: 1) an ultra EP strategy where exports are promoted while providing a neutral treatment for imports; 2) a neutral

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[10] Edwards (1992) discusses the 'desirable' properties of Leamer's (1988) indices, and prefers it to the previously constructed ones. Leamer (1988) also constructs "norm" based indices to calculate the degree of government intervention.

[11] See Chenery, Robinson and Syrquin (1986).

(outward-oriented, or free trade) strategy, where there is no special incentives or disincentives for exports and imports; 3) an import substitution regime, where there are significant import restrictions and a strong anti-export bias. The last two categories are: 4) a protected export promotion strategy; and 5) a "de facto import substitution (DIP)" strategy, which is a short-term "debt-led growth" strategy. Thus Liang classifies Taiwan'67 (i.e., in 1967) as an ultra EP, South Korea'68 and Singapore'67 as free trade, South Korea'78 as PEP, Colombia'69 as DIP, and Israel'68 and Argentina'69 as import-substituting (IS) countries. South Korea moved from a free trade strategy in 1968 to a PEP strategy in 1978.

The incentive structure based approach quickly received its criticisms.[12] According to Helleiner (1990, p. 883), this approach "...was quickly driven to the use of qualitative indicators, and ended up with some highly subjective characterizations and extremely uncertain conclusions as to what difference these orientations made." Furthermore, As Helleiner (1990, p. 884) points out, the stability of the incentive based categorizations over time is questionable.

The third category relates to the *choice of trade policy instruments*. Under this category, the degree of intervention by government, the mode of its intervention or the policy instruments it employs are considered (Helleiner, 1990, p. 884). In this approach, credibility and stability of government intervention is more critical. An active export promotion strategy increases the

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[12] See Singer (1988) on WDR 1987.

credibility of a commitment to an outward-oriented strategy compared to a neutral treatment of export and domestic sectors. Although this is an important aspect for the success of the outward-oriented trade strategy, it is not clear how this approach can be unambiguously quantified and used in categorizing a country's trade orientation.

1.4 EXPORT-LED GROWTH: DEFINITIONS AND MEASUREMENT ISSUES

The question of how export-led growth relates to trade policy orientation is described by Bhagwati (1988, p.34) as follows:

> The incentives-defined EP strategy also has to be distinguished from the traditional concept of "export-led" growth, in which a country's exports generate income expansion attributable to direct gains from trade and indirect beneficial effects...The incentives-related EP definition has literally nothing to do with such beneficial external phenomena. Whether the success of an EP strategy, defined in terms of freedom from bias against exports, requires the presence of a beneficial external environment is a separate issue.

Thus, export-promotion is a conceptually related but different phenomena than export-led growth. The former is a choice of trade policy, whereas the latter links such a policy to economic growth. If a country is pursuing an export-led growth strategy, it expects economic growth to be a consequence of direct and indirect effects associated with an export-promotion policy. Whether an (ultra-) export-promotion strategy leads to export-led growth is an empirical question.

Adelman (1984, p. 938) distinguishes between outward-oriented growth and export-led growth in a sources-of-growth accounting framework: "...[i]n searching for alternative strategies, one should distinguish between an open-development strategy, in which trade is an element of growth, and an export-led strategy in which trade is the major source of growth."[13]

In another framework, export-led growth is defined as the case where "... export growth is causally prior to output growth" by Jung and Marshall (1985, p.3). In the same spirit, Chow (1987, p. 56) points out that

> [i]f there is a definite unidirectional causality from export expansion to the development of manufacturing industries...then it will lend credence to the export-led growth strategy; exports will not only promote the growth of national income but also lead to structural transformation in the developing economies.

Indeed, using the statistical definition of Granger-causality, if export growth is causally prior to output growth, then export growth can be used to reduce the variance of the forecast of output growth. In this sense, Adelman's definition is the case where export growth is an element in reducing the variance of the forecasts of output growth, and export-led growth is the case where export growth is the major factor in reducing the variance of the forecast error of output growth. It would seem that the current literature on export-output causality which uses bivariate models has not tested the export-led growth hypothesis in Adelman's sense. The causality-based approaches can be taken as evidence on the export-led growth hypothesis in Bhagwati's sense. This is because

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[13] In a sources-of-growth accounting framework, Chenery (1980) used input-output tables to calculate the shares of export expansion, domestic demand expansion, import-substitution, and technological change in the real growth rates of eight countries.

under this approach export-led growth is when exports are found to contribute (positively) to output growth. In fact, Lal and Rajapatirana (1987, pp. 195-197) argue that the causality (from export growth to output growth) approach only tests for the export-led growth hypothesis, and not the outward-orientation strategy. According to them, the causality from output growth to export growth should be considered as evidence in favour of outward-oriented growth. As a result, one has to be careful in interpreting the empirical research as to alternative definitions of the export-led growth hypothesis.

CHAPTER II.

EXPORTS AND ECONOMIC GROWTH: A Review of the Empirical Literature

2.1. INTRODUCTION

This chapter surveys the empirical literature on the relationship between exports and economic growth. Section 2.2 provides a systematic account of the approaches used to examine the export-output growth relationship. Section 2.3 emphasizes the role of imports. Section 2.4 formally demonstrates that the causal approach to testing for the relationships between export growth and economic growth is not affected by the accounting identity linking the two, while Section 2.5 concludes.

2.2. EMPIRICAL APPROACHES TO EXPORTS AND ECONOMIC GROWTH

The empirical study of the export-output growth relationship evolved through the following four approaches. First, a rank correlation approach was extensively used in the 1970s and early 1980s. Second, a cross-section production function approach was the most popular tool of analysis in the first-half of the 1980s. Third, time series estimations of production functions, and fourth, Granger-causality tests and their variants have become popular. Today, the rank correlation approach is mostly abandoned, while one still encounters cross-section and time-series production function estimations.[14] The most recent approach is the cointegration and error correction modelling of the relationship between an export variable and an output variable. The following discussion provides an historical account of the studies of the empirical relationships between exports and economic growth.

Testing for rank correlation in cross-sections: The idea is to test whether those countries ranking high (low) in terms of their export growth also rank high (low) in their output growth. This has been the main methodology used in early analyses of the exports-output growth relationship. Michaely (1977), Balassa (1978), Heller and Porter (1978), Tyler (1981), Kavoussi (1984) are some of the influential studies which report a positive rank correlation between export growth and output growth.

In evaluating the results from these studies, one should note that the simple (Pearson's) and rank (Spearman's) correlations do not indicate anything further than a *linear association* between the variables in question. Nor do they have any explanatory power or imply causality. The results from such analyses, therefore, can at best be suggestive as to the *ex-post* nature of the relationship.

Estimation of (pooled) cross-section production functions: This approach attempts a sources-of-growth accounting exercise based on a neoclassical production function. In this framework,

[14] The recent interest in cross-section production function estimation is rather due to the testing of the neoclassical growth theory versus endogenous growth theory through the 'convergence' hypothesis. See, for example, Barro (1991), Mankiw, Romer, Weil (1992), and Knight, Loayza, and Villanueva (1993). See also Friedman (1992) and Quah (1993) for a critique of this literature.

exports are considered a factor of production through their higher productivity, economies of scale, and externality effects on the domestic sector. There are two versions of this approach. The first version uses the following specification:

$$\Delta Y/Y = \alpha + \beta_1 * (I/Y) + \beta_2 * (\Delta L/L) + \beta_3 * (\Delta X/X) + u \qquad \textbf{(2.1)}$$

where $\Delta Y/Y$ is the growth rate of output, $\Delta I/Y$ is the share of investment in GDP, $\Delta L/L$ is the growth rate of the labour force, and $\Delta X/X$ is the growth rate of exports. Then, the additional impact of the export growth variable on the output growth rate can be tested using a t-test on the coefficient of the export growth variable.

Michalopoulos and Jay (1973), Krueger (1978, chapter XI), Balassa (1978), Tyler (1981), Kavoussi (1984), and Ram (1985, 1987) used equation (2.1) or a variation of it in their studies. In general, all of these authors found a positive and significant coefficient for the export growth variable in the production function.

The second approach is due to Feder (1983).[15] In his seminal study, Feder (1983) attempted to identify the externality and higher productivity effects of export expansion in a sources-of-growth model. The details are given in the appendix to this chapter. The estimated equation (Feder's equation (11)) is the

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[15] Balassa (1978) estimated a production function similar to Feder's. However, the theoretical development is due to Feder (1983).

following:

$$\Delta Y/Y = \alpha * (I/Y) + \beta * (\Delta L/L) + [\delta/(1+\delta)+F_x] * (\Delta X/X)*(X/Y) \qquad \textbf{(2.2)}$$

where δ is a measure of marginal factor productivity difference between the non-export and the export sectors, F_x is a measure of inter-sectoral externalities, α is the marginal productivity of capital in the non-export sector, and β is the marginal product of labour in the non-export sector.

Feder (1983, p. 63) also shows that the last coefficient, $[\delta/(1+\delta)+F_x]$, can be referred to as the social marginal productivity of investment in exports. As a result, Feder (1983, p.63) interprets the above equation as follows:

> the rate of growth of GDP is composed of the contribution of factor accumulation (i.e., growth of capital and labour) and the gains brought about by shifting factors from a low productivity sector (non-exports) to a high real productivity sector (exports).[16]

Rewriting equation (2.2), Feder (1983) obtains:

$$\Delta Y/Y = \text{constant} + \alpha*(I/Y) + \beta*(\Delta L/L) + \gamma*(\Delta X/X)*(X/Y) + \epsilon, \qquad \textbf{(2.3)}$$

where $\gamma = [\delta/(1+\delta)+F_x]$, and ϵ is a well-behaved disturbance term.

The parameter estimates to equation (2.3) are given in Table 2.1. The results indicate a positive and significant γ, which implies that the marginal productivity in the export sector is higher than it is in the domestic goods sector.

[16] Note that the last variable on the RHS is not the growth rate of exports, but rather the incremental export-output ratio. This is the measure Michaely (1977) proposed.

TABLE 2.1 FEDER'S (1983) ESTIMATION OF EQUATION (2.3)

Feder (1983)	α	β	γ	N	Period	R-Bar-Sq.
extended sample	0.178 [3.54]	0.747 [2.86]	0.422 [5.45]	31	1964-73	0.69
limited sample	0.196 [2.43]	0.737 [1.98]	0.390 [3.99]	19	1964-73	0.65

N.B. Square brackets show the t-statistics.

Source: Feder (1983).

In an attempt to separate further the externality effect and the productivity differential, Feder derived the following equation:

$$\Delta Y/Y = \alpha * (I/Y) + \beta * (\Delta L/L) + [\delta/(1+\delta)-\theta] * (\Delta X/X)*(X/Y) + \theta * (\Delta X/X) \quad \textbf{(2.4a)}$$

or,

$$\Delta Y/Y = \alpha * (I/Y) + \beta * (\Delta L/L) + \gamma * (\Delta X/X)*(X/Y) + \theta * (\Delta X/X) \quad \textbf{(2.4b)}$$

where θ comes from the production function for the domestic sector, $N = F(K_n, L_n, X) = X^{\theta} * \psi(K_n, L_n)$. That is, exports are assumed to affect the production of domestic goods with constant elasticity.[17] It is noteworthy that if $[\delta/(1+\delta)] = \theta$, then equation (2.1) is obtained.

Parameter estimates of equation (2.4b) are shown in Table 2.2.

[17] See Esfahani (1991, fn. 6) for a criticism of this specification. Esfahani (1991, p.96) includes an intermediate imported good in his production function and in his approach, Feder's specification "...implies that if the country does not export, nothing is going to be produced in the economy even if the flow of imports continues." Esfahani derives the following modification: $N = F(K_n, L_n, X) = \theta X * \psi(K_n, L_n)$.

From these results, Feder (1983. pp. 69-70) concluded that:

> the gain in productivity due to closer-to-optimal allocation associated with export expansion contributed more than 2.2 percentage points to the growth of the strictly semi-industrialized countries, and close to 1.8 percentage points if the less strict definition of industrialization is used.

TABLE 2.2 FEDER'S (1983) ESTIMATION OF EQUATION (2.4)

Feder (1983)	α	β	γ	θ	N	Period	R-BAR-SQ.
extended sample	0.124 [3.01]	0.696 [3.40]	0.305 [4.57]	0.131 [4.24]	31	1964-73	0.81
limited sample	0.139 [2.05]	0.587 [1.92]	0.302 [3.58]	0.124 [2.99]	19	1964-73	0.77

N.B. Square brackets show the t-statistics

Source: Feder (1983).

Kavoussi (1984) introduced the commodity composition of exports into the production function by making the coefficient of $\Delta X/X$ (in equation (2.1)) a linear function of it. Thus, he obtained:

$$\Delta Y/Y = a + b * (I/Y) + c * (\Delta L/L) + (d_1 + d_2 * MX) * (\Delta X/X) + u \tag{2.5}$$

where MX is the share of manufactured goods in total merchandise exports. Then, the following equation was estimated:

$$\Delta Y/Y = a + b * (I/Y) + c * (\Delta L/L) + d_1 * (\Delta X/X) + d_2 * (\Delta X/X)(MX) + u. \tag{2.6}$$

His results indicated that (p. 248):

> in less advanced countries, export expansion enhances the growth of total factor productivity regardless of the composition of exports...in the more advanced economies, the effect of export expansion on the growth of total factor productivity is very sensitive to the share of manufactured goods in total exports.

Esfahani (1991) included intermediate goods imports in the production of export goods sector. He argued that "...the first and foremost purpose of exports (i.e., provision of foreign exchange for imports) has been neglected, and too much emphasis has been placed on the externality effects of competing in world markets." (Esfahani, 1991, p. 113) Furthermore, his empirical results showed that (p. 113):

> the major contribution of exports to the GDP growth rate is to relieve the import shortage that many [semi-industrialized countries] confront. Once the import supply effect of exports has been taken into account, there does not seem to be any significant externality effect left. Moreover, contrary to a number of previous studies, increases in the share of manufactured goods among exports do not seem to help the export externality effect.

However, Esfahani (1991, p. 114) continued to support the export promotion policies in semi-industrialized countries on the grounds that:

> export promotion policies [...] can be quite valuable in supplying foreign exchange, which relieves import shortages and permits output expansion. Although this role of exports may be temporarily replaced by foreign assistance, long-term growth of any developing country depends on the steady and strong expansion of its export sector.

Levine and Renelt (1992) investigated the robustness of the results from cross-country production functions to the set of explanatory variables used. Using Leamer's extreme bounds analysis, Levine and Renelt (1992,p. 942) found that "...almost all results are fragile [to changes in model specification]." The only robust correlations are between economic growth and the share of investment in GDP, and between investment share and the ratio of international trade to

GDP. More interestingly, the authors found (p. 953) that:

> if one substitutes imports or total trade for exports in cross-country growth or investment regressions, one obtains essentially the same coefficient estimate and coefficient standard error. Thus, researchers who identify a significant correlation using an export performance measure should not associate this result with exports per se, because it could be obtained using a corresponding measure of imports or total trade.

Although this still indicates an association of openness with economic growth, the effects of an export expansion becomes difficult to evaluate. Furthermore, the authors do not find a robust relationship between growth and the above trade variables, when controlled for the share of investment in GDP. As a result, they suggest (p. 954) that "...the relationship between trade and growth may be based on enhanced resource accumulation and not necessarily on the improved allocation of resources."

The time-series estimation of production functions: As longer spans of data became available, some authors estimated time-series aggregate production functions for individual developing countries. Two important studies are by Ram (1987) and Greenaway and Sapsford (1994b).

Ram (1987) estimated time-series production functions for 88 countries for the period 1960-82.[18] His overall findings generally suggested a positive sign for the export variables, but with large variations across the countries. Thus, he warned against the

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[18] He first estimated a regression of output growth on population growth, gross domestic investment/GDP ratio, and the growth rate of exports. Second, he replaced the last variable in his first model by the incremental export-output ratio.

"...hazards of relying entirely on cross-section results." (Ram, 1987, p. 57)

Greenaway and Sapsford (1994b) investigated the link between exports and economic growth for 19 countries which experienced periods of trade liberalization between 1950 and 1984. They also examined the sensitivity of the results to the specifications chosen. Their results showed that, while there is generally a positive link between trade liberalization and export growth, the link between export growth and output growth is ambiguous. A similar result was also obtained by Harrigan and Mosley (1991). The authors found that the structural adjustment programs (where trade liberalization is a component) lead to increased export earnings, but the effect on output growth is rather weak. Again, these findings indicate that the empirical link between export growth and economic growth is ambiguous.

Granger-Sims Causality Tests: The observed positive correlation between export growth and output growth can also arise if output growth causes export growth. The rank correlation studies cannot provide insights on this matter. The production function approach assumes that export growth causes output growth and there is no simultaneity. The motivation behind testing for Granger-Sims causality between exports and output growth is to address these shortcomings. This approach also has the flexibility to test whether the data at hand are compatible with other theories. For example, export growth may lead to a decrease in the rate of output growth, or vice versa. Furthermore, cross-section studies assume identical production functions across countries. As noted by van den Berg and Schmidt (1994), the nonstationary nature of many time series makes period averaging inappropriate. This is because a nonstationary series does not have constant mean, and its variance tends to go to infinity. The causal approaches offer a way out of these problems, although they do not offer a complete sources-of-growth framework.

Kravis (1970) was the first to suggest a Granger-type causality test in the exports-output growth framework. Kravis (1970, p. 853) wrote that: "...if...growth...was dominated by external demand[,] we should expect to find...an association between the timing of changes in exports and in G.N.P. with the latter following the former..." He further suggested (p. 853) that the U.S. in the 19th century showed signs of "export-dominated growth", with changes in exports leading the changes in GNP.

In the framework of Granger-causality tests, Jung and Marshall (1985) tested for the causal links between export growth and output growth for 37 countries. Their results were 'surprising' as they could establish a causal link from export growth to output growth only in four cases: Indonesia, Egypt, Costa Rica, and Ecuador. In the cases of South Korea and Taiwan, they found "export-reducing growth (ERG)" and, "internally-generated exports (IGE)", respectively.

Chow (1987) approached the problem using a Sims-type causality test. Chow (1987) used total exports and manufactured output as his variables. His sample consisted of eight countries (Argentina, Brazil, Hong Kong, Israel, South Korea, Mexico, Singapore, and Taiwan), with data from the 1960s to 1980s. The results showed no causality in the case of Argentina, unidirectional causality from exports to manufactured output in Mexico, and feedback between the two in all other cases. Consequently, Chow (1987, p.61) concluded that: "...depending on the size of the domestic market, export growth can cause industrialization, either unidirectionally, or bidirectionally by influencing the development of manufacturing industries."[19]

Bahmani-Oskooee, Mohtadi, and Shabsigh (1991) re-examined the causal relationship between export growth and economic growth for 20 countries. Their study employed a Granger-type test, with lag-lengths chosen by Akaike's FPE criterion. Their results showed the following causal links from export growth to output growth: 1) unidirectional positive causality (the Dominican Republic and Taiwan); 2) unidirectional negative causality (Paraguay, Peru, and El Salvador); 3) positive feedback between the two (South Korea and Thailand); 4) internally generated exports (South Africa); 5) no causality (Brazil, Ecuador, Greece, Guyana, Honduras, Jamaica, Morocco, the Philippines, Sri Lanka, and Tunisia); and 6) positive causality from exports to growth but negative causality from growth to exports in the case of Indonesia. However, the authors took their evidence (p. 414) as "...some support in favour of the export-led growth hypothesis."

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[19] Sephton (1989) criticized the findings of Chow (1987) on methodological grounds. His points included inadequate filtering of the series and very few degrees of freedom, among others.

Kunst and Marin (1989) and Marin (1992) are two key papers that explicitly tested for the causal relationship between export growth and productivity growth. The former study investigated the role of export growth in explaining productivity growth in the Austrian manufacturing sector. The results indicated a unilateral causality from productivity growth, measured as manufacturing output per employee, to manufacturing sector exports. This finding is compatible with a version of Verdoorn's law - a causal link from output growth to export growth due to productivity growth. Marin (1992) extended the above analysis to Germany, the U.K., the U.S., and Japan. For these countries, the findings are different from the Austrian case. In all four countries, exports were found to Granger-cause productivity.

Giles, Giles and McCann (1992), Bahmani-Oskooee and Alse (1993), Kugler and Dridi (1993), Dutt and Ghosh (1994), and van den Berg and Schmidt (1994) are the only published studies to date that have applied the recently developed cointegration tests to the study of exports and economic growth in developing countries.[20] Bahmani-Oskooee and Alse (1993, pp. 535-536) argued that the previously conducted Granger-Sims tests for export-output causality should be re-examined. Their reasoning is as follows (ibid. p. 536):

> ... [N]one of the studies have checked for the cointegrating properties of the time series involved. Standard Granger or Sims tests are only valid if the original time series from which growth rates are

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[20] The concept of cointegration and the tests for cointegration are explained in Chapter IV.

> generated are not cointegrated. [...] If a country's exports and output data are found to be cointegrated, then the conclusions reached by previous studies using the simple Granger test are all nullified.

Secondly, the authors argue that in the case where exports and output are cointegrated, an error correction model should be constructed in order not to lose the long-run information in the series. Upon empirical investigation, the authors found evidence of cointegration between exports and GDP (in log levels) for the following nine countries: Colombia, Greece, South Korea, Malaysia, Pakistan, the Philippines, Singapore, South Africa, and Thailand.[21] As surveyed above, the causality testing approach did not generally support the hypothesis that increased exports lead to increased output growth.[22] However, by taking into account the long-run information, the results from cointegration and error correction models have been more favourable to the hypothesis.

Giles, Giles and McCann (1992) analyzed the role of exports in New Zealand's economic growth performance by means of cointegration, error-correction, and vector autoregressive models. The authors argued that the commodity composition of exports is important in studying the relationships between exports and economic growth. They, therefore, used disaggregated export data (by Standard International Trade Classification (SITC)) as well as aggregate data. Their findings rejected the export-led growth

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[21] Bahmani-Oskooee and Alse (1993) used quarterly data from 1973 to 1988. The quarterly data for the real GDP figures were generated by using temporal disaggregation methods.

[22] Tables 2.A.1 and 2.A.2 give a summary of the previous literature on the topic in more detail.

hypothesis at the aggregate level, but not when disaggregated data are used. In particular, they found that the export of live animals and meat, minerals, chemicals, plastics, manufactured goods, and metals have contributed positively to economic growth in New Zealand.

Kugler and Dridi (1993), and Dutt and Ghosh (1994) examined only whether exports and GDP are cointegrated or not. Their findings indicated cointegration of the series in many cases. However, these authors did not analyze the direction of causality. Furthermore, the study by van den Berg and Schmidt (1994) showed that cointegration findings are sensitive to the tests employed.

Until recently, a bivariate framework has been used to test for the exports-output causality and cointegration. This may have led to biased inferences due to omitted variables. As Esfahani (1991) suggested, imports provide an important channel through which export growth can enhance output growth. Another problem is whether there is a minimum level of economic development required for the export promotion policies to lead to export-led growth. This question received much attention in the literature using cross-section data, and has produced mixed results. The export-output causality literature has generally used bivariate models and ignored the level of economic development. The only study to address this problem to date is by Suliman *et al.* (1994). The authors used a trivariate model including exports, manufacturing output, and degree of financial development (measured by the ratio of currency to money supply). The conclusion one can draw from these studies is that a multivariate error-correction and causality framework is required for drawing inferences about the relationship between exports and output growth. In this context, the following section gives more insights into the role of imports.

2.3. IMPORTS: AN OMITTED VARIABLE IN THE EXPORTS-OUTPUT GROWTH RELATIONSHIP?

Esfahani (1991) argued that export earnings mainly help an LDC economy by relaxing the foreign exchange constraint. This view is also shared by Khan and Knight (1988) in a different (but related) perspective. They argue that (p. 315):

> ...in most developing countries imports of intermediate and capital goods are themselves critical inputs in the production of exports. Consequently, imports compression can adversely affect export performance. Furthermore, slower export growth reduces foreign exchange availability, which in turn forces the country to import less...These two feedbacks may lead to a 'vicious circle' of declining imports and exports.

Another topic in the relationship of exports and imports is the degree of import dependence of domestic production and its behaviour over time. For example, Chu (1988, p. 265) showed that "...the level of import content in exports increased during the course of Taiwan's export-led growth." Chu (1988, pp. 271-272) gives the following as one of the possible explanations:

> ...for many of Taiwan's export industries, import substitution did not precede export promotion. Therefore, when export production begins, the technology adopted is usually imported from abroad...once the new technology, usually import-intensive, has been introduced for export purposes, it will also have an impact on production for the domestic market and thus contribute to the overall increase of the level of import dependence.

These observations and findings have major implications. First, when a developing country starts to follow an export-oriented growth strategy, it is reasonable to expect that the import bill will also increase because of the import requirements in the exportables' production. This effect might be magnified in the case of low income countries where there is no significant industrial base. This may explain why a certain level of economic development should be attained before exports show a significant impact on economic growth. Second, Chu's findings that a new technology will also affect the production for the domestic market support the increased productivity/technological change case put forth in favour of the export-led growth strategy. However, as he states, this contributes further to the increase in overall import dependence. This, in turn, can be detrimental to economic growth, especially when external demand conditions are unfavourable.

Hoffmaister (1992) investigated the link between exports and imports in another context. He examined the "cost of export subsidies" in Costa Rica over the 1980s. His paper is especially important since it points to the drawbacks of an export-promotion (ultra-export-promotion in Bhagwati's sense) strategy under import-dependence. The costs of export promotion arise from: One, administrative costs; two, the cost of subsidies and other incentives; and three, an increased import bill. In the case of Costa Rica, Hoffmaister (1992, p. 166) calculated that the subsidies increased total exports by US$ 275 million over the period 1984:2 - 1989:4. This amounted to a 10 percent increase in total exports. The direct cost of the subsidization program was estimated to be US$ 205 million. The administrative costs and the increase in the import bill are not included in this figure. Given that Costa Rican exports contain about 40 per cent of domestic value added, the net gain in export earnings is US$ 110 million. Without accounting for the administrative costs of the subsidization scheme, "...[t]his implies that out of each dollar transferred from taxpayers to exporters via the export subsidy, 46 cents ended up subsidizing the import of intermediate inputs" (Hoffmaister, 1992, p. 166). This is an important result that shows that an export-promotion strategy through direct subsidization of exports ends up by subsidizing the intermediate imports, (i.e., de facto), it becomes a protected-export-promotion regime in the sense of Liang (1992).

These examples show that imports of intermediate goods and the import contents of exportables and domestic goods are too important to be ignored in studies of linkages between exports and economic growth, or, more generally, in trade strategy and economic growth relationships.

2.4. GRANGER-CAUSALITY TESTS AND ACCOUNTING IDENTITIES

In the study of exports and economic growth relationship, some authors argued that the positive correlation between exports and output growth is inherent because of an accounting identity effect, i.e., since exports are a part of output themselves [Michaely

(1977), Sheehey (1992, 1993)].[23] In response to these criticisms, it was argued that the correlation between export growth and output growth net of exports could be used instead, or that the production function approach gives a structural interpretation to the relationship between exports and output growth.[24] Despite the increasing number of studies investigating export-output causality, no author has formally demonstrated whether or not the Granger-causality tests suffer from an accounting identity effect. In this section, it is demonstrated that a variable X does not Granger-Cause Y if the only relationship between the two is an accounting identity. The proof is as follows.[25]

The national income identity, in levels, for the current period (t) can be written as follows:

$$Y_t = C_t + I_t + G_t + X_t - M_t. \tag{2.7}$$

One may argue that if the relationship between X_t and Y_t arises only because of the above identity, X_{t-i} $(i=1,\ldots,\infty)$ and Y_t should be uncorrelated. This argument is not correct since a built-in correlation can still arise under an autoregressive process for Y_t. This is because Y_{t-i} and X_{t-i} are correlated, and Y_t and Y_{t-i} are also correlated.

Suppose one assumes that each series in levels in equation

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[23] See also Greenaway and Sapsford's (1994a, pp.159-160) discussion of the inherent correlation problem.

[24] See Michaely (1977), Balassa (1978), Tyler (1981), Feder (1983) and the Appendix to Greenaway and Sapsford (1994b).

[25] This section follows Atukeren (1994).

(2.7) has a unit root.[26] Then, equation (2.7) can be re-written as:

$$Y_{t-1} + \epsilon_{Yt} = (C_{t-1} + \epsilon_{Ct}) + (I_{t-1} + \epsilon_{It}) + (G_{t-1} + \epsilon_{Gt}) + (X_{t-1} + \epsilon_{Xt}) - (M_{t-1} + \epsilon_{Mt}) \tag{2.8}$$

Notice that the Y, C, I, G, X and M are still in levels, driven by stochastic trends and current white noise innovations (ϵ_t). A unit root process is a difference stationary one, and by taking first differences, equation (2.8) can eventually be written as follows.[27]

$$\epsilon_{Yt} = \epsilon_{Ct} + \epsilon_{It} + \epsilon_{Gt} + \epsilon_{Xt} - \epsilon_{Mt}, \tag{2.9}$$

where all ϵ_t satisfies $E(\epsilon_t)=0$, $E(\epsilon^2{}_t)=\sigma^2$, and $E(\epsilon_t\epsilon_s)=0$ for $t\neq s$.

In the context of equation (2.9), innovations in exports are inherently contemporaneously correlated with innovations in output. However, the lagged innovations in exports are not correlated with the current innovations in output, since ϵ_{Yt} is serially uncorrelated, or $E(\epsilon_{Yt}\epsilon_{Ys})=0$ for $t\neq s$. In the context of Granger-causality tests, this means that X (or any other variable on the RHS of equation (2.7)) does not cause Y if the only relationship

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[26] This is a plausible assumption since most macroeconomic series are found to have unit roots in levels. See Nelson and Plosser (1982). Kugler (1991) and Bahmani-Oskooee and Alse (1993) also report unit root processes for exports and output series. Note that assuming a unit root process for each series is not necessary for the results of this argument to hold.

[27] $Y_t = Y_{t-1} + \epsilon_t$ and $Y_{t-1} = Y_{t-2} + \epsilon_{t-1}$.
Then, $(Y_t - Y_{t-1}) = (Y_{t-1} + \epsilon_t) - (Y_{t-2} + \epsilon_{t-1})$.
Substituting $Y_{t-1} = Y_{t-2} + \epsilon_{t-1}$ in this equation, one can obtain:
$(Y_t - Y_{t-1}) = (Y_{t-2} + \epsilon_{t-1} + \epsilon_t) - (Y_{t-2} + \epsilon_{t-1})$.
Or, $(Y_t - Y_{t-1}) = \epsilon_t$. The same procedure can be applied to C, I, G, X, and M.

between the variables is an accounting identity.[28] In view of Granger's definition of causality, the above results can be summarized as follows. Let X and Y be two distinct covariance stationary variables. X does not Granger-cause Y if Y cannot be better predicted by using the history of X in addition to all the information available in the universe, including the history of Y itself. In equation (2.9), the history (lags) of ϵ_{Xt} are uncorrelated with ϵ_{Yt}. Thus, exports do not Granger-cause output if the relationship between the two comes *only* from an accounting identity.

This shows that the Granger-causality tests do not suffer from an accounting identity relationship. Indeed, the observed lack of causality between exports and output may be indicative of a spurious relationship between the two under the rank correlation or the production function approaches. In that case, where the rank correlation and production function approaches obtained a positive relationship between the two, Granger-causality tests would indicate no causality. Thus, these results are compatible if the relationship is only due to an accounting identity. On the other hand, if a (positive) Granger-causal relationship from exports to output is detected, this can be attributed to the positive externalities or the foreign-exchange-providing role of exports in enhancing economic growth.

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[28] This is why it is not necessary to assume a random walk process for each variable in equation (2.7). Some or all of the variables may follow deterministic trends, but the Granger-causality tests are still conducted between the innovations of each series.

2.5. THE QUESTION OF DIRECTION AND SIGN IN EXPORT-OUTPUT CAUSALITY

One important contribution of the Granger-Sims causality tests in the export growth - output growth relationship is the attention brought to the direction as well as the sign of causality. For example, one may observe a positive relationship between export growth and (real) output growth, but this result may be due to a causal flow from output growth to export growth. In this case, it would be incorrect to infer that export growth enhances output growth. In what follows, we provide a discussion of the possible causal flows between export growth and real output growth. The abbreviations follow the convention in the literature. The four possible cases of causality are the following.

EXPORT PROMOTION (EXPORT-LED GROWTH) (EP): This is the case where an expansion in exports causally leads to the growth of real GDP. This may occur due to increased efficiency in resource allocation, intersectoral productivity spillovers, or because exports provide the foreign exchange for intermediate goods and raw materials imports.

INTERNALLY GENERATED EXPORTS (IGE): In this case, one still observes the positive correlation between export growth and output growth, but the direction of causality runs from output growth to export growth. This is referred to as the internally generated exports hypothesis. Jung and Marshall (1985, p. 4) give the following example.

> Consider a growing economy where learning and technical progress are proceeding rapidly in a few industries. The learning and technical progress that are taking place may have little to do with any conscious government policy to

> promote exports or even to promote production in those industries. It may be more related to the accumulation of human capital, cumulative production experience, technology transfer from abroad through licensing or direct investment, or physical capital accumulation...Given this unbalanced growth, it is unlikely that demand for goods from these boom industries will grow as rapidly as their production. Thus producers are likely to turn to foreign markets to sell their goods...Ordinary correlations between export growth and output growth are unable to discriminate between the export promotion hypothesis and the internally generated exports hypothesis.

Afxentiou and Serletis (1991, pp. 168-169) discuss the IGE hypothesis based on Verdoorn's law.[29] The authors give the following explanation.

> Based on Verdoorn's law, and the strength of increasing returns to scale in industrial activities, which include manufacturing, public utilities, and construction, and the rate of absorption of new equipment, which is a function of the rate of growth of the working population, the principal determinant of GDP productivity, according to Kaldor, is the growth of productivity in the industrial sector. Stimulated by increased productivity, the growth of output is enhanced, and in the words of Kaldor (1967, p. 42): '[...] the very fact of a faster growth of output...could be expected to act as a stimulus to exports; when output and capacity are both enlarged, productivity is increased and unit costs are reduced. It is easier to sell abroad'.

As the above arguments suggest, the IGE hypothesis is also linked to the assumptions of the endogenous growth theory where increasing returns, human capital accumulation and cumulative production experience are the key elements. This supports Lal and Rajapatirana's (1987) argument that a causal finding from output growth to export growth can be interpreted as evidence for outward-

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[29] See also Chan, Clark and Davis (1990) and their Table 1 on p. 107 for a political economy approach.

oriented growth.

GROWTH REDUCING EXPORTS (GRE): This is also a plausible hypothesis since export promotion programs involve welfare costs elsewhere in the economy. For example, the rent-seeking activities under such programs increases the welfare cost of export promotion programs.[30] In this respect, both import-substitution and export-promotion programs introduce distortions in the economy. The effect may be such that the gain in exports is less than the welfare costs involved. The GRE hypothesis is implied by the "Dependency School" in economic development.[31] This situation is termed as the growth reducing exports hypothesis. The 'Dutch Disease' is also consistent with the GRE hypothesis. Empirically, the GRE hypothesis is characterized by a finding of negative causal link from export growth to output growth.

EXPORT REDUCING GROWTH (ERG): The export reducing growth hypothesis means that producers supply the home markets first in the face of economic growth in the domestic economy. Jung and Marshall (1985, p. 4) suggest another reason for the ERG hypothesis: "...real growth that is induced by an exogenous increase in consumer demand that is heavily concentrated in exportable and non-traded goods could lead to a decline in exports. Thus, output growth could cause decreased export growth."

The empirical support for the ERG hypothesis comes from a

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[30] See Yeldan and Roe (1991) and Hoffmaister (1992) for theoretical and empirical analyses of the problems with export subsidies.

[31] See, Frank (1969).

finding of negative causal link from output growth to export growth.

2.6. CONCLUSIONS

This chapter reviewed the empirical literature on the relationship between export growth and economic growth. Two major approaches have dominated the empirical work in this area. The first one utilized cross-section data either using rank correlations or employing a production function. The results have strongly supported the hypothesis that exports are significantly associated with economic growth. This effect may arise from economies of scale brought about by the external markets, increased productivity through international competition and new technology, more efficient use of resources and reduced managerial slack, and the positive effects of all these on the domestic goods sector. Trade liberalization and re-alignment of exchange rates may also improve the domestic resource allocation and reduce deadweight losses from an inward-oriented regime. The second approach took the form of causality tests. The evidence from this approach has generally been unfavourable to the export-led growth hypothesis.

The role of intermediate goods imports in the exports-economic growth relationship has also been examined. A discussion of the literature showed that the links are too important to be ignored. In this context, an outward-oriented strategy is better than an (ultra) export-led strategy. As a result, the literature presented so far indicates that there are static and dynamic gains in pursuing an outward-oriented strategy, and that he export-led growth strategy does not appear to be first-best. With regard to the empirical methodology, a multivariate approach to tests of causality and cointegration would be more useful in analyzing the growth performance of developing countries. Finally, it has been demonstrated that tests of Granger-causality do not suffer from an accounting identity effect. Thus, the finding of a causal relationship from exports to output growth can be interpreted as evidence of positive externalities or the role of foreign exchange by exports in enhancing economic growth.

APPENDIX TO CHAPTER 2.

1) FEDER'S (1983) MODEL

This appendix summarizes the theoretical developments in Feder's (1983) paper. Some of the empirical results have been given in Chapter 2. Further details are given in the original source.

Feder divides the economy into two sectors, non-export and export. To derive a testable hypothesis, the export sector's production is assumed to affect the non-export sector's production. That is:

$$N = F(K_n, L_n, X) \tag{A.1}$$

$$X = G(K_x, L_x) \tag{A.2}$$

where, N = non-exports,
X = exports,
K_n, K_x, = respective sector capital stocks,
L_n, L_x = respective sector labour forces.

The respective marginal factor productivities between the two sectors are assumed to deviate from unity by a factor δ:

$$(G_K/F_K) = (G_L/F_L) = 1 + \delta. \tag{A.3}$$

Totally differentiating equations (A.1) and (A.2), one obtains:

$$dN = F_K I_n + F_L dL_n + F_X dX \tag{A.4}$$

$$dx = G_K I_x + G_L dL_x \tag{A.5}$$

where, I_n and I_x are respective sectoral gross investments, dL_n and dL_x are sectoral changes in labour force, and F_x describes the marginal externality effect of exports on the output of non-exports. Since GDP $(Y) = N + X$, one can also derive:

$$dy = dN + dX. \tag{A.6a}$$

Substituting (A.4) and (A.5) into (A.6a), one obtains:

$$dY = F_K I_n + F_L dL_n + F_X dX + G_K I_x + G_L dL_x. \qquad \textbf{(A.6b)}$$

From equation (A.3), $G_K = (1+\delta)\ F_K$ and $G_L = (1+\delta)\ F_L$. Thus, re-arranging equation (A.6b) yields:

$$dY = F_K I_n + F_L dL_n + F_X dX + (1+\delta) F_K I_x + (1+\delta) F_L dL_x \qquad \textbf{(A.7a)}$$

or,

$$dY = F_K\ (I_n + I_x) + F_L\ (dL_n + dL_x) + F_X dX + \delta(F_K I_x + F_L dL_x). \qquad \textbf{(A.7b)}$$

Note that total investment and the change in the total labour force can be written as $I = I_n + I_x$ and dL = dLn + dLx, respectively. Also note that from equations (A.3) and (A.5), one can obtain:

$$F_K I_X + F_L dL_X = \frac{1}{1+\delta}(G_K I_X + G_L dLX) = \frac{dX}{1+\delta}. \qquad \textbf{(A.8)}$$

Combining (A.8) and (A.7b) and using the above identities, one finally obtains:

$$dY = F_K I + F_L dL + (\delta/(1+\delta) + F_X) dX. \qquad \textbf{(A.9)}$$

Feder also specifies a linear relationship between the marginal productivity of labour in a given sector and average output per labourer (an implicit Cobb-Douglas technology) in the economy as:

$$F_L = \beta(Y/L). \qquad \textbf{(A.10)}$$

Dividing both sides of (A.9) by Y, denoting $F_K = \alpha$, and writing dX/Y = (dX/X)(X/Y), Feder obtains the following estimable equation, which forms a basis for his empirical results:

$$dY/Y = \alpha(I/Y) + \beta(dL/L) + (\delta/(1+\delta)+F_X)\ (dX/X)(X/Y). \tag{A.11}$$

Feder notes that this equation reduces to a neoclassical sources of growth model, if marginal productivities are equalized across sectors (δ=0) and if there are no inter-sectoral externalities (F_X=0).

Feder further attempts to decompose $(\delta/(1+\delta)+F_X)$ into its components. For that task, he specifies the following production function, where exports affect the production of non-exports with constant elasticity:

$$N = F(K_n, L_n, X) = X^{\theta}\,\psi(K_n, L_n) \tag{A.12}$$

where θ is a parameter. Then, $\partial N/\partial X \equiv F_X = \theta(N/X)$. **(A.13)**

Therefore, equation (A.11) can be re-written as:

$$\frac{dY}{Y} = \alpha\frac{I}{Y} + \beta\frac{dL}{L} + \left(\frac{\delta}{1+\delta} + \theta\frac{N}{X}\right)\frac{dX}{X}\frac{X}{Y} \tag{A.14}$$

$$But,\ \theta\left(\frac{N}{X}\right) = \theta\frac{(N/Y)}{(X/Y)} = \theta\frac{[1-(X/Y)]}{(X/Y)} = \frac{\theta}{(X/Y)} - \theta. \tag{A.15}$$

Therefore, substituting (A.15) into (A.14), one obtains:

$$\frac{dY}{Y} = \alpha\frac{I}{Y} + \beta\frac{dL}{L} + \left(\frac{\delta}{1+\delta} - \theta\right)\frac{dX}{X}\frac{X}{Y} + \theta\frac{dX}{X}. \tag{A.16}$$

Note that if it is assumed that $\delta/(1+\delta) = \theta$, then the model reduces to the familiar:

$$dY/Y = \alpha\ (I/Y) + \beta\ (dL/L) + \theta\ (dX/X). \tag{A.17}$$

Furthermore, under equation (A.16), it is possible to separate the effects of marginal productivity differentials and externality effects of the exports sector on non-exports.

2) EMPIRICAL STUDIES OF EXPORTS AND ECONOMIC GROWTH: A SUMMARY

TABLE 2.A.1 A SUMMARY OF CORRELATION AND PRODUCTION FUNCTION STUDIES OF EXPORTS AND OUTPUT GROWTH RELATIONSHIP

Study	Data Set	Economic Growth	Export Growth	Technique	Other Variables	Conclusions
Michaely (1977)	Cross-Section 41 Countries 1950-1973	Per Capita GNP Growth	Growth in the share of exports in GDP	Spearman's Rank Correlations	None	Support for EOG Hypothesis; Threshold Effect
Balassa (1978)	Cross-Section 10 countries 1956-1967 and 1967-1973	GNP Growth	Export Growth or Real Export Growth	Rank Correlation, Production Functions	L, I, Foreign Investment	Support for EOG Hypothesis
Williamson (1978)	Cross-Section 22 Countries 1960-1974	Changes in GDP	Lagged Exports	OLS, Linear Models	Country Dummies, Direct Investment, Other Foreign Capital	Support for EOG Hypothesis
Fajana (1979)	Time Series, 1954-1974, Nigeria	GDP Growth	Export Shares or Export Change/Output	OLS	Trade Balance, Current Account	Support for EOG Hypothesis
Tyler (1981)	Cross-Section 55 Countries	GDP Growth	Export Growth	OLS, Production Functions	L, I	Support for EOG Hypothesis, Threshold Effect
Feder (1983)	Cross-Section 31 Countries	GDP Growth	Export Growth or Export Change/Output	OLS	L, I	Support for EOG Hypothesis
Kavoussi (1984)	Cross-Section 73 Countries	GDP Growth	Export Growth	Rank Correlation, Production Function (OLS)	L, I	Support for EOG Hypothesis, Threshold Effect
Balassa (1985)	Cross-section, 10 countries	GNP growth	Export Growth	OLS, production functions	L,I	Support for EOG hypothesis

TABLE 2.A.1 A SUMMARY OF CORRELATION AND PRODUCTION FUNCTION STUDIES OF EXPORTS AND OUTPUT GROWTH RELATIONSHIP
(Continued)

Study	Data Set	Economic Growth	Export Growth	Technique	Other Variables	Conclusions
Ram (1985)	Cross-Section 73 Countries, 1960-1960 and 1970-1977	Real GDP Growth	Real Export Growth	OLS, Tests for Heteroskedasticity and specification bias (Hausman)	L, I	Support for EOG Hypothesis, Threshold Effect
Esfahani (1991)	Cross-Section	Real GDP Growth	Real Export Growth	Simultaneous Equation Models	Intermediate Imports	Support for EOG Hypothesis
Salvatore and Hatcher (1991)	Time-Series, 1963-1973, 1973-1985, 26 Countries in 4 Groups by Trade Policy Orientation	Real GDP Growth	Real Export Growth	OLS, Production Functions	L, I Growth in Industrial Production	Support for EOG Hypothesis
Edwards (1992)	Cross-Section, 30 Countries, 1970-1982	Real GDP per Capita	Openness and Government Intervention Indices	OLS, Tests for Measurement Error, Endogeneity and Outliers	Human Capital, Political Instability, Government Size	Support for positive robust relationship between openness and growth
Levine and Renelt (1992)	Cross-Section	Real GDP Growth	Real Exports	OLS, Extreme Bounds Tests for Robustness	L, I Imports, Trade Volume	No Support for EOG Hypothesis
Ukpolo (1994)	Time-series production functions for 8 African countries, 1969-1988	Real GDP growth	Real exports (fuel, non-fuel primary, and manufactured exports)	OLS with Cochran-Orcutt.	Investment, Labour, private and public investment	Support for EOG in the case of non-fuel primary exports
Greenaway and Sapsford (1994a)	Cross-section, 104 countries, 1960-1973, 1973-1980, 1980-1988.	Real (PPP) GDP growth.	Growth in exports to output ratio.	OLS, tests for heteroskedasticity.	None	Support for EOG hypothesis, indirect evidence of threshold effects
Greenaway and Sapsford (1994b)	Time-Series, 19 Countries	Real GDP Growth	Real Export Growth	OLS	I, L	No Support for EOG Hypothesis

Source: Greenaway and Sapsford (1994b) with modifications. L stands for the growth in labour input. 'I' stands for the growth in capital input. EOG is for "Export Oriented Growth".

TABLE 2.A.2 A SUMMARY OF THE STUDIES TESTING FOR CAUSALITY AND COINTEGRATION BETWEEN EXPORTS AND REAL OUTPUT GROWTH

Study	Data Set	Economic Growth	Export Growth	Technique	Other Variables	Conclusions
Jung and Marshall (1985)	37 LDCs, 1950-1981	Real GDP	Real Exports	Granger's test with fixed lags (2)	None	Limited Support for EOG Hypothesis (4 out of 37)
Chow (1987)	1960-1984, 8 LDCs	Real Manufacturing GDP	Real Manufacturing Exports	Sims's test with filter (1-0.75L)[2]	None	Strong support for EOG (Except for Argentina)
Darrat (1987)	Hong Kong, S. Korea, Singapore, Taiwan, 1955-1982	Real GDP/GNP	Real Exports	White's Exogeneity Test	None	EOG only for S. Korea
Kunst & Marin (1989)	Austria, 1956-1982	Productivity (Output/Worker) (Manufacturing)	Manufactured Exports	Granger's test, AIC for lag-lengths, subset autoregressions	Terms of Trade, OECD GDP	No Support for EOG
Chan, Clark, & Davis (1990)	Taiwan, 1952-1987	Real GNP	Real Exports	Granger's Test, lags up to 4, Impulse Responses	Foreign Investment, Government Expenditures	No Support for EOG. Real GDP causes real exports.
Ahmad & Kwan (1991)	47 African Countries, 1981-1987	Real GDP, Real GDP per Capita	Total Exports (TX), Manufactured Exports (MX), (MX)/(TX)	Granger's Test, Pooled Time-Series, AIC for Lag Selection	None	No Support for EOG. Real GDP may cause (MX/TX).
Kovacic & Djukic (1991)	Yugoslavia, 1952-1987	Real GDP, Manufacturing Real GDP	Real Exports, Manufactured Real Exports	Tests for cointegration, Granger's Test, 4 different lag selection criteria	None	No CI, Support for EOG. Manufacturing GDP causes manufactured exports.
Sharma, Norris & Cheung (1991)	Germany, Italy, Japan, UK, USA, 1960-1987	Real GDP/GNP (Y)	Real Exports (X)	Granger's Test, FPE Criterion, Variance Decompositions	Capital, Labour	X causes Y in Germany and Japan; Y causes X in USA and UK.
Afxentiou & Serletis (1991)	16 Developed Countries, 1950-85	Real GNP/GDP, (Y)	Real Exports, (X)	Tests for cointegration, Granger's Test, Schwarz Criterion	None	Feedback between Y and X in the USA, Y causes X in Norway, Canada, and Japan. No support for EOG Hypothesis.
Bahmani-Oskooee, Mohtadi, Shabsigh (1991)	20 LDCs, 1951-1986	Real GDP	Real Exports	Granger's Test, FPE criterion	None	Weak support for EOG Hypothesis. X causes Y (+ sign) in 3 cases. 2 cases of positive feedback.

TABLE 2.A.2 A SUMMARY OF THE STUDIES TESTING FOR CAUSALITY / COINTEGRATION BETWEEN EXPORTS AND REAL OUTPUT GROWTH (Continued)

Study	Data Set	Economic Growth	Export Growth	Technique	Other Variables	Conclusions
Kugler (1991)	USA, Japan, Switzerland, Germany, France, 1970-1987, Quarterly Data (SA)	Real GDP/GNP	Real Exports	Tests for Cointegration, Granger's Test, AIC, Johansen and Stock & Watson Procedures	Consumption, Investment	Weak support for EOG. Export cointegrate with the other variables only in France and Germany.
Serletis (1992)	Canada, 1870-1985	Real GNP (Y)	Real Exports (X)	Tests for Cointegration, Granger's Test, Schwarz Criterion	Real Imports (M)	X causes Y, M causes Y and X causes M. Support for EOG Hypothesis.
Marin (1992)	Germany, UK, USA, Japan, 1960-1987, Quarterly Data	Productivity (Manufacturing Output per Worker) (Y)	Manufacturing Exports (X)	Tests for Cointegration, Schwarz Criterion, Granger's Test, Error Correction Models	Terms of Trade, OECD GDP	X causes Y in all countries except UK. Strong support for EOG Hypothesis.
Oxley (1993)	Portugal, 1865-1985	Real GDP (Y)	Real Exports (X)	Tests for cointegration, Granger's Test, FPE Criterion, Johansen's Procedure, Error Correction Models	None	Y causes X. No Support for EOG Hypothesis
Gordon & Sakyi-Bekoe (1993)	Ghana, 1955-1987	Real GDP (Y)	Real Exports (X)	Sensitivity of Causal Findings using 5 techniques	Investment	Results are sensitive to the tests used. Granger's test yields: Y causes X. Holmes and Hutton's test yields X causes Y.
Dodaro (1993)	87 Countries, 1967-1986	Real GDP/GNP (Y)	Real Exports (X)	Granger's test with 2 lags	None	In 4 cases, X causes Y, in 10 cases Y causes X, 2 cases of feedback. (with + signs)
Kugler & Dridi (1993)	11 LDCs, 1960-1989	Real GDP/GNP (Y)	Real Exports (X)	Tests for Cointegration, Johansen's Procedure, AIC	Consumption, Investment	X is cointegrated with the other variables in 7 cases. Support for EOG Hypothesis
Bahmani-Oskooee & Alse (1993)	9 LDCs, 1973-1988, Quarterly Data	Real GDP/GNP (Y)	Real Exports (X)	Tests for Cointegration, Error Correction Models	None	Strong Support for X causes Y and vice versa.

N.B. AIC: Akaike Information Criterion, FPE: Final Prediction Error, EOG: Export Oriented Growth, CI: cointegrated.

TABLE 2.A.2 A SUMMARY OF THE STUDIES TESTING FOR CAUSALITY / COINTEGRATION BETWEEN EXPORTS AND REAL OUTPUT GROWTH
(Continued)

Study	Data Set	Economic Growth	Export Growth	Technique	Other Variables	Conclusions
Dutt and Ghosh (1994)	26 LDCs, 1953-1991	Real GDP (Y)	Real Exports (X)	Various cointegration tests	None	20 out of 26 cases are cointegrated.
van den Berg and Schmidt (1994)	17 Latin American countries, 1960-1987	Real GDP	Real Exports	Various cointegration tests	I, L.	Cointegration between Y and X in many cases. (Results are sensitive to the tests.)
Giles, Giles, and McCann (1992)	New Zealand, 1963-1991, annual data.	Real GDP (Y)	Aggregate and disaggregated real Exports in SITC categories (X)	Cointegration, error correction, vector autoregressions	None	No support for X in the aggregate. Some support for X causes Y in SITC categories: 1,4,5, and 6.
Love (1994)	20 low-income and lower-middle-income developing countries. At least 25 observations. (Largest sample: 1960-1990)	Real GDP (Y) and real GDP net of exports (Y-X).	Real exports	Granger-causality test, vector autoregressive models, lags selected by the FPE criterion.	Government expenditures.	X causes Y in 14 cases (with a + sign in 10 cases). However, X causes (Y-X) only in five cases (+ sign). This study considers the case where X causes Y with a negative sign as indirect evidence for export-led growth provided that the country in question has an inward-looking regime.
Suliman et al. (1994)	South Korea, 1967-1989.	Real manufacturing GDP (MY).	Real Exports (X).	Granger-causality, vector autoregressive models. Lags selected by the FPE criterion.	The level of financial development (FD), measured by the ratio of curry to money supply.	X causes MY indirectly via FD.

N.B. AIC: Akaike Information Criterion, FPE: Final Prediction Error, EOG: Export Oriented Growth, CI: cointegrated.

CHAPTER III.

TESTS FOR AND EXTENSIONS OF GRANGER-CAUSALITY

3.1 INTRODUCTION

This dissertation uses vector autoregressive (VAR) models and their extensions to identify the causal links between exports, imports, and economic growth in developing countries. This chapter and the next provide an in-depth perspective on the tools of analysis. This chapter is organized as follows. First, a definition of Granger-causality is offered. This is followed by a discussion of the empirical problems in implementing tests of Granger-causality. Second, tests of Granger-causality are compared with other tests for causality with respect to their small sample performances. Third, it is emphasized that multivariate extensions to Granger-causality tests bring new issues and definitions which need to be addressed. In this context, the cases of indirect and spurious causality are defined and Hsiao's (1982) framework is extended to derive parametrically testable hypotheses for the cases of direct, indirect, and two types of spurious causality. Finally, a sequential procedure for testing the strength or decisiveness of Granger (non) causality is developed. The procedure has Bayesian foundations. It is based on the comparison of the posterior odds of competing causal hypotheses. The issues regarding the modelling of causal relationship with non-stationary variables are left to the next chapter.

3.2 ECONOMETRIC APPROACHES TO TESTING FOR 'CAUSALITY'

3.2.1. INTRODUCTION

Identifying the causal links between the variables of interest is a primary concern in economics. There are two major approaches to tackle this problem. The first one uses *a priori* restrictions to make a distinction between endogenous and exogenous variables. This means that the causal ordering among the variables of interest is known *a priori*. Choosing the relevant variables is not a trivial issue, since this amounts to placing zero parameter restrictions on all other variables. In this sense, the right-hand-side variables which are not contemporaneously correlated with the error terms of their respective equations are considered to be (weakly) exogenous, and are identified as the causes for the dependent variables. Data mining is an important problem of this approach.

Under the second approach, economic theory suggests only the variables of interest, and the researcher uses the data and the statistical tests of significance to place zero restrictions on the parameter space of a general model. The result of this exercise is a specific model. The seminal work of this methodology is Davidson *et al.* (1978). This approach avoids data mining. However, a price paid for this is that the end result, (i.e., the specific model), may be compatible with more than one theory.

Sim's (1980) vector autoregressive (VAR) approach is related to the second approach described above. Sims (1980) argues that everything causes everything else, and the traditional economic modelling methodology places too many and 'incredible restrictions' on the specification of a model. From an econometric point of view, if this is true, the results based on specific to general modelling would be biased depending on the severity of the omitted variable problem. However, given the limitations of the sample size, one still has to use economic theory to choose the most relevant variables, without classifying them as exogenous and endogenous *a priori*. In a VAR model, lagged values of all the variables in the system appear in each equation in the system. A further step in VAR models is to try to place zero restrictions on the parameter space based on Granger-Sims causality tests. This is an attempt to make the exogenous-endogenous classification of the variables in the system using the data itself. VAR models were very popular in the 1980s, and have been used extensively for purposes of forecasting, and of structural analysis thanks, in large part, to the causal interpretation of the findings.

3.2.2. TESTS OF GRANGER-SIMS CAUSALITY

There are four important features of the Granger-Sims notion of causality. First, there is no true instantaneous causality or simultaneous causality. The cause *precedes* the effect. Second, the future cannot 'cause' the present. This is the key feature behind Granger-Sims causality tests. Third, for a variable X to be a Granger-Sims cause of another variable Y, X should contain unique information about Y that is not available elsewhere. Fourth, the qualification *prima facie* should be added to any causal inference, since the information set used for such inferences contains considerably less information than is available in the universe. Moreover, the unstated assumption on the choice of the information set is that "...possible causation is not considered for any arbitrarily selected group of variables, but only for variables for which the researcher has some prior belief that causation is, in some sense, likely." (Granger, 1988, p. 201)

Granger (1988, p. 201) elaborates on the whole idea of testing for causality as follows:

> ...one may start with a 'degree of belief' that y_t causes x_{t+1}, measured as a probability, and after using a causality test based on these definitions, one's 'degree of belief' may change. For example, before the test the degree of belief could be 0.3 and after the test this could increase to 0.6. The extent to which the belief probability changes will depend on the perceived quality and quantity of data, the size and relevance of...[the information set]...and the perceived relevance, quality or power of the test. Naturally, using just statistical techniques, it is unlikely that the probability will go to one, or to zero, and if one does not like the definitions being used, then the tests are irrelevant and the degree of belief cannot change.

Granger's approach to testing for causal claims can now be presented. Let x and y be two distinct (covariance) stationary stochastic processes. This is not a trivial starting point, since filtering of non-stationary variables to achieve stationarity also affects the outcome of Granger-causality tests. That is, let $E(x_t)=0$, $E(x^2_t)=\sigma^2$, and $E(x_t x_s)/\sigma^2 = \delta_k$, $\delta = 1$ if $t=s$, and $\delta < 1$ if $t \neq s$, and $\delta_k = \delta_{-k}$; and one can similarly define y. Now, let $\underline{\underline{X}}_t = \{x_s : s < t\}$ and $\underline{\underline{Y}}_t = \{y_s : s < t\}$. Also, let A_t be all the information in the universe accumulated since time t-1. More specifically, this set can be reduced to include only the relevant information in the universe, and in the bivariate case, A_t consists only of $\{x_t, y_t\}$. The set $A_t - x_t$ consists of all the elements of A_t except x_t, and the sets A_t and $\underline{\underline{A}}_t - \underline{\underline{X}}_t$ are also defined analogously to $\underline{\underline{X}}_t$ (or $\underline{\underline{Y}}_t$). In other words, the set $\underline{\underline{A}}_t - \underline{\underline{X}}_t$ contains the lagged values (up to t-1) of all the relevant variables in the universe, excluding the history of the x variable. Furthermore, let $\sigma^2(y \mid \underline{\underline{A}})$ be the mean square error of the minimum mean-square linear prediction error of y_t given the information set $\underline{\underline{A}}_t$, (i.e., the mean square error of the residuals from a least squares regression of y_t on past y and x). Granger's (1969) definition of causality can then be written as follows.[32]

Definition 1: Causality. If $\sigma^2(y_t \mid \underline{\underline{A}}) < \sigma^2(y_t \mid \underline{\underline{A} - X})$, then x causes y_t. That is, x causes y_t if y_t can be better predicted by using all available relevant information than if the same information apart from the history of x had been used.

Definition 2: Feedback. If

$$\sigma^2(y_t \mid \underline{\underline{A}}) < \sigma^2(y_t \mid \underline{\underline{A} - X}), \text{ and}$$
$$\sigma^2(x_t \mid \underline{\underline{A}}) < \sigma^2(x_t \mid \underline{\underline{A} - Y}),$$

then a feedback between x and y is said to occur.

Definition 3: Instantaneous Causality. If

$$\sigma^2(y_t \mid \underline{\underline{A}}, x_t) < \sigma^2(y_t \mid \underline{\underline{A}}),$$

then, an instantaneous causality from x to y is said to occur. In

[32] The subscript "t" is omitted from the information sets for simplicity.

other words, the current value of y is better predicted if the current value of x is included in the prediction than if it is not.

Note that instantaneous causality is more likely to occur when temporally aggregated data are used. For example, a finding of instantaneous causality using annual data may disappear as one employs quarterly or monthly data. The definition of feedback is especially interesting as it emphasizes the *prediction* aspect of Granger's definition of causality and not *precedence*. Obviously, if causality in Granger's sense were defined only in terms of precedence or temporal ordering, then feedback would mean that x precedes y and y precedes x at the same time.

It is worth noting that Granger's definition of causality, or Granger-causality from now on, is not applicable to deterministic situations. Zellner (1984) sees this as a drawback. However, one can think of the case of Christmas card sales and Christmas. The former event precedes the latter and again from the former event we know conventionally that Christmas is not far away. But, since Christmas is not a stochastic event, we do not fall into a fallacy of saying that Christmas card sales Granger-cause Christmas. Furthermore, it is possible to predict perfectly or know in advance when Christmas will be this year by looking at its past alone. Therefore, Christmas card sales would not contribute to one's predictions, thus falling short of the condition for Granger-causality.

In applied research, the above definitions of Granger-causality are formulated in the following parametrically testable form:

$$y_t = \alpha_1 + \sum_{j=1}^{p} \beta_{1j} y_{t-j} + \sum_{j=1}^{q} \delta_{1j} x_{t-j} + \epsilon_{1t} \tag{3.1}$$

$$x_t = \alpha_2 + \sum_{j=1}^{r} \beta_{2j} y_{t-j} + \sum_{j=1}^{s} \delta_{2j} x_{t-j} + \epsilon_{2t}. \tag{3.2}$$

After estimating equation (3.1) and (3.2) by ordinary least squares, F-tests are carried out on the δ_{1j} and β_{2j} coefficients. Then, the following *prima facie* inferences can be drawn:

(a) If $\delta_{1j} = 0$ and $\beta_{2j} = 0$, for all j, there is *no Granger-causality* in any direction.

(b) If $\delta_{1j} \neq 0$ and $\beta_{2j} = 0$, for all j, *X Granger-causes Y unilaterally*.

(c) If $\delta_{1j} = 0$ and $\beta_{2j} \neq 0$, for all j, *Y Granger-causes X unilaterally*.

(d) If $\delta_{1j} \neq 0$ and $\beta_{2j} \neq 0$, for all j, *there is a feedback between X and Y*.

Granger's (1969) model imposes the same lag structure on all variables, i.e., p=q=r=s. In a more general case p, q, r, and s need not be the same. This gives a modified version of Granger's (1969) and Sim's (1980) approaches, popularized by Hsiao (1979, 1981). The idea behind specifying different lag lengths is the principle of parsimony. Given the limited sample sizes in economics, imposing identical lag structures on each variable in a VAR model quickly exhausts the available degrees of freedom, especially when more than two variables are involved. To ease this problem, Hsiao (1979, 1981) suggested the determination of lag lengths in a VAR model using a statistical model selection criterion. Under this approach, it is even possible to exclude a variable completely from an equation. Therefore, the individual equations of a model need not contain all the variables in the model. This is called the *constrained-VAR* approach. However, one still faces the problem of determining whether a variable appears in an equation and, if it does, selecting the appropriate lag length. For this purpose, Hsiao (1979, 1981) used Akaike's (1969) final prediction error (FPE) criterion. In addition to the FPE criterion, some of the other popularly used criteria are the following:[33] Akaike's (1974) information criterion (AIC), Schwarz (1978) Bayesian information criterion (BIC), Shibata (1981) criterion (SHIBATA), Hannan and Quinn (1979) criterion (HQ), Craven and Wahba's (1979) generalized cross validation criterion (GCV), among others. In fact, the problem at hand is a time-series identification problem. The conventional Box-Jenkins approach to time-series analysis relies on the visual inspection of autocorrelation functions and partial autocorrelation functions to identify a univariate time series.[34] However, the above mentioned criteria provide a mechanical rule for time-series identification: choose the model where the criterion used reaches a minimum. The same rule applies in VAR identification. The formulae for the above model selection criteria are as follows:

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[33] See, Ramanathan (1989, pp. 165-166 and pp. 219-222) for more details on various model selection criteria.

[34] Note that, identification in this context refers to time series model identification rather than the simultaneous equation context.

$$AIC = (ESS/T)\exp(2k/T) \quad (3.3)$$

$$FPE = (ESS/T)[(T+k)/(T-k)] \quad (3.4)$$

$$GCV = (ESS/T)[1-(k/T)]^{-2} \quad (3.5)$$

$$HQ = (ESS/T)(\ln T)^{(2k/T)} \quad (3.6)$$

$$BIC = (ESS/T)\ T^{(k/T)} \quad (3.7)$$

$$SHIBATA = (ESS/T)[(T+2k)/T] \quad (3.8)$$

where ESS is the error sum of squares, T is the sample size and k is the number of estimated parameters.

Of these six criteria, AIC, FPE and SCHWARZ are the most commonly used ones. Although all the above criteria have a similar structure, (i.e., (ESS/T) g(k,T)), there are conceptual differences in their interpretation.[35] The AIC has information-theoretic foundations in statistics. The Schwarz criterion is valid for the case of normally and independently distributed residuals and is the result of a Bayesian procedure of seeking the most probable (*a posteriori*) model. Thus, these two criteria do not concern themselves as to whether a true model exists or not (Charemza and Deadman 1992, p. 295). Furthermore, the AIC criterion has a tendency to overparameterize, even in large samples.[36] The Schwarz criterion avoids this problem and identifies the true model asymptotically.

The FPE criterion selects the model with the smallest ex-post prediction error. The FPE criterion "...balances the risk due to

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[35] The following discussion partly follows Charemza and Deadman (1992, pp. 293-295).

[36] See Hannan (1980).

the bias when a lower order is selected and the risk due to the increase of variance when a higher order is selected" [Hsiao (1981, p. 88)]. Therefore, as Charemza and Deadman (1992, p. 295) argue, the FPE criterion can, in principle, even reduce a true model in size if this would lead to improving the predictive quality of the model, given a particular sample. Thus, if used as a model selection criterion for Granger-causality tests, the FPE criterion may lead to biased inferences.

In small samples, it is even more difficult to decide what is the best model selection criterion. Lütkepohl (1985), Nickelsburg (1985), and Mills and Prasad (1992) examined the small sample properties of several model selection criteria using Monte-Carlo simulations. Lütkepohl's simulations pointed out the Schwarz criterion as the one which (p.35) "...chooses the correct autoregressive order most often and leads to the smallest mean squared forecasting error in samples of the size usually available in practice." Mills and Prasad's results also showed that the Schwarz criterion has better small sample properties than the others. More specifically, Mills and Prasad (1992, p. 221) found that the Schwarz BIC criterion is more reliable and usually better than other criteria and never considerably worse in its probability to identify the true model. Nickelsburg's study emphasized the number of post-estimation degrees of freedom as the relevant sample size. Using such sample sizes of 25, 50, and 100, and specifying different bivariate VAR models, Nickelsburg (1985, p. 191) found that "...for reasonable sample sizes there is no criterion which performs well. If one chooses an overfitting criterion, then the degree of freedom loss, which is substantial in VARs, severely inhibits inference. On the other hand, criteria which are more parsimonious tend to be the most sensitive to the underlying structure and too often underfit the model." Mills and Prasad (1992, p. 221) indeed confirm this result with a qualification: the Schwarz criterion "...show[s] a tendency to underfit when there is insufficient information in the data (low signal to noise ratio) such as when the parameter value is small relative to the equation variance." However, as an overall conclusion, they suggested (pp. 221-222) that the Schwarz criterion "...should probably be the first choice of applied researchers."

The issue of how the model selection criteria are used to specify a VAR model and the problems associated with this procedure can now be addressed. The Schwarz criterion is used as an example. From equation (3.7), the Schwarz criterion can be re-written as:

$$\text{Schwarz} = (ESS_{(a,b)}/T)\ T^{(a+b+1)/T} \qquad \textbf{(3.9)}$$

where T is the sample size, $SEE_{(a,b)}$ is the error-sum-of-squares when $Y_{t-1},\ldots,Y_{t-a}$ and $X_{t-1},\ldots X_{t-b}$ are used as regressors, and (a+b+1) is the number of estimated parameters.

First of all, there is an *ad hoc* decision to be made at this stage. The maximum number of lags that can appear in an equation should be specified. Therefore, the effective sample size T is equal to N (total sample size) minus M (maximum number of lags in the equation). This problem is not a trivial one, since starting with a number of lags less than what the true model contains would obviously lead to biased inferences on the nature of the causal relationships. For this reason, it is advisable to start with a sufficiently large number of lags. An inspection of the cross-correlograms may, also, be useful in choosing the maximum lag length, M.

Secondly, the search procedure to choose the optimum 'a' and 'b' (i.e., the lag lengths for Y and X with the minimum value of the Schwarz criterion) for a bivariate model requires the estimation of $(M+1)^2$ regressions for each equation. To overcome this *computational burden*, Hsiao (1979) suggested the determination of the lag length for the dependent variable of each regression first. Then, the lags of the second variable are introduced over the specification for the first variable. Finally, one checks whether the introduction of the second variable's lags has led to a lower value of the model selection criteria. This procedure involves 2(M+1) regressions. It also indicates whether the introduction of a second variable leads to an improvement in the predictive accuracy of the equation.

3.3. AN OVERVIEW OF SOME OTHER TESTS OF CAUSALITY

The most commonly used causality test is Granger's test and its extensions. The second most frequently used test is due to Sims (1972) and its variants. The Sims test is a two-sided test in that both the lags and the leads of a variable, say y, are regressed on the current value of another one, say x. In Sims's test, too, x and y are defined as in Granger's test, i.e., they are two distinct stationary stochastic processes. In line with Granger's test, the future cannot cause the present. Sims's test uses this assumption more explicitly. That is, y does not cause x (in the Granger-Sims sense) if in a regression of y_t on lagged, current and future x's, the latter coefficients are not statistically different than zero. Formally, Sims's test can be expressed as follows:

$$y_t = \alpha + \sum_{j=-m}^{k} \beta_j x_{t-j} + \epsilon_t \tag{3.10}$$

where ϵ_t is a normal i.i.d. error term. In equation (3.10), the Sims's test amounts to testing the joint significance of β_j, (j = -m,...,-1). If the null hypothesis is rejected, one also rejects the hypothesis of no causality from y to x. Similarly, another test can be conducted to see whether x causes y. When one starts with economic time series in levels, it is usually necessary to de-trend them before conducting Granger's or Sims's tests.[37] Therefore, the choice of a suitable filter, and the sensitivity of the causal inferences to the filter used have been the issues surrounding the Sims's test. More recently, Geweke, Meese and Dent (1983) extended the specification of Sims's test to include Sargent's (1976) modification to Granger's test. The resulting specification is the following:

$$y_t = A_0 D_t + \sum_{j=1}^{k} \beta_j y_{t-j} + \sum_{j=-m}^{k} \delta_j x_{t-j} + v_t \tag{3.11}$$

where v_t is a normal i.i.d error term.

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[37] See Hosoya (1977) for testing for Granger-Sims causality with non-stationary variables.

Compared to equation (3.10), equation (3.11) has a more general specification, containing a deterministic part A_0D_t (deterministic trend, intercept, seasonal dummies) and lags of the dependent variable. However, the causality test is undertaken on the leads of the x variable as in Sims's test. Apart from the Sims test, there are a number of other alternatives to Granger's test. For example, Haugh (1976), Pierce (1977), and Pierce and Haugh (1977) test for the significance of cross-correlations between the lagged and current values of two (weakly) stationary variables, say X and Y. If the lagged values of X is significant in the cross-correlation function between X and Y, then Pierce and Haugh interprets it as 'X causes Y'. While this approach is useful in transfer function identification, the fact that the association between lagged X and current Y is being tested without reference to better prediction (causation, in the Granger view) makes the approach of Pierce and Haugh questionable as a causality test. In fact, the test has not been popular in the literature.

Other tests of causality include Hoover (1991), and Holmes and Hutton (1992). Holmes and Hutton (1992, pp. 338-339) argue that all the existing tests of causality are parametric in nature, and are sensitive to the particular form of the test employed, method of detrending non-stationary time series, lag length selection, and functional form specification, among others. They suggest the use of a non-parametric test - a multiple-rank F test.[38] Hoover's

[38] See Holmes and Hutton (1992) and the references cited therein.

(1991) methodology depends on *event analyses* and is philosophically different from the previous tests. Hoover (1991) views causality as a matter of control, and follows Simon (1953) in that respect. Hoover's methodology for testing causal orderings is based on the tests of the stability of marginal and conditional distributions for the variables in question under different policy regimes identified by event studies. Using this method, he tests for the U.S. money-income causality for the 1950-1985 period. His results show that money does not cause prices, but that prices cause money.

3.4. SMALL SAMPLE PROPERTIES OF CAUSALITY TESTS

The power of the causality tests, especially in small samples, is a critical issue in selecting an appropriate test in view of the typical sample sizes in economics. Guilkey and Salemi (1982) conducted a Monte-Carlo study of this problem, using Sargent's (1976) version of Granger's test, and two versions of Sims's test, namely, the original Sims (1972) test and the modification offered by Geweke, Meese and Dent (1983). In particular, Guilkey and Salemi (1982, p. 668) sought answers to the following questions:

1) How likely is a user of each version of the test to reach a correct decision regarding the causal ordering of the time series?
2) How accurately does each test procedure recover population values of the test regression coefficients?
3) How sensitive are answers to the first and second questions to sample size, contemporaneous correlation of the exogenous errors, and the strength of the causal inter-relationship?
4) How important a source of bias is the finite parameterization of the test regressions that is required in small samples?

The authors used three different sample sizes, namely, T=75, T=125, and T=200, and allowed for different pre-set lag lengths.

For the case where a unidirectional causality exists, the authors obtained the following conclusions (pp. 673-675):

1) The Granger test performs slightly but significantly better than the other tests.

2) The results are extremely sensitive to sample size, the strength of causation, and to lag length selection.

3) The advantages of Granger's test over the two versions of Sims's test diminish as the sample size increases.

For the case where X_1 and X_2 are mutually uncaused in the population, the authors reached the following conclusions (pp. 675-676):

1) The Granger and Geweke, Meese, Dent procedures perform similarly to each other and better than the original Sims specification.

2) The performance of each procedure improves with sample size, most rapidly for the Sims procedure.

3) When set *a priori*, shorter lag versions of the tests are more accurate than the longer lag versions.

With respect to how each procedure recovers the population coefficients the authors found that (p. 676):

1) The procedures provide, on average, accurate small sample estimates of population coefficients.

2) Consistent with asymptotic theory, the dispersion of coefficient estimates about their sample means decreases substantially as sample size increases.

3) Coefficient bias decreases substantially as sample size increases from 75 to 200.

The overall conclusion of the authors is (p. 679) that:

> ...the small sample performances of the Granger and Modified Sims tests are superior to that of the Sims test...[however]...the Granger test consistently outperforms the Modified Sims procedure by small amounts. Since the Granger test is computationally the least expensive of the three and results in fewest degrees of freedom lost from formation of lags and leads, we

recommend it confidently to the practitioner.

Nevertheless, as the authors note, the performance of the tests in a multivariate case under omitted variables requires further investigations.

3.5. DIRECT CAUSALITY, INDIRECT CAUSALITY AND SPURIOUS CAUSALITY

3.5.1. DEFINITIONS

This section presents Hsiao's (1982) definitions of direct, indirect, and two types of spurious Granger-causality in a trivariate context. Indirect or spurious types of causality are assumed away in the bivariate case, and all that is being tested is whether X is a *prima facie* cause of Y, or not. As Klein (1988, p. 10) argues: "...[t]here are few, if any, stable bi-variate relationships in economics, and we must always be alert to 'third factors'." In the context of causality tests, Lütkepohl (1982) has shown that omitted variables may lead to the detection of non-causality when there is indeed a causal relationship (through indirect causality), or one may conclude that there is Granger-causality from X to Y, when there is in fact none (spurious causality). However, it is true that if there is a true (direct) Granger-causality from X to Y, this should be detected regardless of the omitted variables, given the information set. One should still interpret this finding as direct but *prima facie* causality, since the information set cannot possibly include all the possibly relevant variables in the universe due to the lack of degrees of freedom in estimation.

Direct, indirect and spurious causality are defined by Hsiao (1982). In the following discussion, the variables y, x, and m are assumed to be weakly stationary processes. To integrate this discussion into the topic of this dissertation, the variables are named as the innovations in real GDP (y), real exports (x), and real imports (m), respectively. The information set, A, is a stochastic process consisting only of $\{y_t, x_t, m_t\}$. Analogously, $\underline{\underline{A}}_t = \{y_s, x_s, m_s: s < t\}$.

Definition 4 <u>(Direct Causality)</u>. If $\sigma^2(y|\underline{\underline{A}}) < \sigma^2(y|\underline{\underline{A-X}})$ <u>and</u> $\sigma^2(y|\underline{\underline{Y}},\underline{\underline{X}}) < \sigma^2(y|\underline{\underline{Y}})$, then exports cause real GDP relative to A, denoted by $x \Rightarrow y$, where $x \Rightarrow y$ reads as x Granger-causes y.

This definition says that in order for x to Granger-cause y directly, x must better predict present y regardless of the inclusion or exclusion of the other variables in the information set. In other words, if exports Granger-cause real GDP directly, then real GDP should be better predicted by using exports, whether or not imports are included into the equation.

Definition 5 <u>(Feedback)</u>. If $x \Rightarrow y$ and $y \Rightarrow x$, then there is a *direct feedback* between x and y, denoted by $x \Leftrightarrow y$.

Definition 6 <u>(No Causality)</u>. x does *not* cause y when *either* (i) $\sigma^2(y|\underline{\underline{A}}) = \sigma^2(y|\underline{\underline{A-X-M}})$ <u>or</u> (ii) $\sigma^2(y|\underline{\underline{A}}) = \sigma^2(y|\underline{\underline{A-X}})$ and $\sigma^2(m|\underline{\underline{A}}) = \sigma^2(m|\underline{\underline{A-X}})$.

The first part of this definition says that x does not cause y if y cannot be better predicted using any of the other variables in the information set. The second part rules out indirect links from x to y by stating that x does not improve the prediction of y obtained by using the past of y and m, and m cannot be better predicted using x. In an applied context, this means that exports do not cause real GDP if the prediction of real GDP cannot be improved by using the exports or the imports variable. Alternatively, if exports do not cause imports, and exports do not improve the prediction of real GDP obtained by using imports and lagged real GDP, then it is concluded that exports do not cause real GDP.

Definition 7 <u>(Type I Spurious Causality)</u>. If $\sigma^2(y|\underline{\underline{Y}},\underline{\underline{X}}) = \sigma^2(y|\underline{\underline{Y}})$ and $\sigma^2(y|\underline{\underline{A}}) < \sigma^2(y|\underline{\underline{A-X}})$, then Type I spurious causality from x to y occurs.

That is, if x contributes to the prediction of y only in a multivariate relationship, but not in a bivariate one, then this is called Type I spurious causality. From a philosophical point of view, this type of spurious causality may arise if m is a co-requisite or an initial condition for x to cause y.

Definition 8 <u>(Indirect Causality)</u>. If $\sigma^2(y|\underline{\underline{A}}) = \sigma^2(y|\underline{\underline{A-X}}) < \sigma^2(y|\underline{\underline{A-M}}) < \sigma^2(y|\underline{\underline{A-X-M}})$, $\sigma^2(m|\underline{\underline{A}}) < \sigma^2(m|\underline{\underline{A-X}})$ and $\sigma^2(m|\underline{\underline{M}},\underline{\underline{X}}) < \sigma^2(m|\underline{\underline{M}})$ then x is said to cause y indirectly, denoted by $x \twoheadrightarrow y$. That is, in a multivariate context, y is better predicted using m but not x. Furthermore, m is better predicted by using x both in multi- and bivariate contexts. However, if m is not present in the system (i.e., in a bivariate case), x helps better predict y. This indicates that the x variable reflects the effect of m, if m is excluded from the information set, leading to the detection of an indirect but not spurious causality. This can occur when exports drive imports and imports drive real GDP.

Definition 9 (Type II Spurious Causality). When $\sigma^2(y|\underline{\underline{A}}) = \sigma^2(y|\underline{\underline{A-X}})$ *and* $\sigma^2(m|\underline{\underline{A}}) = \sigma^2(m|\underline{\underline{A-X}})$ (i.e., the condition (ii) of no causality holds), *but* if $\sigma^2(y|\underline{\underline{A}}) = \sigma^2(y|\underline{\underline{A-X}}) < \sigma^2(y|\underline{\underline{A-M}}) < \sigma^2(y|\underline{\underline{A-X-M}})$ *and* $\sigma^2(x|\underline{\underline{A}}) < \sigma^2(x|\underline{\underline{A-M}})$, $\sigma^2(x|\underline{\underline{X}},\underline{\underline{M}}) < \sigma^2(x|\underline{\underline{X}})$, then Type II spurious causality from x to y is said to occur.

This definition elaborates on the no causality condition and shows how one can detect causality when, in fact, there is none. This happens when m is the primary driving force for both y and x. Past x serves as a proxy when m is missing. In the present context, this effect can occur if imports are the driving force for both real GDP and exports, and exports pick up a relationship when imports are excluded.

Hsiao's (1982) extension of Granger-causality concepts into a three variable framework shows the fragility of the conclusions from bivariate tests. In higher dimensional systems the definitions get more complicated, but, the logical structure remains. One objective of the current study is to include an imports variable in the information set, and so to try to establish the causal relationships between real GDP, real exports and real imports in the light of above definitions.

3.5.2 PARAMETRIC TESTS FOR DIRECT, INDIRECT, AND SPURIOUS CAUSALITY

In this section, parametrically testable versions of Hsiao's (1982) definitions of direct, indirect, and spurious causality are derived. The hypotheses are directly derived from the definitions in section 3.5.1. To illustrate the hypotheses parametrically, consider the following trivariate vector autoregressive system:

$$y_t = \alpha_1 + \sum_{j=1}^{a} \beta_{1j} y_{t-j} + \sum_{j=1}^{b} \gamma_{1j} x_{t-j} + \sum_{j=1}^{c} \delta_{1j} m_{t-j} + \epsilon_{1t} \tag{3.12}$$

$$x_t = \alpha_2 + \sum_{j=1}^{d} \beta_{2j} y_{t-j} + \sum_{j=1}^{e} \gamma_{2j} x_{t-j} + \sum_{j=1}^{f} \delta_{2j} m_{t-j} + \epsilon_{2t} \tag{3.13}$$

$$m_t = \alpha_3 + \sum_{j=1}^{g} \beta_{3j} y_{t-j} + \sum_{j=1}^{h} \gamma_{3j} x_{t-j} + \sum_{j=1}^{k} \delta_{3j} m_{t-j} + \epsilon_{3t}. \tag{3.14}$$

Then, direct, indirect, and spurious causality can be defined as follows.

<u>Direct Causality:</u> if, in equation (3.12):

$$\sum_{j=1}^{b} \gamma_{1j} \neq 0$$

and, if in a regression of:

$$y_t = \alpha + \sum_{j=1}^{k} \beta_j y_{t-j} + \sum_{j=1}^{m} \gamma_j x_{t-j} + \epsilon_t \tag{3.15}$$

the gamma coefficients on the lags of x are jointly significant, then x is a direct Granger-cause of y_t.

<u>No Causality:</u> if, in equations (3.12) and (3.14), either

$$(i) \qquad \sum_{j=1}^{b}\gamma_{1j} = 0 \textit{ and } \sum_{j=1}^{c}\delta_{1j} = 0,$$

or,

$$(ii) \qquad \sum_{j=1}^{b}\gamma_{1j} = 0 \textit{ and } \sum_{j=1}^{h}\gamma_{3j} = 0,$$

then, x does not Granger-cause y_t.

<u>Type I Spurious Causality:</u> if, in equation (3.15):

$$\sum_{j=1}^{m}\gamma_{j} = 0,$$

but, in equation (3.12):

$$\sum_{j=1}^{b}\gamma_{1j} \neq 0,$$

then, Type I spurious causality from x to y_t is said to occur.

<u>Indirect Causality:</u> if, (i) in equation (3.12):

$$\sum_{j=1}^{b}\gamma_{1j} = 0, \textit{ but } \sum_{j=1}^{c}\delta_{1j} \neq 0,$$

and, (ii) in equation (3.14):

$$\sum_{j=1}^{h}\gamma_{3j} \neq 0,$$

and, if in a regression of:

$$m_t = \alpha + \sum_{j=1}^{n} \delta_j m_{t-j} + \sum_{j=1}^{p} \gamma_j x_{t-j} + \epsilon_t$$

$$\sum_{j=1}^{p} \gamma_j \neq 0,$$

then, x is said to Granger-cause y_t indirectly. Note that condition (ii) requires x to be a direct cause of m.

<u>Type II Spurious Causality:</u> when condition (ii) of no causality holds, but in equation (3.12):

$$\sum_{j=1}^{b} \gamma_{1j} = 0, \quad \sum_{j=1}^{c} \delta_{1j} \neq 0,$$
$$\textit{and in eq.}\,(3.15) \quad \sum_{j=1}^{m} \gamma_j \neq 0.$$

Furthermore, if in a regression of:

$$y_t = \alpha + \sum_{j=1}^{r} \beta_j y_{t-j} + \sum_{j=1}^{s} \delta_j m_{t-j} + \epsilon_t,$$
$$\textit{the term} \sum_{j=1}^{s} \delta_j \neq 0,$$

and, in equation (3.13):

$$\sum_{j=1}^{f} \delta_{2j} \neq 0,$$

and in a regression of:

$$x_t = \alpha + \sum_{j=1}^{t} \gamma_j x_{t-j} + \sum_{j=1}^{w} \delta_j m_{t-j} + \epsilon_t, \quad \textit{the term} \sum_{j=1}^{w} \delta_j \neq 0,$$

then there is a Type II spurious Granger-causality from x to y.

3.6. TESTING THE STRENGTH OF GRANGER (NON-) CAUSALITY

This section first reviews an alternative approach to time series identification. Then, an extension that enables one to test for the strength of Granger (non-) causality is proposed. The possible implications for time series modelling and analysis are also discussed.

Minimizing the Schwarz criterion yields a *unique* lag specification for each variable in each equation of a VAR model. Poskitt and Tremayne (1987) developed a more flexible (or, in their words, "less mechanical") framework for time-series identification based on Jeffreys's (1967) Bayesian concept of the "grades of evidence". The "grades of evidence" approach questions the uniqueness of the selected model by comparing its "posterior odds" with other models. If there are alternative models with posterior odds close enough to the posterior odds of the model chosen by the minimum of the Schwarz criterion, this leads to the formation of a "model portfolio". As a decision rule to determine whether the posterior odds of an alternative specification is close enough (i.e., within a given proximity) to the specification chosen by the minimum Schwarz criterion, Poskitt and Tremayne (1987, p. 127) derive the following ratio:

$$R = \exp[-\frac{1}{2}T\ (BIC_1 - BIC_0)] \tag{3.17}$$

where T is the effective sample size and (BIC_1 - BIC_0) is the difference between the Schwarz values of the models being compared.

As Jeffreys (1967, p. 432) indicates, this ratio has no physical meaning, though "[i]ts function is to grade the decisiveness of the evidence [underlining added]." Poskitt and Tremayne (1987, p. 127) divide the range of this ratio into three broad intervals: first, if $R > 100$, then the alternative model is unconditionally discarded; second, if $\sqrt{10} < R \leq 10$, then there is no substantial evidence in favour of the criterion minimizing model; and third, if $1 < R \leq \sqrt{10}$, then the alternative model is a close competitor to the model chosen by the minimum Schwarz criterion. One should also add that there is a fourth case, where $10 < R \leq 100$. In this case, the alternative model can again be discarded as non-competing. As a result, Poskitt and Tremayne (1987, p. 127) suggest that, in addition to choosing the criterion-minimizing model, one should not discard the closely competing models, and thereby form a *model portfolio*. This portfolio can also be used for forecasting purposes. The evaluation of the forecasting performance of a model portfolio is left as part of a future research agenda.

The formation of a model portfolio can be shown by the following example. Mills (1990, pp. 140-142) fits a univariate ARMA(p,q) model (p being the order of the autoregressive component and q being the order of the moving average component) for the British real consumption series using the Schwarz criterion. A part of his Exhibit 8.11 is replicated below. Table 3.1 shows that the Schwarz criterion reaches a minimum when an ARMA (0,2) model is specified. However, note that some other specifications, such as ARMA(0,1), ARMA(1,1), and ARMA(2,0), yield Schwarz values very close to the one from the most probable model, i.e., ARMA(0,2).

In order to decide whether the ARMA(0,2) model has close competitors, Mills (1990, p. 142) calculated the R-ratios of all the models in Table 3.1, with respect to the ARMA(0,2) model.[39]

TABLE 3.1. ARMA Identification of British Real Consumption Using the Schwarz BIC

		q			
	ARMA(p,q)	0	1	2	3
p	0	-7.848	-7.870	-7.876*	-7.746
	1	-7.785	-7.856	-7.764	-7.632
	2	-7.831	-7.729	-7.628	-7.575
	3	-7.722	-7.434	-7.446	-7.442

Source: Mills (1990, Exhibit 8.11)

The results reported in his Exhibit 8.13 are replicated in Table 3.2 below.

TABLE 3.2. Poskitt and Tremayne's (1987) 'R' values for the British Real Consumption Series

		q			
	ARMA(p,q)	0	1	2	3
p	0	1.66*	1.12*	0.00*	10.4
	1	5.10*	1.44*	7.44*	81.0
	2	2.22*	14.1	86.0	224.
	3	16.0	2837	2274	2466

Source: Mills (1990, Exhibit 8.13)

[39] In view of equation (3.17), BIC_0 is -7.876.

An examination of these R-ratios yields the following ARMA(p,q) model portfolio: (0,0), (0,1), (0,2), (1,0), (1,1), and (1,2) since the corresponding R-ratios are between 1 and 10. It is interesting to see that the model portfolio approach chooses the AR(1) model and the MA(1) model as close competitors for the given data series. At this point, an examination of the autocorrelation functions and partial autocorrelation functions can be useful to refine the resulting portfolio of models.

Poskitt and Tremayne's (1987) developed the model portfolio approach within the linear univariate time-series identification framework. It can, however, be extended to form a portfolio of VAR models.[40] One of the contributions of this dissertation is the following extension of Poskitt and Tremayne's (1987) framework to test for the decisiveness of evidence from Granger-causality tests.

Stage 1 : First, run an autoregression of Y on its own lags up to the maximum lag length (M), and calculate Schwarz BIC values. Second, rank these BICs in increasing order as BIC_i=0,1,...,M-1. BIC_0 is the best maintained hypothesis for no-causality from X to Y. Third, use equation (3.17) to compute the R-ratios between BIC_i ($i \neq 0$) and BIC_0, and determine whether there are competing (second best) no-causality models. If there are, form a portfolio of no-causality models.

Stage 2 : Introduce the lags of X up to M on the best and the second best no-causality models, if any, and calculate the Schwarz

[40] See also Poskitt and Tremayne (1983) on the posterior odds of time-series models.

BIC values from such models. Denote the Schwarz BIC values from this step, in increasing order, as: BIC_i, i=1,...,(G+1)M, where M is the maximum lag allowed, and G is the number of closely competing models to BIC_0 from the previous stage. For example, if there are no closely competing models to BIC_0, then G=0, and only M regressions are run at this stage. Adding this to the M regressions from stage 1, one has to run a total of 2M regressions, as suggested by Hsiao (1979). In other words, Hsiao's (1979) approach is a special case where the best univariate model has no competitors.

Under the conventional approach, if BIC_1 is less than BIC_0, there are grounds to conclude that "X Granger-causes Y". However, this requires the testing of the joint significance of the lags of X. Analogously, if BIC_1 is greater than BIC_0, then it is concluded that "X does not Granger-cause Y".

Now, instead of testing the joint significance of the lags of the X variable, if any, calculate the Poskitt-Tremayne R-ratios of BIC_i, i=0,1,...,(G+1)M, as compared to min(BIC_0,BIC_1). Note that one starts with BIC_0, and the remaining BIC_i are in increasing order as described above. If at least one BIC_i (i=1,...,(G+1)M) is less than BIC_0, and the R-ratio between that model and the BIC_0 specification is greater than 10, then the 'causality' model can be said to be superior to the 'no-causality' model(s). Otherwise, the no-causality models are as good as the causality models (in terms of forecasting), and *vice versa*. In general, whether X Granger-causes Y, or not, the strength of this evidence can be evaluated according to the following six cases:

1) BIC_1 is less than BIC_0, the R-ratio is greater than 10, and the F-test is significant. Then, there is *strong evidence* that 'X Granger-causes Y'.

2) BIC_1 is less than BIC_0, the R-ratio is less than 10, and the F-test is significant. Although there is *some evidence* that 'X Granger-causes Y', the evidence cannot be considered as decisive.

3) BIC_1 is less than BIC_0, the R-ratio is less than 10, and the F-test is insignificant. Then, there is *no substantial evidence* that 'X Granger-causes Y'. However, one should not conclude strongly in favour of no-causality from X to Y, since a 'causality' model is competing or closely competing with it, and non-causality may be due to a low signal to noise ratio.

4) BIC_0 is less than BIC_1. There are, however, closely competing or competing models under BIC_i. The F-tests are significant. Again, one cannot conclude strongly in favour of causality or non-causality.

5) BIC_0 is less than BIC_1. There are, however, closely competing or competing models under BIC_i. Nevertheless, the F-tests are insignificant. Then, there is again *no substantial evidence* that 'X does not Granger-cause Y'.

6) BIC_0 is less than BIC_1, and there are no closely competing or competing models under BIC_i, i.e., $R > 10$. Then, there is *strong evidence* that 'X does not Granger-cause Y'.

As shown in cases (1) through (6), the strength of the findings from Granger-causality tests can be *systematically* evaluated by using the model portfolio approach. Furthermore, since the sample size explicitly determines the magnitude of the R-ratio in equation (3.17), the decisiveness of the causal evidence in small samples can also be evaluated.

It should be noted that a concern on the uniqueness of the model chosen by minimizing a model selection criterion has been expressed previously in the literature. For example, Hsiao (1979) suggested a deliberate under- and over-fitting exercise on the chosen model and testing the significance of the additional lags and the excluded lags by the likelihood ratio test. However, choice of the lag lengths in over- or under-fitting remains *ad hoc*. The model portfolio approach differs from this respect by offering a systematic alternative, based on the posterior odds of different lag structures.

Thornton and Batten (1985) also considered the formation of some sort of a model portfolio, and suggested that perhaps one should be agnostic and conclude in favour of Granger-causality if this result is confirmed at each and every lag (up to M). The model portfolio approach is also different than this approach, since only the closely competing lag structures are considered. Also, insignificant lags may lead to insignificant F-statistics, and thus the failure to reject non-causality when it is false.

Recently, George and McCulloch (1993) approached the variable selection problem in regression analysis by using a portfolio formation approach. George and McCulloch (1993) searched for the 'promising' subsets of predictor variables based on their higher frequency of appearance in the Gibbs sample. The resulting subsets are identified as those with higher posterior probability. One may also approach the lag-length selection problem in VARs using George and McCulloch's method. However, the model portfolio approach developed in this dissertation has some advantages. For example, the use of the Schwarz BIC is now a popular practice employed by applied researchers. Furthermore, optimality properties of the Schwarz BIC have been demonstrated both asymptotically and in finite samples. The model portfolio approach, indeed, adds one more step to the conventional practice by comparing the posterior odds of different lag structures. This additional step has implications in terms of the strength of the causal inferences obtained. Furthermore, because the model portfolio formed by using the Schwarz BIC includes the best model and the second best models within a given proximity, this approach yields a higher probability of identifying the true order of VAR models.

Finally, note that the choice of lag structure also affects the impulse response functions (IRFs) and variance decompositions (VDCs) derived from the VAR models. As Runkle (1987) and Spencer (1989) demonstrated, the results from IRF and VDC analyses are sensitive to the specification of the VAR models, i.e., to the choice of lag lengths. Therefore, a portfolio of IRFs and VDCs resulting from the model portfolio can be formed, and the sensitivity of the results can be further investigated.

CHAPTER IV.

COINTEGRATION AND VECTOR ERROR CORRECTION MODELS: Concepts, Tests, and Issues

4.1. INTRODUCTION

The analysis of causal relationships, where the variables of interest are non-stationary, requires additional tools to those discussed in Chapter III. These tools are the recently developed techniques of cointegration analysis and vector error correction models. This chapter reviews the basic concepts of and tests for cointegration and vector error correction modelling, and addresses their implications for testing for Granger-causality. The study of the causal relationships between exports, imports, and economic growth in the light of these advances in time series modelling is one of the contributions of this dissertation.

4.2. GRANGER-CAUSALITY AND COINTEGRATION

This section explains the relationship between the concept of cointegration and Granger-causality. The exposition emphasizes the points where the application of cointegration analysis contributes to the testing of the export-output causality, rather than providing an exhaustive review of the literature.[41]

[41] Perman (1991) and Dickey, Jansen and Thornton (1991) survey the cointegration literature. Banerjee *et al.* (1993) is a comprehensive treatment of integration and cointegration issues.

4.2.1. INTEGRATION AND COINTEGRATION: CONCEPTS

Most economic variables in levels exhibit non-stationarity. Therefore, the usual applied econometric methodology is to detrend the variables of interest first, (i.e., make them stationary), and then proceed with further analysis. The variables in levels are avoided since they could lead to spurious correlations, as shown by Granger and Newbold (1974).

The detrending procedure can take two forms. The first one is to fit a time trend (linear or non-linear) and then use the residuals from that regression as the detrended series. The second approach is to take the first differences of the series of interest and use the first differences as the detrended series. An advantage of the second method is that if the series are in log levels, then the first differenced series are approximately the percentage changes over the previous period. Nevertheless, the choice between first differencing and fitting a time trend is not a trivial one. Formally speaking, if stationarity is achieved after fitting a time trend, the variable is said to be *trend stationary*. On the other hand, if stationarity is achieved after differencing, the variable is said to be *difference stationary*. A difference stationary process is a random walk, or it has a *stochastic trend*. A trend stationary process arises because of the effect of a *deterministic trend*. Equations (4.1) and (4.2) illustrate the examples of stochastic and deterministic trends, respectively:

$$X_t = X_{t-1} + \epsilon_t \tag{4.1}$$

$$Y_t = \alpha Y_{t-1} + \beta t + v_t \tag{4.2}$$

where, $0 < \alpha < 1$, t is a linear time trend, and ϵ_t, v_t are independent white-noise processes.

The correct way of detrending equations (4.1) and (4.2) is to take the first differences and fit a time trend, respectively. However, in practice, one does not know whether a series at hand is difference stationary or trend stationary in nature. Suppose that one applies a linear time trend to equation (4.1) and takes the first differences in equation (4.2). The first case is illustrated by equation (4.1'):

$$X^*_t = \alpha + \delta t + \epsilon^*_t. \qquad \textbf{(4.1')}$$

Subtracting (4.1') from (4.1), one can obtain:

$$(X_t - X^*_t) = (X_{t-1} - \alpha - \delta t) + (\epsilon_t - \epsilon^*_t). \qquad \textbf{(4.3)}$$

Equation (4.3) is still non-stationary, since it includes the X_{t-1} term. This result also points out to the dangers of using time trends to correct for non-stationarity in economic time series. For example, if one applied the same procedure to another variable following a stochastic trend, and regressed one of these series on the other one, the results might suffer from spurious correlations.

Suppose that first differencing is applied to equation (4.2) to achieve stationarity. Equation (4.2) lagged by one period is:

$$Y_{t-1} = \alpha Y_{t-2} + \beta(t-1) + v_{t-1}. \qquad \textbf{(4.2')}$$

Subtracting (4.2') from (4.2) yields:

$$(Y_t - Y_{t-1)} = \alpha(Y_{t-1} - Y_{t-2}) + \beta + (v_t - v_{t-1}). \qquad \textbf{(4.4)}$$

From equation (4.4), one can see that first differencing eliminated the effect of the time trend. However, the equation contains an extra parameter (β) than it would contain if it were correctly detrended. However, this result is not as dramatic as the case of fitting a time trend to random walks. In the case of equation (4.4), the results will still be unbiased but inefficient due to the loss of degrees of freedom. As a result, first differencing appears as a dominant strategy in detrending variables to achieve stationarity.

A random walk, such as in equation (4.1), is also called an *integrated process of order one*, or an I(1) process. Most economic series in levels are found to be I(1) processes.[42] In general, a stochastic process is said to be integrated of order d, I(d), if stationarity is achieved after differencing (d) times. By the same token, a deterministic trend model is an I(0) process once the trend has been removed, since no differencing is required. A linear combination of I(d) and I(n) processes, with d > n, yields an I(d) process. For example, if, in a bivariate linear regression, the dependent variable is I(0) and the independent variable is I(1), the error term follows an I(1) process. An interesting case appears when both variables are I(1) processes. Consider the following bivariate linear regression:

$$Y_t = \alpha + \beta X_t + \epsilon_t \tag{4.5}$$

where both Y_t and X_t are I(1) variables. Linear combinations of two I(1) series are usually I(1). However, there may exist a β such that $\epsilon_t = y_t - \beta X_t$ is I(0), that is the error term is stationary. In

[42] See Nelson and Plosser (1982). Greene (1993, p. 559) suggests that price-level series are generally I(2) processes, and money stocks or price level series in an hyperinflation, such as interwar Germany and post- WW II Hungary, exhibit I(3) behaviour.

general, if a linear combination of two I(d) series generate another series which is I(d-1), then the two series are said to be *cointegrated.* With respect to equation (4.5), the vector $[1, -\beta]'$ is called the *cointegrating vector*. In such a case, the two non-stationary series move together without drifting too far apart. Whether the variables in a regression are cointegrated or not bears important consequences for applied researchers. If the series are cointegrated, the usual practice of first differencing to detrend the series causes the loss of valuable long-run information. This can be illustrated by the following example.

Let X_t and Y_t be two I(1) series. Suppose that a regression involving the first differences of these series is run, that is, $\Delta X_t = \beta\ \Delta Y_t + \epsilon_t$, where ΔX_t and ΔY_t are mean zero I(0) series, and ϵ_t is a white noise error term, i.e., $(X_t - X_{t-1}) = \beta(Y_t - Y_{t-1}) + \epsilon_t$. In the long run, $Y_t = Y_{t-1}$ and $X_t = X_{t-1}$, and $E(\epsilon_t)=0$. Therefore, the above model does not possess a long-run solution. Now, consider the following specification:

$$(X_t - X_{t-1}) = \delta(X_{t-1} - \alpha Y_{t-1}) + \beta(Y_t - Y_{t-1}) + \epsilon_t \qquad \textbf{(4.6)}$$

where δ is expected to be negative.[43]

There exists a long-run equilibrium in this model, if the term $(X_{t-1} - \alpha Y_{t-1})$ is I(0). If so, the above specification is called an *error-correction model* (ECM), the error-correction term being the lagged residuals from a regression of Y_t on X_t in levels. The error correction term can also be interpreted "...as the extent to which

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[43] See Granger and Newbold (1987, pp. 224-226) for the derivation of the first term on the RHS.

the system is out of equilibrium" [Granger (1988, p.203)].

The immediate question is "how to test for cointegration?" Following the example from equation (4.5), the requirement for Y_t and X_t to be cointegrated is that ϵ_t is I(0). Thus, testing whether the error term is I(0) is the idea behind the cointegration tests. One may be tempted to fit the following linear regression to ϵ_t and use the t-test to see whether γ is less than 1:

$$\hat{\epsilon}_t = \gamma\hat{\epsilon}_{t-1} + v_t \tag{4.7}$$

where v_t is a well-behaved error term.

The problem with this method is that the OLS estimate of γ is biased downwards, as $\gamma \rightarrow 1$.[44] For the case where $|\gamma| < 1$, the OLS estimator is given by:

$$\hat{\gamma} = \frac{\sum_{t=2}^{T} \hat{\epsilon}_t\hat{\epsilon}_{t-1}}{\sum_{t=2}^{T} \hat{\epsilon}_{t-1}^2}. \tag{4.8}$$

It can also be shown that plim $\hat{\gamma} = \gamma$, and

$$\sqrt{T}(\hat{\gamma}-\gamma) \rightarrow N(0,1-\gamma^2). \tag{4.9}$$

However, when $\gamma = 1$, this is not the case. As Dickey and Fuller (1979, 1981) show, in this case $T(\hat{\gamma}-\gamma) \overset{d}{\rightarrow} v$, where v is a random variable with a positive var(v) < ∞. Furthermore, in finite samples $E(\gamma) < 1$. Under cointegration, two results emerge. First, the OLS estimate of γ converges to its probability limit at a faster rate

[44] See Evans and Savin (1981, 1984).

than it would for the stationary case. More technically, the variance of γ, when γ is equal to one, is $O(1/T^2)$ rather than $O(1/T)$, where $O(.)$ is the (big-O) order in probability.[45] This property of cointegrated time series is known as *super-consistency*.[46] Second, the OLS estimator will be biased downwards in finite samples. Thus, the usual t-statistics cannot be used to test whether or not $\gamma = 1$.

If, in a bivariate regression, the two variables are found to be cointegrated, then an error correction mechanism can be formed that combines the short-run dynamics with long-run equilibrium information. In general, an error-correction model involving two variables can be expressed as follows:

$$\Delta X_t = -\delta_1 z_{t-1} + \sum_{i=1}^{m} \alpha_{1i} \Delta X_{t-i} + \sum_{i=1}^{n} \beta_{1i} \Delta Y_{t-i} + \epsilon_{1t} \tag{4.10}$$

$$\Delta Y_t = -\delta_2 z_{t-1} + \sum_{i=1}^{p} \alpha_{2i} \Delta X_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta Y_{t-i} + \epsilon_{2t} \tag{4.11}$$

where at least one of δ_1, $\delta_2 \neq 0$, $z_t = X_t - \alpha Y_t$, and z_t is $I(0)$.

These equations also form a bivariate vector-error-correction model. The "Granger Representation Theorem", discussed in Engle and Granger (1987) and Banerjee *et al*. (1993, pp. 146-152), states that if a vector of series are cointegrated, then there exists an error-correction mechanism. The reverse is also true. Note the similarity

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[45] See also Stock (1987).

[46] In a multivariate setting, the super-consistency of the OLS estimators does not hold if there are multiple cointegrating vectors. Johansen's (1988) test, however, can be used to test for multiple cointegrating vectors, if any.

between this model and equations (3.1) and (3.2) in the previous chapter. The difference is the existence of an error-correction term in at least one of the equations (4.10) and (4.11). This point is crucial for making causal inferences. Engle and Granger (1987) also show that cointegration implies Granger-causality at least in one direction. As Granger (1988, p. 203) explains, this relationship "...is a somewhat surprising result, when taken at face value, as co-integration is concerned with the long run and equilibrium, whereas causality [...] is concerned with short-run forecastability. However, what it essentially says is that, for a pair of series to have attainable equilibrium, there must be some causation between them to provide the necessary dynamics."

This is a new and significant approach to testing for causal relationships among economic variables. Furthermore, the cointegration approach to Granger-causality tests points to an important drawback in the previous literature: the missing error-correction variable from the specifications. Granger (1988, pp. 203-204) explains the significance of this term in causality tests as follows:

> ...in the error correction model, there are two possible sources of causation of x_t by y_{t-j}, either through the z_{t-1} term, if $\delta_1 \neq 0$, or through the lagged Δy_t terms, if they are present in the equation...Without z_t being explicitly used, the model will be mis-specified...Thus, many of the papers discussing causality tests based on the traditional time-series modelling techniques could have...reached incorrect conclusions about non-causality...It does seem that many of the causality tests that have been conducted should be re-considered.

4.2.2 INTEGRATION AND COINTEGRATION: TESTS

This section describes the formal tests for integration and cointegration. Particular attention is paid to three tests which have been most frequently used in the literature. These are: the Augmented Dickey-Fuller (ADF) test, Phillips and Perron's (PP) test, and Engle and Yoo's (1989) three-step procedure.

4.2.2.1 THE (AUGMENTED) DICKEY-FULLER TEST

Fuller (1976) shows that the t-statistic cannot be used to test whether γ, in equation (4.1), is equal to 1 or not. He also provides tables for critical values to be used in this case. First, rewrite equation (4.7) to get:

$$\Delta\epsilon_t = \delta\epsilon_{t-1} + v_t \tag{4.12}$$

where $\delta = (\gamma-1)$, and v_t is a well-behaved error term. If the null hypothesis of $\delta = 0$ cannot be rejected, then there are grounds to conclude that ϵ_t has a unit root. In general, consider the following autoregressive process:

$$x_t = \lambda_0 + \lambda_1 x_{t-1} + \lambda_2 x_{t-2} + \ldots + \lambda_{n+1} x_{t-n-1} + u_t \tag{4.13}$$

where u_t is a white-noise term. Equation (4.13) can be re-parameterized to obtain:

$$\Delta x_t = \lambda_0 + (\sum_{i=1}^{n+1}\lambda_i - 1)x_{t-1} - \sum_{z=1}^{n+1}[(\sum_{i=z+1}^{n+1}\lambda_i)\Delta x_{t-z}] + u_t. \tag{4.14}$$

or, in the following regression:

$$\Delta x_t = \beta_0 + \beta_1 x_{t-1} + \sum_{i=1}^{n}\alpha_i\Delta x_{t-i} + u_t. \tag{4.15}$$

Stationarity of x_t requires that $\beta_1 < 0$. The augmented Dickey-Fuller (ADF) test follows from equation (4.15). Usually, a linear trend term is also added. In the ADF test, the role of the lagged dependent variables in (4.15) is to ensure a well-behaved error term, u_t. The more general specification for the ADF test is the following:

$$\Delta x_t = \beta_0 + \beta_1 x_{t-1} + \gamma t + \sum_{i=1}^{n} \alpha_i \Delta x_{t-i} + u_t. \tag{4.16}$$

Equation (4.16) also allows for the testing of joint hypotheses. For example, if $\gamma = \beta_0 = \beta_1 = 0$, then a random walk (without drift) follows. Alternatively, if $\beta_1 < 0$ and γ is positive and significant, then an upward-sloping trend stationary process is detected. Tables for critical values are given in Fuller (1976) and Dickey and Fuller (1979,1981).

4.2.2.2. THE PHILLIPS-PERRON TEST

Phillips (1988) and Phillips and Perron (1988) pointed out that the ADF strategy is biased towards failing to reject the null hypothesis of a unit root when the error term is not white-noise. Phillips and Perron provide a semi-parametric correction to the error term from the ADF regression, such as equation (4.16). The correction follows Newey and West (1987). Phillips and Perron's modified t-test is derived as follows. Consider the following equation:[47]

[47] See also Banarjee *et al.* (1993, pp. 108-110) and Dutt and Ghosh (1994).

$$X_t = \alpha + \beta X_{t-1} + u_t. \tag{4.17}$$

Compute S^2_t and S^2_k from equations (4.18) and (4.19).

$$S_t^2 = \frac{1}{T}\sum_{t=1}^{T} u_t^2 \tag{4.18}$$

$$S_k^2 = \frac{1}{T}\sum_{t=1}^{T} u_t^2 + \frac{2}{T}\sum_{s=1}^{k} w_s \sum_{t=s+1}^{T} u_t u_{t-s} \tag{4.19}$$

where $w_s = 1-s/(k+1)$, and k is the truncation lag which makes the error term white noise. Based on (4.18) and (4.19), the modified t-statistic can now be computed:

$$Z_t = \left(\frac{s_t}{s_k}\right) t_\beta - \frac{\frac{1}{2}(s_k^2-s_t^2)/s_k}{2\sqrt{\frac{1}{T^2}\sum_{t=1}^{T}(x_t-\bar{x})^2}} \tag{4.20}$$

where t_β is the t-statistic from equation (4.17).

The power of ADF tests is low when moving average terms are involved in the error term of equation (4.16). The Phillips-Perron correction, and hence the P-P test, raise the power of unit tests in the case of non-spherical disturbances.[48] Perman (1991, p. 10-11) suggests that "...if normality, autocorrelation or heterogeneity statistics are significant, a prima-facie case exists for adopting the Phillips and Perron approach."

4.2.2.3. THE ENGLE-YOO THREE-STEP PROCEDURE

The ADF and the PP tests can be applied for testing both

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[48] The PP test has low power when negative MA parameters are involved. See Banarjee *et al.* (1993, pp. 108-113) for further discussion.

integration and cointegration. The latter results when the tests are applied to the residuals from the levels regression, or the cointegrating regression. Engle and Granger (1987) propose a two-step procedure to model cointegrated series. First, test whether the series in question are I(1). If so, estimate the cointegrating regression, and then run the ADF test on the residuals. If the residuals are not found to have a unit root, the series in question are said to be cointegrated. Then, form an error correction model of the form (4.10) and (4.11). As Cuthbertson, Hall, and Taylor (1992, pp. 140-141) show, the two-step procedure has two problems. First, while the cointegrating regression gives (super) consistent estimates of the cointegrating vector, these estimates are not fully efficient. Second, the distribution of the estimators of the cointegrating vector provided by the cointegrating regression is generally non-normal and so inference cannot be drawn about the significance of the parameters.

Engle and Yoo (1989) provide a correction, or a third step, to the Engle and Granger (1987) two-step procedure. This additional step makes the parameter estimates from the first stage asymptotically equivalent to full information maximum likelihood estimates, and also provides standard errors so that the usual t-tests can be applied. In sum, Engle and Yoo's (1989) three-step procedure amounts to the following:[49]

First, estimate the cointegrating regression: $Y_t = \alpha X_t + v_t$,

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[49] The exposition here closely follows Cuthbertson, Hall and Taylor (1992, p. 141).

and obtain the OLS estimate of α, α'.

Second, estimate the second stage dynamic regression using the v_t series from the first stage. This imposes a long-run constraint. Or, $\Delta Y_t = \Phi(L)\Delta Y_{t-1} + \Omega(L)\Delta X_t + \delta v'_{t-1} + u_t$, where $\Phi(L)$ and $\Omega(L)$ are lag polynomials, and u_t is a white-noise error term. Obtain OLS estimate of δ, δ'.

Third, run the regression: $u_t = \theta(-\delta' X_t) + w_t$. Then, the correction for the first stage estimates, α', is given by: $\alpha'' = \alpha' + \theta$. The correct standard errors are also given by the standard errors for θ.

Note that the Engle and Granger's (1987) approach assumes that there is a *unique* cointegrating vector in step one. This will necessarily be the case in a bivariate regression. However, in a multivariate setting, there may be multiple cointegrating vectors. In general, if there are N variables in a regression (including the dependent variable), then there can be at most N-1 cointegrating vectors. The OLS estimates may produce a linear combination that may result in misleading conclusions about cointegration. If, say, in a trivariate system, two cointegrated vectors are found, one or both of them may not be economically meaningful. Therefore, one should use economic theory to pick the most meaningful vector. The actual mechanics of Johansen's (1988) procedure are well explained in Johansen (1988), Dickey, Jansen and Thornton (1991), and Cuthbertson, Hall and Taylor (1992).

4.3. BREAKING TRENDS, UNIT ROOTS, AND SPURIOUS COINTEGRATION

Another important topic in testing for the (non-) existence of unit roots is breaking trends. In response to the overwhelming evidence in favour of unit roots in macroeconomic time series, Perron (1989) and Rappoport and Reichlin (1989) argued that macroeconomic series may indeed be stationary around a breaking trend. In that case, a shock to the series is thought to reflect the effect of an *exogenous* event rather than being a realization from the tail of the distribution generating the series in question. In such a case, the ADF and P-P tests, for example, are biased towards accepting the null hypothesis of a unit root, and one would fail to reject the unit root hypothesis too often. In other words, the series in question can be considered as a *seemingly nonstationary process*.

Christiano (1992) and Zivot and Andrews (1992) argued that Perron's (1989) and Rappoport and Reichlin's (1989) approaches suffer from a pre-test bias. The argument goes as follows: since one uses visual inspection or other methods to identify a break, Perron's (1989) test is biased towards rejecting the null hypothesis. To deal with the pre-test bias, Christiano used a bootstrapping methodology, whereas Zivot and Andrews calculated critical values taking account of this bias. In view of these developments, Zivot and Andrews's (1992) tests will be used in the empirical work of chapter five.

Zivot and Andrews (1992) develop the following models, based on Perron (1989), to test for breaking trends. The first model is a *crash* model, involving a one-time change in the intercept:

$$Y_t = \mu^A + \theta^A DU_t(\lambda) + \beta^A t + \alpha^A Y_{t-1} + \sum_{i=1}^{p} c_i \Delta Y_{t-i} + \epsilon_t^A. \tag{4.21}$$

The second one is a "changing-growth" model, which involves a change in the slope of the series without a sudden change in its level:

$$Y_t = \mu^B + \beta^B t + \gamma^B DT_t^*(\lambda) + \alpha^B Y_{t-1} + \sum_{i=1}^{p} c_i \Delta Y_{t-i} + \epsilon_t^B. \tag{4.22}$$

The third model combines the previous two, and can be interpreted as a sudden change in the level of the series followed by a different growth path:

$$Y_t = \mu^C + \theta^C DU_t(\lambda) + \beta^C t + \gamma^C DT_t^*(\lambda) + \alpha^C Y_{t-1} + \sum_{i=1}^{p} c_i \Delta Y_{t-i} + \epsilon_t^C. \tag{4.23}$$

where $DU_t(\lambda) = 1$ if $t > T\lambda$, 0 otherwise; $DT^*(\lambda) = t - T\lambda$ if $t > T\lambda$, 0 otherwise. The parameters λ correspond to their estimated values of the break function. The error terms are assumed to follow i.i.d $N(0,\sigma^2)$. The critical values for models A, B, and C are provided by Zivot and Andrews (1992, pp. 256-157).

The significance of breaking trends is twofold. The first one relates to the question of whether shocks to macro variables are permanent or transitory. Thus, this line of research is important for empirical business cycle research. The second one, which has not been pointed out in the literature yet, questions the validity of cointegrating relationships. For example, suppose that in a bivariate model, variables Y and X, are found to be I(1) and also cointegrated upon testing by ADF or P-P tests and the Engle-Granger two-step procedure. Now, further suppose that Y (or X) has indeed been found to be stationary around a breaking trend upon testing by Zivot and Andrews (1992) procedure. If Y is indeed I(0) around a breaking trend and X is a random walk, then Y and X cannot be cointegrated. In such a case, the original finding of cointegration can be considered as spurious. Given the popularity of unit root testing and cointegration modelling, tests for breaking trends are an important issue.

CHAPTER V.

A MULTIVARIATE TIME SERIES ANALYSIS OF EXPORTS, IMPORTS, AND ECONOMIC GROWTH IN DEVELOPING COUNTRIES

5.1. INTRODUCTION

This chapter investigates the empirical relationships among exports, imports and per capita real GDP growth in developing countries. The methodology employed uses the techniques of modern multivariate time series analysis. The chapter is organized as follows. First, the selection of the countries and the data used are discussed, along with various summary statistics. This is followed by a rigorous time series analysis to identify possible causal relationships among exports, imports and per capita real GDP growth in the sample countries.

The current study differs from previous ones in several respects. In particular, a multivariate approach, using three variables rather than the usual bivariate approach, is employed. The inclusion of the imports variable enables one to test the "exports as a source of foreign exchange" hypothesis, i.e., whether there may be an indirect linkage from export growth to output growth through the imports variable. This also allows one to test for the existence of spurious or indirect causalities [Hsiao (1982)]. For example, if imports cause both exports and output while there is no causal relationship between exports and output, then in the absence of the imports variable a spurious causal relationship between exports and output is likely to be found. If this is the case, it suggests that doubt is cast on some of the previous findings that exports caused output.

The current study is also different in that it investigates the existence of long-run cointegrating relationships and derives additional sources of causality from the resulting vector error correction models (VECMs). Furthermore, Perron-Zivot-Andrews tests for breaking trends in each series for each country are undertaken - an approach which has not previously been applied. Its significance arises from the fact that the results from Granger-causality tests are sensitive to the filtering technique used. For example, if a series is judged to be I(1), then its first differences will be used for inferences about Granger-causality. However, if this series is really stationary around a breaking trend, then first differencing becomes an inappropriate filter. Finally, a sensitivity analysis of the results is attempted using the procedure presented in Chapter III. This analysis tries to establish the strength of the causal evidence in the face of finite sample sizes. An overall evaluation of the results and a comparison with previous work are left to the next chapter.

5.2. SAMPLE SELECTION, DATA SOURCES, AND SUMMARY STATISTICS

The World Development Report 1987 (WDR'87) lists 41 developing countries with respect to their trade orientation in the 1965-1985 period. The trade orientation refers to the *overall* orientation of an economy as calculated by the ratio of effective foreign exchange rates for exports and imports. The major oil exporters and countries with data problems or with too short a sample period were excluded from this sample, leaving 32 countries for further investigation. Table 5.1 lists these countries with respect to their trade orientation in the 1965-1973 and 1973-1985 periods. The countries on the diagonal are those that had approximately the same overall trade orientation in both periods. The off-diagonal countries are the ones which changed their trade policies.

Some remarks about the choice of variables, data sources and data quality are in order. First, per capita real GDP is used as a measure of income. The advantage of this variable is to exclude the effects of population growth, which can be important in developing countries. In the case of exports, a real aggregate measure is used. This is in line with one of the objectives of this study - to test the "exports as a source of foreign exchange" hypothesis. An aggregate measure is also used in the case of imports. Although it may be appealing to use capital goods and raw materials imports, the preference is given to an aggregate measure because it relates to openness more closely.

The data for per capita real GDP have been obtained from the Summers and Heston (1991) data bank. The series for real per capita GDP (1985 international prices, Laspeyres index) are available from 1950 to 1988. The sample period used in this study starts from the late 1950's or early 1960's because most LDCs did not undertake a policy of export promotion prior to that date. The sample ends in 1988 for most countries. This gives a sample size of close to 30 for most cases.

The data for exports and imports have been obtained from the

IMF's "International Financial Statistics (IFS)" database. The more problematic data are the deflators for exports and imports. The IFS database contains import and export price indices from the 1960's to the late 1980's only for 11 of the 32 countries. These countries include: Thailand, the Philippines, Nicaragua, Malaysia, South Korea, Tunisia, Brazil, Kenya, Sri Lanka, India, and Israel. Earlier studies have used the consumer price index (CPI) to deflate exports where an export price index was not available. As Bahmani-Oskooee *et al.* (1991, fn. 6) discuss, the CPI fails to pick up changes in terms of trade. Furthermore, a cross-country comparison of empirical results may not be appropriate if the CPI is used to deflate exports in some countries, while an export price index is used in others. To overcome these problems, the United Nations Conference on Trade and Development (UNCTAD) series for export and import unit value indices have been used for the remaining 21 countries.[50] This approach is an improvement in data quality over most of the previously published studies. Table 5.2 shows the growth rates of each variable for the 1965-1980 and 1980-1988 periods. Table 5.3 describes the developments in gross domestic investment, external debt indicators and per capita real GDP.

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[50] UNCTAD; Handbook of International Trade and Development Statistics, various issues, Geneva.

TABLE 5.1 CLASSIFICATION OF THE LDCs WITH RESPECT TO CHANGES IN THEIR TRADE ORIENTATION

1973-1985 \ 1965-1973	Strongly Outward Oriented	Moderately Outward Oriented	Moderately Inward Oriented	Strongly Inward Oriented
Strongly Outward Oriented	Hong Kong S. Korea			
Moderately Outward Oriented		Brazil Thailand Malaysia Israel	Tunisia	Chile Uruguay Turkey
Moderately Inward Oriented		Costa Rica Ivory Coast Guatemala	Philippines Nicaragua Kenya El Salvador Honduras Senegal	Sri Lanka Pakistan
Strongly Inward Oriented			Bolivia Madagascar	India Argentina Dom. Rep. Ethiopia Ghana Peru Sudan Tanzania Zambia

Source: World Development Report, 1987, Figure 5.1, p. 83.

TABLE 5.2 GROWTH RATES BY GEOGRAPHICAL LOCATION: 1965-1980 AND 1980-1988

		GROWTH RATE OF:					
		Y		X		M	
LOCATION	COUNTRY	1965-1980	1980-1988	1965-1980	1980-1988	1965-1980	1980-1988
ASIA	Hong Kong	8.6	3.3	9.5	12.3	8.3	10.4
	India	3.6	5.2	3.7	4.7	1.6	5.4
	Israel	6.8	3.2	8.9	7.6	6.3	4.4
	Korea, S.	9.6	9.9	27.2	14.7	15.2	9.9
	Malaysia	7.3	4.6	4.4	9.4	2.9	0.4
	Pakistan	5.1	6.5	4.3	8.4	0.4	3.8
	Philippines	5.9	0.1	4.7	0.4	2.9	-1.7
	Sri Lanka	4.0	4.3	0.5	5.8	-1.2	3.4
	Thailand	7.2	6.0	8.5	11.3	4.1	6.2
	Turkey	6.3	5.3	5.5	15.3	7.7	10.3
AFRICA	Ethiopia	2.7	1.4	-0.5	-0.7	-0.9	7.2
	Ghana	1.4	2.1	-1.8	1.1	-1.4	-1.4
	Ivory Coast	6.8	2.2	5.6	1.5	8.0	-2.2
	Kenya	6.4	4.2	0.3	0.1	1.7	-0.6
	Madagascar	1.8	0.6	0.8	-3.5	-0.4	-1.8
	Senegal	2.0	3.3	2.4	7.0	4.1	2.8
	Sudan	3.8	2.5	-0.3	2.7	2.3	-7.9
	Tanzania	3.7	2.0	-4.0	-5.4	1.6	0.5
	Tunisia	6.6	3.4	10.8	3.0	10.4	-1.6
	Zambia	1.9	0.7	1.7	-3.7	-5.5	-4.8
SOUTH AMERICA							
	Argentina	3.5	-0.2	4.7	0.1	1.8	-8.0
	Bolivia	4.5	-1.6	2.8	-0.5	5.0	-2.6
	Brazil	8.8	2.9	9.3	6.0	8.2	-2.9
	Chile	1.9	1.9	7.9	4.5	2.6	-6.0
	Peru	3.9	1.1	2.3	-2.5	-0.2	-3.2
	Uruguay	2.4	-0.4	4.6	2.1	1.2	-4.2
CENTRAL AMERICA							
	Costa Rica	6.2	2.4	7.0	2.9	5.7	-0.3
	Dom. Rep.	7.9	2.2	1.7	0.0	5.5	2.3
	El Salvador	4.3	0.0	2.4	-4.4	2.7	-0.6
	Guatemala	5.0	-0.2	4.8	-2.0	4.6	-3.0
	Honduras	5.0	1.7	3.1	2.8	2.5	-0.3
	Nicaragua	2.6	-0.3	2.3	-6.3	5.8	2.5

Source: World Development Report 1990 (WDR'1990), Tables 2 and 14.

TABLE 5.3 GROSS DOMESTIC INVESTMENT, PER CAPITA REAL GDP, AND EXTERNAL DEBT STATISTICS

LOCATION	COUNTRY	Growth of GDI 1965-1980	Growth of GDI 1980-1988	DSR 1988	External Debt (Mi. US $) 1988	Per Capita Real GDP 1960	Per Capita Real GDP 1988
ASIA	Hong Kong	8.6	3.0	....	......	2273	13380
	India	4.5	4.3	21.8	57,513	621	784
	Israel	5.9	1.4	....	......	3843	9373
	Korea, S.	15.9	10.5	19.1	37,156	969	5156
	Malaysia	10.4	0.0	17.5	20,541	1736	4773
	Pakistan	2.4	6.5	23.5	17,010	817	1555
	Philippines*	8.5	-10.9	25.6	29,448	1178	1944
	Sri Lanka	11.5	-0.9	17.2	5,189	1391	1962
	Thailand	8.0	5.0	11.3	20,530	1008	2908
	Turkey	8.8	4.4	34.1	39,592	1694	3590
AFRICA	Ethiopia	-0.1	2.0	37.4	2,978	266	325
	Ghana	-1.3	4.9	19.7	3,099	1072	887
	Ivory Coast*	10.7	-11.4	13.0	14,125	1002	1263
	Kenya	7.2	-1.1	19.4	5,888	586	905
	Madagascar	1.5	-0.7	39.0	3,602	1030	608
	Senegal	3.9	2.0	18.4	3,617	1151	1123
	Sudan	6.4	-5.1	9.5	11,853	816	891
	Tanzania	6.2	0.3	17.1	4,729	271	492
	Tunisia	4.6	-6.1	24.2	6,672	1342	2924
	Zambia	-3.6	-4.5	14.2	6,498	1022	736
SOUTH AMERICA							
	Argentina*	4.6	-7.7	32.6	58,936	3425	4051
	Bolivia*	4.4	-19.5	32.9	5,456	1123	1373
	Brazil*	11.3	0.0	35.9	114,592	1417	3995
	Chile*	0.5	-0.5	14.9	19,645	3222	4127
	Peru*	0.3	-3.9	8.1	18,579	2131	2846
	Uruguay*	8.0	-9.2	27.3	3,825	4481	5188
CENTRAL AMERICA							
	Costa Rica*	9.4	5.8	17.4	4.530	2215	3802
	Dom. Rep.	13.5	4.6	13.4	3,923	1306	2226
	El Salvador	6.6	0.1	16.6	1,608	1356	1697
	Guatemala	7.4	-3.4	26.5	2,633	1684	2225
	Honduras	6.8	-0.6	25.5	3,318	943	1328
	Nicaragua	1.5	4.0	....	8,052	1931	1890

Source: WDR'1990, Tables 8 and 24. GDI is "Gross Domestic Investment". DSR is "Debt-Service Ratio", ratio of exports to total external debt. (*) indicates the "Highly Indebted Countries". Per capita real GDP figures are from Heston and Summers (1991).

5.3. UNIT ROOTS, BREAKING TRENDS, AND COINTEGRATION TESTS

This section presents the results of tests for unit roots, breaking trends, and cointegration in the above data on 32 developing countries.

5.3.1. UNIT ROOT TESTS

Considering the robustness of its test statistics to nonspherical disturbances, the Phillips-Perron test (P-P) is employed to determine the order of integration. The results of the P-P test are shown in Table 5.4. The variables Y, M, and X refer to the natural logarithms of per capita real GDP, real imports, and real exports in levels, respectively. The notation (1-L) stands for first differences. Since the power of the unit root tests is low in small samples, the resulting statistics have been evaluated at a 10 percent level of significance. The critical values, reported by SHAZAM version 7.0, are taken from MacKinnon (1991). One problem in running the P-P test is to determine the truncation lag. In this study, the value of k has been chosen by the SHAZAM program, using the highest significant lag order from either the autocorrelation or the partial autocorrelation function of the first differenced series. The findings indicate that: One, all per capita real GDP series, except for Hong Kong, Thailand and Senegal have been found to be I(1) processes; two, all real imports series contain unit roots except for the Philippines and Ghana; and three, real exports series for India, the Philippines, Ghana, the Ivory Coast, Senegal, Sudan, Zambia, Brazil, and Peru indicate I(0) variables.

TABLE 5.4 PHILLIPS-PERRON UNIT ROOT TESTS ON Y, M AND X, AND THEIR FIRST DIFFERENCES

COUNTRY	PHILLIPS-PERRON TESTS FOR: Y	M	X	(1-L)Y	(1-L)M	(1-L)X
ASIA						
Hong Kong	-3.39[2]	-1.93[1]	-1.65[1]	-4.67[2]	-4.33[2]	-3.86[1]
India	-2.60[1]	-2.59[1]	-3.67[1]	-6.94[2]	-6.26[2]	-9.91[2]
Israel	-1.38[1]	-1.26[1]	-2.45[1]	-4.99[1]	-5.76[4]	-6.22[2]
Korea, S.	-1.96[1]	-1.64[1]	-0.88[3]	-4.98[5]	-5.59[1]	-3.89[2]
Malaysia	-1.85[1]	-2.00[1]	-1.58[1]	-3.63[1]	-5.71[2]	-5.81[2]
Pakistan	-1.33[1]	-1.80[1]	-1.84[1]	-3.60[2]	-5.41[2]	-5.86[5]
Philippines	-1.65[2]	-3.22[2]	-3.45[1]	-3.07[3]	-5.12[2]	-7.23[1]
Sri Lanka	-1.60[1]	-1.56[5]	-1.28[1]	-6.07[2]	-5.14[3]	-5.42[2]
Thailand	-3.61[1]	-1.57[1]	-1.82[1]	-5.78[1]	-3.79[3]	-6.63[4]
Turkey	-1.47[1]	-1.92[1]	-2.17[1]	-2.87[1]	-3.43[2]	-4.50[1]
AFRICA						
Ethiopia	-3.08[1]	-2.07[3]	-2.84[3]	-7.16[3]	-6.10[1]	-3.58[5]
Ghana	-1.93[5]	-6.68[3]	-4.33[1]	-5.75[3]	-13.84[3]	-7.83[1]
Ivory Coast	0.46[1]	-1.12[1]	-3.28[1]	-5.20[2]	-5.50[1]	-6.82[3]
Kenya	-1.67[1]	-1.56[5]	-1.28[1]	-6.14[2]	-5.14[3]	-5.42[2]
Madagascar	-0.97[1]	-1.81[1]	-2.62[1]	-4.89[1]	-7.31[5]	-9.40[2]
Senegal	-3.40[1]	-2.77[1]	-4.58[1]	-6.51[2]	-7.67[1]	-9.71[3]
Sudan	-2.50[1]	-2.07[4]	-3.87[1]	-5.95[5]	-6.12[1]	-5.91[2]
Tanzania	-1.66[3]	-1.94[1]	-2.07[1]	-7.20[1]	-9.80[3]	-5.16[2]
Tunisia	-0.14[1]	-2.25[1]	-3.10[3]	-3.92[1]	-4.37[1]	-6.28[1]
Zambia	-1.40[1]	-2.26[1]	-3.85[1]	-5.95[2]	-4.79[1]	-8.34[2]
SOUTH AMERICA						
Argentina	-0.86[1]	-2.07[1]	-2.51[1]	-6.85[3]	-5.01[2]	-4.96[3]
Bolivia	-0.50[1]	-1.89[1]	-1.09[2]	-4.85[2]	-7.99[1]	-8.61[2]
Brazil	-1.32[1]	-0.94[1]	-3.33[1]	-5.34[1]	-3.90[1]	-6.41[2]
Chile	-2.37[1]	-2.71[1]	-2.08[1]	-4.86[6]	-5.47[2]	-7.18[2]
Peru	-1.30[1]	-3.43[3]	-3.45[1]	-4.04[3]	-5.12[4]	-6.82[1]
Uruguay	-2.57[1]	-2.42[1]	-2.77[3]	-5.97[2]	-4.70[1]	-5.42[4]
CENTRAL AMERICA						
Costa Rica	-1.14[1]	-1.60[4]	-2.21[1]	-5.98[4]	-4.40[5]	-8.16[2]
Dom. Rep.	-1.70[1]	-3.08[3]	-1.94[1]	-7.25[3]	-9.64[3]	-6.98[2]
El Salvador	-1.10[1]	-1.85[1]	-1.99[1]	-3.82[1]	-4.50[1]	-7.93[1]
Guatemala	-0.25[1]	-1.71[1]	-1.65[1]	-3.42[1]	-6.10[2]	-8.00[2]
Honduras	-2.00[1]	-1.43[1]	-1.07[4]	-4.39[1]	-5.44[2]	-5.95[4]
Nicaragua	-1.44[1]	-2.75[2]	-0.49[1]	-7.30[3]	-6.80[2]	-5.60[1]

N.B. The 10 % critical value is: -3.13. The numbers in brackets show the truncation lag, k, in P-P tests. All variables are in natural logs.

5.3.2. TESTS FOR BREAKING TRENDS

The next step in investigating the unit root hypothesis is the robustness of the results in the face of possible exogenous breaks in the series. The testing methodology follows that of Perron (1989) and Zivot and Andrews (1992) with a modification - the most likely break points have been chosen by visual inspection of the data series. Therefore, the critical values are taken from Zivot and Andrews (1992, Tables 2-5, Panel B.)

Tables 5.5 to 5.7 show the results from the Zivot-Andrews (1992) procedure. In some cases, the visual inspection of the series did not suggest any breaking trends. Such cases have been labelled as "No Visible Break in the Series". In Tables 5.5 to 5.7, lambda refers to the location of the most likely break point year as a percentage of the sample size. Models A, B, and C refer to a one-time level change in the series, a change in the rate of growth of the series, and a combination of level and growth rate change, respectively. The critical values, which are a function of the model used and the value of lambda, are taken from Zivot and Andrews (1992). The null hypothesis (Ho) is that there is no exogenous break in the series. The lag lengths have been determined following the procedure in Perron (1989) and Zivot and Andrews (1992): start with a general model and reduce it lag by lag by using t-tests. The maximum lag is set to four and a top-bottom strategy is followed using a critical t-value of 1.64, as suggested by the above authors.

TABLE 5.5 BREAKING TREND TESTS FOR PER CAPITA REAL GDP

COUNTRY	Year	Lambda	Model	t-stat.	5 % C.V.	Ho
ASIA						
Hong Kong	1973	0.35	A	-3.73 [1]	-3.76	Accept
India	1979	0.76	B	-2.69 [0]	-3.83	Accept
Israel	1976	0.67	C	-3.62 [1]	-4.24	Accept
Korea, S.	1979	0.65	A	-6.50 [0]	-3.78	Reject
Malaysia	1983	0.85	A	-3.13 [1]	-3.73	Accept
Pakistan	1967	0.28	A	-3.56 [5]	-3.76	Accept
Philippines	1983	0.85	A	-9.32 [1]	-3.72	Reject
Sri Lanka	1977	0.69	B	-5.57 [0]	-3.85	Reject
Thailand	1970	0.35	A	-4.48 [0]	-3.74	Reject
Turkey	1977	0.52	C	-3.77 [0]	-4.24	Accept
AFRICA						
Ethiopia	No Visible Break in the Series					
Ghana	1974	0.59	B	-6.87 [4]	-3.95	Reject
Ivory Coast	1978	0.66	B	-4.41 [0]	-3.90	Reject
Kenya	1966	0.66	C	-2.00 [0]	-4.20	Accept
Madagascar	1967	0.28	C	-3.80 [0]	-4.17	Accept
Senegal	1974	0.52	A	-4.31 [0]	-3.76	Reject
Sudan	1974	0.52	A	-1.02 [4]	-3.76	Accept
Tanzania	No Visible Break in the Series					
Tunisia	1973	0.55	B	-0.45 [0]	-3.96	Accept
Zambia	1973	0.48	B	-4.17 [1]	-3.95	Reject
SOUTH AMERICA						
Argentina	1973	0.54	B	-3.36 [2]	-3.95	Accept
Bolivia	No Visible Break in the Series					
Brazil	1961	0.31	A	-0.68 [0]	-3.76	Accept
Chile	No Visible Break in the Series					
Peru	1974	0.52	B	-5.11 [1]	-3.96	Reject
Uruguay	No Visible Break in the Series					
CENTRAL AMERICA						
Costa Rica	1979	0.69	B	-5.55 [3]	-3.85	Reject
Dom. Rep.	1968	0.46	A	-1.44 [3]	-3.74	Accept
El Salvador	1978	0.66	C	-3.74 [2]	-4.11	Accept
Guatemala	1981	0.71	A	-4.46 [0]	-3.80	Reject
Honduras	No Visible Break in the Series					
Nicaragua	1970	0.35	A	-4.48 [0]	-3.74	Reject

N.B. Ho is the null hypothesis that there is no exogenous break in the series. The number in [.] is the lag length in the equation. The critical values are from Zivot and Andrews (1992).

TABLE 5.6 BREAKING TREND TESTS FOR REAL IMPORTS

COUNTRY	Year	Lambda	Model	t-stat.	5 % C.V.	Ho
ASIA						
Hong Kong	1973	0.35	A	-4.77[1]	-3.76	Reject
India	No Visible Break in the series					
Israel	1976	0.67	C	-3.62[1]	-4.24	Accept
Korea, S.	1969	0.27	B	-3.65[2]	-3.87	Accept
Malaysia	1975	0.61	B	-4.45[4]	-3.95	Reject
Pakistan	1967	0.45	A	-5.24[0]	-3.76	Reject
Philippines	1983	0.85	C	-5.04[1]	-3.92	Reject
Sri Lanka	1977	0.67	C	-5.61[3]	-4.20	Reject
Thailand	1970	0.45	C	-3.83[1]	-4.23	Accept
Turkey	1977	0.52	C	-3.77[0]	-4.24	Accept
AFRICA						
Ethiopia	1978	0.61	C	-4.63[1]	-4.24	Reject
Ghana	No Visible Break in the Series					
Ivory Coast	1978	0.66	B	-4.18[0]	-3.90	Reject
Kenya	No Visible Break in the Series					
Madagascar	1972	0.45	B	-3.13[0]	-3.95	Accept
Senegal	1976	0.59	C	-4.45[0]	-4.24	Reject
Sudan	1983	0.85	A	-3.49[0]	-3.75	Accept
Tanzania	1973	0.48	B	-4.41[1]	-3.96	Reject
Tunisia	1968	0.39	B	-2.56[3]	-3.94	Accept
Zambia	1975	0.55	B	-4.22[2]	-3.96	Reject
SOUTH AMERICA						
Argentina	1980	0.68	B	-4.92[1]	-3.85	Reject
Bolivia	1973	0.42	C	-4.78[1]	-4.22	Reject
Brazil	1974	0.50	B	-3.60[0]	-3.96	Reject
Chile	No Visible Break in the Series					
Peru	No Visible Break in the Series					
Uruguay	No Visible Break in the Series					
CENTRAL AMERICA						
Costa Rica	1980	0.72	B	-5.61[0]	-3.80	Reject
Dom. Rep.	No Visible Break in the Series					
El Salvador	1978	0.61	C	-4.63[1]	-4.24	Reject
Guatemala	No Visible Break in the series					
Honduras	1968	0.29	B	-2.92[0]	-3.87	Accept
Nicaragua	1978	0.75	C	-3.71[0]	-4.11	Accept

N.B. The same as Table 5.5.

TABLE 5.7 BREAKING TREND TESTS FOR REAL EXPORTS

COUNTRY	Year	Lambda	Model	t-stat.	5 % C.V.	Ho
ASIA						
Hong Kong	1974	0.39	C	-4.25[4]	-4.22	Reject
India	No Visible Break in the Series					
Israel	No Visible Break in the Series					
Korea, S.	1973	0.42	B	-4.94[2]	-3.94	Reject
Malaysia	1981	0.80	B	-4.09[0]	-3.82	Reject
Pakistan	No Visible Break in the Series					
Philippines	No Visible Break in the Series					
Sri Lanka	1977	0.67	C	-3.92[2]	-4.18	Accept
Thailand	1970	0.35	B	-4.54[1]	-3.93	Reject
Turkey	1980	0.65	A	-3.96[0]	-3.85	Reject
AFRICA						
Ethiopia	No Visible Break in the Series					
Ghana	No Visible Break in the Series					
Ivory Coast	No Visible Break in the Series					
Kenya	1973	0.55	B	-3.20[3]	-3.96	Accept
Madagascar	1973	0.48	B	-5.67[0]	-3.96	Reject
Senegal	No Visible Break in the Series					
Sudan	1973	0.48	C	-7.20[3]	-4.22	Reject
Tanzania	1967	0.25	B	-3.36[4]	-3.84	Accept
Tunisia	No Visible Break in the Series					
Zambia	1975	0.55	B	-4.49[3]	-3.96	Reject
SOUTH AMERICA						
Argentina	1975	0.52	C	-6.22[1]	-4.24	Reject
Bolivia	1973	0.46	B	-3.73[3]	-3.94	Reject
Brazil	1966	0.33	B	-4.49[4]	-3.87	Reject
Chile	1973	0.45	C	-4.05[1]	-4.23	Accept
Peru	1973	0.52	B	-3.99[0]	-3.96	Reject
Uruguay	No Visible Break in the Series					
CENTRAL AMERICA						
Costa Rica	No Visible Break in the Series					
Dom. Rep.	1969	0.54	A	-4.49[0]	-3.76	Reject
El Salvador	1978	0.61	C	-5.25[0]	-4.24	Reject
Guatemala	No Visible Break in the Series					
Honduras	1977	0.58	C	-2.31[0]	-3.95	Accept
Nicaragua	1978	0.75	B	-2.35[1]	-3.83	Accept

N.B. The same as Table 5.5.

The overall lesson from Tables 5.5 to 5.7 is that breaking trends are common in macroeconomic series. In the above sample, 38 of the 96 series have been found to have breaking trends. The results of the present study are generally in line with Perron (1989), Zivot and Andrews (1992) and Serletis (1994). The difference is that these studies examine industrialized countries. The current study contributes to this literature by undertaking an examination of breaking-trends in developing countries.

Table 5.8 puts the results of P-P unit root tests and the tests for breaking trends together. The entry STS denotes *split-trend-stationary*, another term for breaking trend I(0) processes.[51] A careful examination of the Tables 5.4 to 5.7 indicates that there are some discrepancies between the results in those Tables and the ones reported in Table 5.8. These are explained as follows.

First, for India, the Y variable is reported as a difference stationary process, whereas the P-P tests suggest a trend stationary process. However, a univariate time series analysis of the Y variable indicates an ARMA(1,1) process with an MA parameter of -0.9607, significant at the 1 percent level. It is known that the power of the unit root tests is very low especially in the case of MA parameters near unity. The P-P test particularly lacks power in the case of negative MA parameters and leads to the rejection of the unit hypothesis very often whether or not it is false.[52] For this reason, the per capita real output process in India is modelled as a difference stationary process.

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[51] See Davis and Kanago (1992).

[52] See Banarjee *et al.* (1993, p. 113)

Second, for India, the Philippines, and the Ivory Coast, the X variable is reported as a difference stationary process in Table 5.8, whereas Table 5.4 indicates the respective X variables as trend stationary processes. The ADF tests resulted in t-statistics of -5.37, -5.40, and -4.05 for India, the Philippines and the Ivory Coast, respectively. The univariate analysis of these series does not indicate any significant MA terms. Therefore, these results indicate I(1) processes, and the real export variables for these countries were also modelled as difference stationary processes.

Finally, in the case of Turkey, the P-P tests point out an I(2) process for real exports. Univariate time series analysis led to an AR(1) process, and the ADF test indicated a t-statistic of -3.62, significant at the 5 percent level, with white noise residuals. Again, the real export series for Turkey is modelled as an I(1) process.

Given these qualifications, Table 5.8 is the basis for the sample periods and residuals for the VAR models to be used in the tests for Granger-causality. It should be noted that the sample periods are shorter than the original samples because of the lags involved in the estimation of the Zivot-Andrews procedure.

TABLE 5.8 COMBINED RESULTS FROM TABLE 5.4 AND TABLES 5.5 TO 5.7: CLASSIFICATION OF VARIABLES AS SPLIT-TREND STATIONARY, TREND STATIONARY AND DIFFERENCE STATIONARY PROCESSES

COUNTRY	PERIOD	Y	M	X
ASIA				
Hong Kong	1966-88	TS	STS	STS
India	1956-88	DS	DS	DS
Israel	1956-88	DS	DS	DS
Korea, S.	1963-88	STS	DS	STS
Malaysia	1956-87	DS	STS	STS
Pakistan	1960-88	DS	STS	DS
Philippines	1956-88	STS	STS	DS
Sri Lanka	1956-88	STS	STS	DS
Thailand	1956-88	STS	DS	STS
Turkey	1966-88	DS	DS	STS
AFRICA				
Ethiopia	1960-88	DS	DS	DS
Ghana	1960-88	STS	TS	TS
Ivory Coast	1960-86	STS	STS	DS
Kenya	1956-88	DS	DS	DS
Madagascar	1960-88	DS	DS	STS
Senegal	1960-88	STS	STS	TS
Sudan	1960-88	DS	DS	STS
Tanzania	1960-88	DS	STS	DS
Tunisia	1956-86	DS	DS	DS
Zambia	1960-88	STS	STS	STS
SOUTH AMERICA				
Argentina	1960-88	DS	STS	STS
Bolivia	1960-88	DS	STS	DS
Brazil	1961-87	DS	DS	STS
Chile	1960-88	DS	DS	DS
Peru	1960-88	STS	TS	STS
Uruguay	1960-88	DS	DS	DS
CENTRAL AMERICA				
Costa Rica	1960-88	STS	STS	DS
Dom. Rep.	1960-88	DS	DS	STS
El Salvador	1960-88	DS	STS	STS
Guatemala	1960-88	STS	DS	DS
Honduras	1960-88	DS	DS	DS
Nicaragua	1958-86	STS	DS	DS

N.B. DS: Difference Stationary, TS: Trend Stationary, STS: Split-(Breaking) Trend Stationary.

5.3.3. COINTEGRATION TESTS

The next step in the procedure is to test whether a long-run equilibrium relationship exists among the variables. The variables in question are chosen from Table 5.8. The countries with at least two I(1), difference statinary, variables were chosen for cointegration analysis, which left 18 countries for further testing. These countries and the relevant variables for cointegration analysis are shown in Table 5.9.

TABLE 5.9. COUNTRIES AND VARIABLES TO BE TESTED FOR COINTEGRATION

COUNTRY	PERIOD	VARIABLES
ASIA		
India	1956-88	Y,M,X
Israel	1956-88	Y,M,X
Pakistan	1960-88	Y,X
Turkey	1966-88	Y,M
AFRICA		
Ethiopia	1960-86	Y,M,X
Kenya	1956-88	Y,M,X
Madagascar	1960-88	Y,M
Sudan	1960-88	Y,M
Tanzania	1960-88	Y,X
Tunisia	1960-86	Y,M,X
SOUTH AMERICA		
Bolivia	1960-87	Y,X
Brazil	1961-87	Y,M
Chile	1960-88	Y,M,X
Uruguay	1960-88	Y,M,X
CENTRAL AMERICA		
Dom. Rep.	1960-88	Y,M
Guatemala	1960-88	Y,X
Honduras	1960-88	Y,M,X
Nicaragua	1958-87	M,X

N.B. All variables in natural logarithms.

Both Augmented Dickey-Fuller (ADF) and Phillips-Perron (P-P) tests have been used to test for cointegration. In cases where a trivariate model is involved and no cointegration is detected among the three variables, a pairwise testing strategy has also been pursued. The reason is as follows. Suppose that Y and X are indeed cointegrated and that their linear combination produces an I(0) error term. If M, which is I(1), is added to this relationship, the combination of the I(0) term from Y and X and the M variable will produce an I(1) error term. This will result in the non-cointegration of Y, M, and X, whereas Y and X are indeed co-integrated. For this reason, a pairwise testing methodology (Y and M, Y and X, M and X) has also been followed.

In addition, reverse regressions need to be estimated. This is because, if there is a long-run relationship among Y, X, and M, the empirical detection of this relationship should not depend on the choice of the dependent variable. However, this may not be the case in practice because of finite sample sizes. Therefore, in a trivariate case, test statistics were calculated from reverse regressions, i.e., a regression of Y on X and M, M on Y and X, and X on Y and M. Tables 5.10 and 5.11 give the results of the ADF and P-P tests for cointegration, respectively.

The ADF tests lead to the finding of cointegration in five countries only, and the P-P test adds two more countries. Nevertheless, further pairwise cointegration tests are needed to obtain more conclusive results. A trivariate model is used in the case of Israel, Ethiopia, Kenya, Chile, Uruguay, and Honduras.

TABLE 5.10 AUGMENTED DICKEY-FULLER TEST FOR COINTEGRATION

LOCATION	COUNTRY	DEPENDENT VARIABLE	CONSTANT, NO TREND	CONSTANT, TREND	RESULT
ASIA	India	Log(Y)	-2.80[0]	-2.51[0]	Not CI
		Log(M)	-2.56[0]	-2.67[0]	Not CI
		Log(X)	-2.04[0]	-4.11[0]	CI
	Israel	Log(Y)	-3.17[0]	-3.31[0]	Not CI
		Log(M)	-3.20[0]	-3.70[0]	Not CI
		Log(X)	-2.44[0]	-3.09[0]	Not CI
	Pakistan	Log(Y)	-2.53[0]	-2.15[1]	Not CI
		Log(X)	-2.06[0]	-2.29[0]	Not CI
	Turkey	Log(Y)	-1.82[0]	-1.78[0]	Not CI
		Log(M)	-1.65[0]	-2.19[0]	Not CI
AFRICA	Ethiopia	Log(Y)	-1.58[4]	-2.01[0]	Not CI
		Log(M)	-0.08[0]	-1.85[0]	Not CI
		Log(X)	-3.21[3]	-3.54[3]	Not CI
	Kenya	Log(Y)	-1.88[0]	-1.97[0]	Not CI
		Log(M)	-0.86[5]	-2.53[5]	Not CI
		Log(X)	-2.71[0]	-2.86[0]	Not CI
	Madagscr.	Log(Y)	-2.18[2]	-1.58[2]	Not CI
		Log(M)	-3.20[0]	-2.18[2]	CI
	Sudan	Log(Y)	-2.26[0]	-2.96[0]	Not CI
		Log(M)	-1.11[4]	-2.29[0]	Not CI
	Tanzania	Log(Y)	-2.32[0]	-2.93[1]	Not CI
		Log(X)	-1.38[0]	-3.99[0]	CI
	Tunisia	Log(Y)	-2.98[1]	-2.41[1]	Not CI
		Log(M)	-2.22[1]	-2.30[1]	Not CI
		Log(X)	-4.17[0]	-4.36[0]	CI
SOUTH AMERICA	Bolivia	Log(Y)	-1.90[0]	-1.85[0]	Not CI
		Log(X)	-1.47[1]	-1.72[1]	Not CI
	Brazil	Log(Y)	-1.13[0]	-2.44[0]	Not CI
		Log(M)	-1.37[0]	-2.48[0]	Not CI
	Chile	Log(Y)	-2.56[0]	-3.42[0]	Not CI
		Log(M)	-2.98[0]	-2.00[2]	Not CI
		Log(X)	-0.48[0]	-3.14[0]	Not CI
	Uruguay	Log(Y)	-1.94[4]	-2.09[1]	Not CI
		Log(M)	-2.54[0]	-2.46[1]	Not CI
		Log(X)	-1.29[4]	-2.38[3]	Not CI
CENTRAL AMER.	Dom. Rep.	Log(Y)	-1.27[3]	-1.68[0]	Not CI
		Log(M)	-1.37[3]	-1.44[3]	Not CI
	Guatemala	Log(M)	-2.41[2]	-2.57[2]	Not CI
		Log(X)	-3.02[2]	-4.72[2]	CI
	Honduras	Log(Y)	-1.68[0]	-1.66[0]	Not CI
		Log(M)	-2.73[0]	-2.57[4]	Not CI
		Log(X)	-2.70[0]	-3.52[0]	Not CI
	Nicaragua	Log(M)	0.01[2]	-2.18[2]	Not CI
		Log(X)	-1.50[0]	-0.74[2]	Not CI

N.B. The 10% critical values for C,NT and C,T are -3.04 and -3.50 for the two variable case, and -3.45 and -3.84 for the trivariate case. [.] is lag-length.

TABLE 5.11 PHILLIPS-PERRON TEST FOR COINTEGRATION

LOCATION	COUNTRY	DEPENDENT VARIABLE	CONSTANT, NO TREND	CONSTANT, TREND	RESULT
ASIA	India	Log(Y)	-2.76[1]	-2.84[1]	Not CI
		Log(M)	-2.71[1]	-2.71[1]	Not CI
		Log(X)	-1.92[1]	-4.10[1]	CI
	Israel	Log(Y)	-3.29[1]	-3.41[1]	Not CI
		Log(M)	-3.22[1]	-3.72[1]	Not CI
		Log(X)	-2.63[1]	-3.14[1]	Not CI
	Pakistan	Log(Y)	-2.59[2]	-1.87[1]	Not CI
		Log(X)	-2.20[1]	-2.40[1]	Not CI
	Turkey	Log(Y)	-1.94[1]	-1.89[1]	Not CI
		Log(M)	-1.79[1]	-2.34[1]	Not CI
AFRICA	Ethiopia	Log(Y)	-1.45[4]	-2.10[1]	Not CI
		Log(M)	-0.20[1]	-1.85[1]	Not CI
		Log(X)	-2.54[3]	-2.61[3]	Not CI
	Kenya	Log(Y)	-1.87[1]	-2.01[1]	Not CI
		Log(M)	-2.14[5]	-2.84[5]	Not CI
		Log(X)	-2.72[1]	-2.98[1]	Not CI
	Madagscr.	Log(Y)	-2.69[2]	-3.51[2]	Not CI
		Log(M)	-3.16[1]	-4.14[2]	CI
	Sudan	Log(Y)	-2.40[1]	-3.06[1]	Not CI
		Log(M)	-2.17[4]	-2.29[1]	Not CI
	Tanzania	Log(Y)	-2.32[1]	-4.16[1]	CI
		Log(X)	-1.44[1]	-3.98[1]	CI
	Tunisia	Log(Y)	-4.71[1]	-3.91[1]	CI
		Log(M)	-3.55[1]	-3.65[1]	CI
		Log(X)	-4.17[1]	-4.37[1]	CI
SOUTH AMERICA	Bolivia	Log(Y)	-1.74[1]	-1.69[1]	Not CI
		Log(X)	-2.15[1]	-2.43[1]	Not CI
	Brazil	Log(Y)	-0.99[1]	-2.38[1]	Not CI
		Log(M)	-1.28[1]	-2.40[1]	Not CI
	Chile	Log(Y)	-2.62[1]	-3.47[1]	Not CI
		Log(M)	-3.00[1]	-3.41[2]	Not CI
		Log(X)	-0.61[1]	-3.10[1]	Not CI
	Uruguay	Log(Y)	-1.85[4]	-3.31[1]	Not CI
		Log(M)	-2.61[1]	-3.89[1]	CI
		Log(X)	-2.45[4]	-3.01[3]	Not CI
CENTRAL AMER.	Dom. Rep.	Log(Y)	-2.61[3]	-1.77[1]	Not CI
		Log(M)	-3.03[3]	-3.36[3]	Not CI
	Guatemala	Log(M)	-6.04[2]	-6.24[2]	CI
		Log(X)	-6.26[2]	-8.88[2]	CI
	Honduras	Log(Y)	-1.85[1]	-1.88[1]	Not CI
		Log(M)	-2.80[1]	-3.35[4]	Not CI
		Log(X)	-2.76[1]	-3.58[1]	Not CI
	Nicaragua	Log(M)	-1.35[2]	-3.90[2]	CI
		Log(X)	-1.47[1]	-2.04[2]	Not CI

N.B. The same as Table 5.10.

Table 5.12 reports the results of the pairwise cointegration tests for these countries plus India. India is included since its cointegrating regression did not indicate a significant M variable. Indeed, Table 5.12 sheds more light on the case of India. Previously, it was found that Y, M and X were cointegrated. The results from Table 5.12 show that indeed X and Y, and X and M are cointegrated. Since the linear combination of X and Y produce an I(0) variable, and the linear combination of X and M produce an I(0) variable, the error term from the trivariate model is I(0), leading to the finding of cointegration among the three variables, when it is false. Pairwise analysis for the other countries indicate the cointegration of M and Y variables for Israel and Uruguay, and M and X variables for Honduras. However, the cointegration of M and X is barely significant at the 10 percent level for Honduras, and an examination of the resulting error correction model did not indicate a significant error correction term. Thus, the cointegration results for Honduras are discarded, and a VAR model rather than a vector error correction model (VECM) is used.

Table 5.13 summarizes all the findings that have been discussed so far and lists the countries, sample periods, models to be used in testing for Granger-causality and cointegrated variables, if any. In sum, VAR models are used for 25 countries. The remaining seven countries are modelled using vector error correction models.

TABLE 5.12 PHILLIPS-PERRON PAIRWISE COINTEGRATION TESTS ON SEVEN COUNTRIES

LOCATION	COUNTRY	DEPENDENT VARIABLE	CONSTANT, NO TREND	CONSTANT, TREND	RESULT
ASIA	India	Y - M	-2.6137[4]	-2.3384[1]	Not CI
		M - Y	-2.8510[4]	-2.6779[1]	Not CI
		Y - X	-2.3375[1]	-2.8880[1]	Not CI
		X - Y	-2.2523[1]	-4.0519[1]	CI
		M - X	-2.3582[1]	-2.7291[1]	Not CI
		X - M	-2.1342[1]	-3.8439[1]	CI
	Israel	Y - M	-3.1682[1]	-3.6506[1]	Not CI
		M - Y	-3.1300[1]	-3.6523[1]	CI
		Y - X	-2.5171[1]	-2.5829[1]	Not CI
		X - Y	-2.5392[1]	-3.0582[1]	Not CI
		M - X	-2.3945[1]	-2.8583[1]	Not CI
		X - M	-2.4648[1]	-3.4406[1]	Not CI
AFRICA	Ethiopia	Y - M	-0.9631[1]	-1.8055[1]	Not CI
		M - Y	-0.1771[1]	-1.7340[1]	Not CI
		Y - X	-1.6358[1]	-1.7007[1]	Not CI
		X - Y	-2.3985[4]	-2.4145[4]	Not CI
		M - X	-2.3985[4]	-2.4145[4]	Not CI
		X - M	-2.4153[3]	-2.4656[3]	Not CI
	Kenya	Y - M	-1.3942[4]	-1.9781[1]	Not CI
		M - Y	-1.9818[5]	-2.2211[4]	Not CI
		Y - X	-2.0196[1]	-1.9904[1]	Not CI
		X - Y	-2.6556[1]	-2.0457[1]	Not CI
		M - X	-2.2018[5]	-2.9289[1]	Not CI
		X - M	-2.2707[5]	-2.8624[5]	Not CI
SOUTH AMERICA	Chile	Y - M	-2.6623[1]	-2.5435[1]	Not CI
		M - Y	-2.9594[1]	-2.9192[1]	Not CI
		Y - X	-2.5792[1]	-2.9943[1]	Not CI
		X - Y	-0.5328[1]	-2.4878[1]	Not CI
		M - X	-2.9243[1]	-2.9875[1]	Not CI
		X - M	-0.6101[1]	-2.0457[1]	Not CI
	Uruguay	Y - M	-1.4364[1]	-3.1726[1]	Not CI
		M - Y	-2.4816[1]	-3.6843[1]	CI
		Y - X	-1.9644[1]	-2.0540[1]	Not CI
		X - Y	-2.6343[3]	-2.8521[3]	Not CI
		M - X	-2.4404[1]	-2.4351[1]	Not CI
		X - M	-2.1675[3]	-2.9048[3]	Not CI
CENTRAL AMER.	Honduras	Y - M	-1.6521[1]	-1.9699[1]	Not CI
		M - Y	-2.3201[1]	-2.2616[1]	Not CI
		Y - X	-2.0128[1]	-1.9502[1]	Not CI
		X - Y	-2.2709[1]	-2.2144[1]	Not CI
		M - X	-2.9650[1]	-3.5641[2]	CI
		X - M	-2.6337[1]	-3.4426[4]	Not CI

N.B. The 10% critical values for C,NT and C,T are -3.04 and -3.50. The number in [.] shows the truncation lag on the PP test. CI stands for "Co-Integrated".

TABLE 5.13 A SUMMARY OF THE INTEGRATION AND COINTEGRATION TESTS: MODELS TO BE USED IN TESTING FOR GRANGER-CAUSALITY

COUNTRY	PERIOD	MODEL	COINTEGRATED VARIABLES
ASIA			
Hong Kong	1968-88	VAR	
India	1957-88	VECM	X,Y
Israel	1957-88	VAR	
Korea, S.	1966-88	VAR	
Malaysia	1958-87	VAR	
Pakistan	1961-88	VAR	
Philippines	1957-88	VAR	
Sri Lanka	1960-87	VAR	
Thailand	1958-88	VAR	
Turkey	1967-88	VAR	
AFRICA			
Ethiopia	1961-86	VAR	
Ghana	1961-88	VAR	
Ivory Coast	1963-86	VAR	
Kenya	1957-88	VAR	
Madagascar	1961-88	VECM	M,Y
Senegal	1961-88	VAR	
Sudan	1964-88	VAR	
Tanzania	1961-88	VECM	X,Y
Tunisia	1961-86	VECM	X,Y,M
Zambia	1964-88	VAR	
SOUTH AMERICA			
Argentina	1962-88	VAR	
Bolivia	1961-87	VAR	
Brazil	1962-87	VAR	
Chile	1961-88	VAR	
Peru	1961-88	VAR	
Uruguay	1961-88	VECM	M,Y
CENTRAL AMERICA			
Costa Rica	1961-88	VAR	
Dom. Rep.	1961-88	VAR	
El Salvador	1962-88	VAR	
Guatemala	1961-88	VECM	X,M
Honduras	1961-88	VAR	
Nicaragua	1959-86	VECM	X,M

N.B. VAR: Vector Autoregressive Model, VECM: Vector Error Correction Model.

5.4. VAR/VEC MODELS AND TESTS FOR DIRECT, INDIRECT, AND SPURIOUS CAUSALITY

This section illustrates the application of Schwarz's (1978) Bayesian information criterion in selecting the order of the vector auto-regressive and vector error correction models for each country. The starting point for this analysis is the results presented in Table 5.13. The methodology is as follows.

First, a univariate model was run for each variable for each country. The variables Y, M, and X at this stage denote the residuals for per capita real GDP, real imports, and real exports. The residuals were obtained using the information in Table 5.8 as follows. For difference stationary variables, first differences were taken. For trend stationary variables, the residuals from a regression of the variable in question on a constant and a linear trend term were calculated. For variables with breaking trends, the residuals from the appropriate model (A, B, or C) of Andrews and Zivot (1992) were used. In determining the order of univariate models, the maximum lag length was set to four. The univariate specification which minimized the Schwarz criterion was chosen as the benchmark model against which bivariate and trivariate models were compared.[53] This is also the "best maintained hypothesis" for non-causality. The value of the lag length chosen by the minimum of the logarithm of the Schwarz criterion is shown in square brackets in Tables 5.14 to 5.16. The other steps in the preparation of Tables 5.14 to 5.16 will be illustrated by using

[53] In the case of countries with cointegrated variables, the lagged error term from the cointegrating regression was added to the univariate specification. In such cases, the univariate specification does not lead to a non-causality model.

Pakistan as an example. In Table 5.14, the univariate specification for the growth rate of per capita real GDP (Y) in Pakistan was identified as an AR(1) model by the Schwarz criterion. In the next step, M and X variables were included over the best univariate specification. This led to two bivariate transfer function models for the Y process. The M variable entered the specification with one lag increasing the Schwarz value for Y from -6.6749 to -6.5676. This means that the M variable does not Granger-cause the Y variable in a bivariate model. The same analysis for the X variable led to the inclusion of four lags of X over the univariate Y specification. The Schwarz value obtained in this case is -6.7845. This shows that there is Granger-causality from exports to per capita real GDP in the case of Pakistan in a bivariate model. To see whether the above findings survive in a trivariate model, the M variable was included over the best bivariate specification for Y and X. Interestingly, the trivariate model is superior to the previous bivariate specification of Y and X, the Schwarz value being -7.0531. That is, exports enter the specification for Y in both models. Thus, X is a direct cause of Y. On the other hand, M enters the specification for Y in a trivariate model, but not in the bivariate model. Thus, M is not a direct cause of X. Furthermore, using the definitions of spurious causality from Chapter III, one can classify the M variable as the Type I spurious cause of Y.

This analysis, as illustrated by the case of Pakistan, was undertaken for all countries and for all variables. The models obtained and the Schwarz statistics which led to them are shown in Tables 5.14 to 5.16. The results of this analysis were further subjected to student's t- or F-tests, where applicable. This was done because the inclusion of a variable may be justified by the Schwarz criterion, yet this variable may not be statistically significant at conventional levels.

The estimates of the cointegrating regressions for seven countries, the error correction models (ECMs) derived from them, and the estimates for the VAR models for the remaining 25 countries, where applicable, can now be reported. The specifications of the ECMs and VARs were directly obtained from Tables 5.14 to 5.16. The estimates of the cointegrating regressions are presented in Table 5.17 and those for the ECMs and VARs are reported in Tables 5.18 and 5.19, respectively. In these Tables, (*) indicates univariate or bivariate models with the minimum Schwarz criterion. The (**) is used if the introduction of a third variable further decreases the Schwarz BIC from its (*) value.

In Table 5.17, the specifications of the cointegrating regressions, that is whether a time trend is included or not, were determined by following the methodology of Dolado, Jenkinson, Sosvilla-Rivero (1990). The residual diagnostics did not indicate econometric problems. As a result, the presence of a long-run equilibrium relationship between imports and output was detected for Madagascar and Uruguay. The export variable was found to be cointegrated with output in the case of India and Tanzania. The relationship is positive in the latter, whereas the former indicates a negative relationship.

TABLE 5.14 LOG-SCHWARZ VALUES FOR THE THREE-VARIABLE VAR/VEC MODELS (Per Capita Real GDP)

COUNTRY	Univariate Y[.]	Y-M[.]	Y-X[.]	Y-M-X[.]	Y-X-M[.]
ASIA					
Hong Kong	-6.5252[1]*	-6.3885[1]	-6.3963[1]		
India	-6.3496[0]	-6.2336[1]	-6.6845[3]*		-6.5912[1]
Israel	-6.0598[1]*	-5.9785[1]	-6.0201[1]		
Korea, S.	-7.5593[1]*	-7.4543[1]	-7.4405[1]		
Malaysia	-6.0060[1]	-6.1477[2]*	-5.9821[1]	-6.1197[1]	
Pakistan	-6.6749[1]	-6.5676[1]	-6.7845[4]*		-7.0531[3]**
Philipns.	-8.3670[1]*	-6.2631[1]	-8.3204[2]		
Sri Lanka	-6.9474[1]	-6.9985[2]*	-6.8908[1]	-6.9037[1]	
Thailand	-7.1696[1]	-7.1287[1]	-7.2395[1]*		-7.1856[1]
Turkey	-7.4162[1]	-7.2577[1]	-7.5203[2]*		-7.4096[1]
AFRICA					
Ethiopia	-7.4944[1]*	-7.4048[1]	-7.3779[1]		
Ghana	-7.0135[1]*	-6.9088[1]	-6.9044[1]		
Ivory C.	-6.6928[1]	-6.5471[1]	-6.6988[1]*		-6.5502[1]
Kenya	-5.4572[1]	-5.5251[1]*	-5.3605[1]	-5.4067[1]	
Madagscr.	-6.3026[0]*	-6.2850[1]	-6.2696[1]		
Senegal	-6.7620[1]*	-6.7600[1]	-6.6869[1]		
Sudan	-4.7778[1]*	-4.6464[1]	-4.6583[1]		
Tanzania	-5.9156[0]*	-5.7870[1]	-5.7916[1]		
Tunisia	-6.4800[0]	-6.4959[1]*	-6.3663[1]	-6.3787[1]	
Zambia	-6.0770[1]*	-6.0639[1]	-6.0633[1]		
SOUTH AMERICA					
Argentina	-6.3294[1]	-6.8882[1]*	-6.2768[1]	-6.9100[1]**	
Bolivia	-6.0884[3]	-6.2791[1]*	-5.9585[1]	-6.1742[1]	
Brazil	-5.9814[1]*	-5.9198[2]	-5.8616[1]		
Chile	-5.3693[1]*	-5.2621[1]	-5.2850[1]		
Peru	-6.3949[1]*	-6.3280[1]	-6.2783[1]		
Uruguay	-5.7059[1]*	-5.5794[1]	-5.5774[1]		
CENTRAL AMERICA					
C. Rica	-7.7821[1]	-7.8826[1]*	-7.7568[1]	-7.7541[1]	
Dom. Rep.	-5.4056[1]	-5.4664[1]*	-5.2891[1]	-5.3340[1]	
El Slvdr.	-6.4318[1]	-6.4958[3]*	-6.3301[1]	-6.4231[1]	
Guatemala	-7.4698[1]*	-7.3713[1]	-7.3468[1]		
Honduras	-6.3650[1]*	-6.2962[1]	-6.2440[1]		
Nicaragua	-3.9465[0]*	-3.8345[1]	-3.8288[2]		

N.B. The numbers in [.] stand for the lag length that has minimized the Schwarz criterion.

TABLE 5.15 LOG-SCHWARZ VALUES FOR THE THREE-VARIABLE VAR/VEC MODELS
(Real Imports)

COUNTRY	Univariate M[.]	M-Y[.]	M-X[.]	M-Y-X[.]	M-X-Y[.]
ASIA					
Hong Kong	-6.0021[1]*	-5.8650[1]	-5.8988[1]		
India	-3.4673[0]*	-3.3892[1]	-3.3483[1]		
Israel	-3.7179[1]*	-3.6092[1]	-3.6891[1]		
Korea, S.	-4.5548[1]	-4.4559[1]	-5.0236[1]*		-4.8876[1]
Malaysia	-5.1502[1]*	-5.0469[1]	-5.1165[1]		
Pakistan	-4.6639[1]*	-4.5437[1]	-4.6595[1]		
Philipns.	-4.8542[1]*	-4.8274[1]	-4.7646[1]		
Sri Lanka	-5.4753[1]	-5.4650[1]	-5.5199[1]*		-5.5813[3]**
Thailand	-4.2161[2]	-4.5018[1]*	-4.3917[1]*	-4.7979[1]**	
Turkey	-5.8938[1]	-5.8448[2]	-6.3889[2]*		-6.3671[2]
AFRICA					
Ethiopia	-4.3539[1]*	-4.2737[2]	-4.2598[1]		
Ghana	-1.8103[2]*	-1.7249[1]	-1.6900[1]		
Ivory C.	-4.5217[2]	-4.6118[3]*	-4.3719[1]	-4.4624[1]	
Kenya	-3.7109[1]*	-3.6322[1]	-3.6981[1]		
Madagscr.	-3.8075[0]*	-3.7235[1]	-3.7068[1]		
Senegal	-5.0723[1]*	-5.0026[3]	-4.9565[1]		
Sudan	-3.3556[1]*	-3.2590[2]	-3.3294[1]		
Tanzania	-2.8602[0]*	-2.7640[1]	-2.7440[1]		
Tunisia	-4.0722[0]	-4.2116[1]*	-3.9793[1]	-4.0301[1]	
Zambia	-3.9841[1]*	-3.8930[1]	-3.8805[1]		
SOUTH AMERICA					
Argentina	-3.6277[1]*	-3.4999[1]	-3.4961[1]		
Bolivia	-3.6962[1]*	-3.5697[1]	-3.6301[1]		
Brazil	-3.4391[1]*	-3.3838[1]	-3.2993[1]		
Chile	-2.9843[1]*	-2.8745[1]	-2.9269[1]		
Peru	-3.0249[3]*	-2.9777[1]	-3.0204[1]		
Uruguay	-3.4602[0]	-3.4900[1]*	-3.3652[1]	-3.3734[1]	
CENTRAL AMERICA					
C. Rica	-7.6280[1]	-7.5857[1]	-7.6855[1]*		-7.5689[1]
Dom.Rep.	-3.0847[3]*	-2.9826[1]	-2.9566[1]		
El Slvdr.	-5.3340[1]*	-5.2187[1]	-5.2479[1]		
Guatemala	-3.9403[0]	-4.2512[2]*	-3.8363[1]	-4.1912[1]	
Honduras	-3.9694[1]*	-3.8656[1]	-3.8389[1]		
Nicaragua	-2.9300[3]*	-2.8293[1]	-2.8296[2]		

N.B. The same as Table 5.14.

TABLE 5.16 LOG-SCHWARZ VALUES FOR THE THREE-VARIABLE VAR/VEC MODELS
(Real Exports)

COUNTRY	Univariate X[.]	X-Y[.]	X-M[.]	X-Y-M[.]	X-M-Y[.]
ASIA					
Hong Kong	-5.0954[1]*	-4.9494[1]	-5.0327[1]		
India	-4.8440[0]*	-4.7678[1]	-4.8228[1]		
Israel	-5.3721[1]*	-5.2613[1]	-5.2701[1]		
Korea, S.	-5.4418[1]	-5.4491[1]*	-5.4632[3]*		-5.3274[1]
Malaysia	-5.1492[1]	-5.2166[1]*	-5.4763[1]*		-5.3553[1]
Pakistan	-3.1944[1]*	-3.0776[1]	-3.0724[1]		
Philipns.	-4.1451[1]*	-4.0310[1]	-4.0283[1]		
Sri Lanka	-4.9608[2]*	-4.8402[1]	-4.8300[1]		
Thailand	-4.8042[1]*	-4.7427[2]	-4.7639[1]		
Turkey	-4.0231[1]	-4.2518[4]*	-4.1909[1]*	-4.2005[1]	
AFRICA					
Ethiopia	-3.8302[1]	-3.9883[4]*	-3.9410[3]*	-3.8850[1]	
Ghana	-1.3778[1]	-1.2499[1]	-1.5915[1]*		-1.4736[1]
Ivory C.	-4.1186[1]	-3.9749[1]	-4.2593[1]*		-4.1394[1]
Kenya	-4.3501[1]*	-4.2557[1]	-4.2575[1]		
Madagscr.	-3.5815[2]*	-3.5232[1]	-3.5506[1]		
Senegal	-3.2701[1]*	-3.1560[1]	-3.1604[1]		
Sudan	-4.2218[1]*	-4.0773[1]	-4.2208[1]		
Tanzania	-3.8626[0]	-3.7582[1]	-4.0824[1]*		-3.8357[1]
Tunisia	-4.6677[0]*	-4.5311[1]	-4.5273[1]		
Zambia	-3.7892[1]*	-3.7041[1]	-3.7332[1]		
SOUTH AMERICA					
Argentina	-4.6625[4]*	-4.5337[1]	-4.5264[1]		
Bolivia	-4.2044[3]	-4.1336[1]	-4.2170[1]*		-4.0874[1]
Brazil	-4.5737[1]*	-4.4432[1]	-4.4344[1]		
Chile	-3.9123[1]*	-3.8426[1]	-3.7947[1]		
Peru	-3.7510[1]*	-3.6696[1]	-3.7109[1]		
Uruguay	-3.3883[0]*	-3.2607[1]	-3.2828[1]		
CENTRAL AMERICA					
C. Rica	-4.4467[1]*	-4.3146[1]	-4.3303[1]		
Dom. Rep.	-4.0744[1]	-4.5783[4]*	-4.5518[4]*	-4.6865[1]**	
El Slvdr.	-4.9912[1]*	-4.9905[1]	-4.8868[1]		
Guatemala	-4.9084[0]*	-4.8417[1]	-4.8405[1]		
Honduras	-4.0259[1]*	-3.9398[1]	-3.9691[1]		
Nicaragua	-3.8244[2]	-4.0621[3]*	-3.9383[4]*	-3.9327[1]	

N.B. The same as Table 5.14.

TABLE 5.17 COINTEGRATING REGRESSIONS

INDIA

$$LRX = 15.3087 - \underset{[-3.52]^{***}}{1.1951}\ LRY + \underset{[19.28]^{***}}{0.0493}\ Time$$

R-BAR-SQ. = 0.9656 D.W. = 1.31 N = 32

MADAGASCAR

$$LRM = -2.9947 + \underset{[8.25]^{***}}{1.3660}\ LRY$$

R-BAR-SQ. = 0.7057 D.W. = 0.83 N = 28

TANZANIA

$$LRX = -8.9611 + \underset{[5.52]^{***}}{2.8065}\ LRY - \underset{[-8.23]^{***}}{0.0995}\ Time$$

R-BAR-SQ. = 0.8042 D.W. = 1.26 N = 28

TUNISIA

$$LRX = -3.3365 + \underset{[3.73]^{***}}{1.5941}\ LRY - \underset{[-2.63]^{***}}{0.3147}\ LRM + \underset{[1.84]^{*}}{0.0191}\ Time$$

R-BAR-SQ. = 0.9486 D.W. = 1.66 N = 29

URUGUAY

$$LRM = 0.7820 + \underset{[14.77]^{***}}{2.3924}\ LRY - \underset{[-9.34]^{***}}{0.0196}\ Time$$

R-BAR-SQ. = 0.8861 D.W. = 1.40 N = 29

GUATEMALA

$$LRX = 1.7117 + \underset{[7.69]^{***}}{0.6885}\ LRM + \underset{[3.47]^{***}}{0.0127}\ Time$$

R-BAR-SQ. = 0.9190 D.W. = 1.24 N = 29

NICARAGUA

$$LRM = 3.6677 + \underset{[3.47]^{***}}{0.3761}\ LRX + \underset{[6.20]^{***}}{0.0345}\ Time$$

R-BAR-SQ. = 0.8027 D.W. = 1.49 N = 28

N.B. (***): significant at 1 %. (*) significant at 10 %.

TABLE 5.18 ESTIMATION RESULTS FROM ERROR CORRECTION MODELS

COUNTRY	D.V.	ECT_{t-1}	Coeff. Y	Coeff. M	Coeff. X
INDIA	Y	[-0.18]			-0.0849 (3) [6.87]***
	X	[-4.47]***			
MADAGSCR.	Y	[0.37			
	M	[-3.19]***			
TANZANIA	Y	[0.86]			
	X	[-2.63]**		0.2931 (1) [2.16)**	
TUNISIA	Y	[0.61]		0.1243 (1) [1.82]*	
	M	[0.36]	1.4537 (1) [2.30]**		
	X	[-3.18]***			
URUGUAY	Y	[-0.65]	0.4383 (1) [1.62]		
	M	[-1.85]*	1.1938 (1) [2.02]**		
GUATEMALA	M	[1.33]	1.3690 (2) [5.94]***		
	X	[-3.13]***			
NICARAGUA	M	[-3.05]***		0.9952 (3) [3.38]**	
	X	[-2.57]**	3.1268 (3) [20.45]***	-0.0469 (1) [-0.14]	-0.1759 (2) [0.19]

N.B. (***): significant at 1%, (**): significant at 5%, (*): significant at 10 %. The values in parentheses are the number of lags included. The values in square brackets show the t-values or the F-statistics, where appropriate. The values under the columns Coeff. Y, M and X are the sum of the coefficients for variables Y, M and X, respectively in the error correction models.

Imports and exports are cointegrated in Guatemala and Nicaragua, the sign of the relationship being positive. Only in one country, Tunisia, were all the variables found to be cointegrated. As a result, three countries in a sample of 32 countries indicated the cointegration of exports with per capita real GDP. The sign of the relationship is positive, except in India.

Table 5.18 presents the estimates of error correction models derived from Tables 5.14 to 5.17. Looking at the case of Guatemala, one can see that the error correction term (ECT_{t-1}) is not significant in the imports equation, and that there is a unidirectional positive causality from output growth to import growth. However, the export equation for Guatemala does not contain any short-run causality from either output or imports to exports. Nevertheless, the significant error correction coefficient indicates that there is a long-run causality from imports to exports.

The "Granger Representation Theorem", reviewed in Chapter IV, implies that if two variables are cointegrated, there exists Granger-causality at least in one direction. The cointegrating regressions, however, do not say anything about the direction of causality. The error correction models combined with the cointegrating regression give a richer account of the relationships among the variables. Using India as an example, when per capita real GDP is the dependent variable, the error correction term is not significant (it also does not carry the "correct" sign), but the coefficients on the export variable are significant and negative. Further, when the real exports variable is the dependent variable, the error correction term is significantly different from zero with the theoretically expected sign. The sign of the long-run relationship is given by the cointegrating regression. This leads to two sorts of causalities between exports and output growth in India. A long-run causality from output to exports (negative) and a short-run causality from exports to output growth (also negative).

What is striking in Tables 5.17 and 5.18 is the absence of a long-run relationship between exports and output growth in most cases. In cases where there is a long-run relationship, the direction of causality is from output growth to export growth. These findings indicate that the contribution of exports to the growth of real GDP is a transitory one, if any. A more detailed examination of these findings is presented in Chapter VI.

The results of the VAR estimation for 25 countries can now be examined. The findings are presented in Table 5.19. The estimated models are those chosen by the minimum Schwarz criterion as indicated in Tables 5.14 to 5.16. For nine countries (Israel, the Philippines, Senegal, Sudan, Zambia, Brazil, Chile, Peru, Honduras), the Schwarz criterion did not indicate any causality in any direction. Thus, univariate models were estimated for these countries. For the remaining 14 countries, the Schwarz criterion indicated the possibility of 38 causal relationships. The t- or F-tests indicated that 22 of them were indeed statistically significant.[54] With respect to the relationship between real exports and per capita real GDP, the Schwarz criterion

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[54] t-tests were conducted when a variable had only one lag. For variables with more than one lag, an F-test was conducted.

indicated the possibility of causality from exports to output in five cases (Pakistan, Thailand, Turkey, the Ivory Coast, and Argentina). Only two of them were found to be statistically significant (Pakistan and Thailand). When it comes to the causality from per capita real output to real exports, the Schwarz criterion suggested six possible causal relationships (South Korea, Malaysia, Turkey, Ethiopia, the Dominican Republic, and Nicaragua). The relationship was found to be statistically significant for Turkey, Ethiopia, and the Dominican Republic. In the case of Turkey and Ethiopia, the relationship has a positive sign, giving support to the *internally generated exports* hypothesis. That is, export growth is basically an outcome of the growth of the domestic economy. In the case of the Dominican Republic, output growth reduces export growth. This is referred to as the *export reducing growth* hypothesis.

Table 5.20 combines Tables 5.14 to 5.16 and Tables 5.17 to 5.19. This table also presents the nature of the causal relationships, if any, and applies Hsiao's (1982) definitions of direct, indirect, and two types of spurious causality.

Some comments are in order regarding the inferences about direct, indirect and spurious causalities. These inferences are drawn using the information in Tables 5.14 to 5.16. Direct causality means that X Granger-causes Y in both bivariate and multivariate specifications. Type I spurious causality occurs if X Granger-causes Y in a multivariate model, but not in a bivariate one. This is illustrated for Argentina as follows. From Table 5.14, the Schwarz value for real output in the univariate model is -6.3294. When real exports are included to this equation, one obtains a Schwarz value of -6.2768. Because the univariate Schwarz value is smaller than that obtained with the bivariate relationships, it can be concluded that real exports do not Granger-cause real output in Argentina. With similar reasoning, real imports Granger-cause real output (Schwarz=-6.8832). If, however, real exports are included when real imports are also in the equation, then the Schwarz value further decreases to -6.9100. That is, exports enter the specification of the real output equation only when imports are included. This is defined as Type I spurious causality.

Type II spurious causality is more complicated to illustrate numerically. But, one can follow the example of Malaysia. In theory, Type II spurious causality occurs when a variable, say M, causes both Y and X. When M is present in the specification, there is no causal relationship between Y and X. However, if M is excluded from the specification, then a causal relationship may be detected between Y and X in a bivariate specification. This is the omitted variable bias in conducting the Granger-type causality tests. In the case of Malaysia, M causes both Y and X directly. In the absence of M, Y is found to cause X, but with a negative sign.

TABLE 5.19. ESTIMATION RESULTS FROM VAR MODELS FOR 25 COUNTRIES

COUNTRY	Y		M		X	
	m	x	y	x	y	m
Hong Kong	---	---	---	---	---	---
Israel	---	---	---	---	---	---
S. Korea	---	---	---	0.6186(1) [1.21]	-0.8121(1) [-1.33]	-0.0590(2) [0.18]
Malaysia	-0.6006(2) [5.66]***	---	---	---	-0.-298(1) [-0.08]	-0.6186(1) [-2.65]**
Pakistan	0.2225(3) [2.85]*	0.0679(3) [4.40]**	---	---	---	---
Philippines	---	---	---	---	---	---
Sri Lanka	0.2622(2) [1.29]	---	0.2807(1) [0.85]	-0.1311(1) [-1.06]	---	---
Thailand	---	0.1328(1) [2.42]**	-2.2891(1) [-3.36]***	0.5863(1) [2.92]***	---	---
Turkey	---	0.0477(2) [0.57]	---	0.0090(2) [0.26]	4.0123(3) [7.96]***	0.7562(1) [2.52]**
Ethiopia	---	---	---	---	3.6068(4) [4.24]**	0.1944(1) [0.75]
Ghana	---	---	---	---	---	-0.7786(1) [-3.05]***
Ivory Coast	---	-0.0750(1) [-1.22]	-2.2226(4) [3.25]**	---	---	-0.5884(1) [-2.52]**
Kenya	0.1911(1) [2.27]**	---	---	---	---	---
Senegal	---	---	---	---	---	---
Sudan	---	---	---	---	---	---
Zambia	---	---	---	---	---	---
Argentina	-0.2069(1) [-4.12]***	0.0685(1) [0.88]	---	---	---	---
Bolivia	-0.1493(1) [-2.65]**	---	---	---	---	0.2597(1) [1.63]
Brazil	---	---	---	---	---	---
Chile	---	---	---	---	---	---
Peru	---	---	---	---	---	---
Costa Rica	-0.5289(1) [-2.38]**	---	---	-0.0646(1) [-1.73]*	---	---
Dominican R.	-0.1717(1) [-1.88]*	---	---	---	-1.9438(4) [8.37]***	-0.1596(1) [-1.05]
El Salvador	-0.5314(3) [3.83]**	---	---	---	---	---
Honduras	---	---	---	---	---	---

N.B. Y, M, and X are the dependent variables whereas y, m, and x denote independent variables. The t- or F-statistics are given in square brackets. The numbers in parentheses show the number of lags included. The stars indicate the level of significance as in Table 5.18.

TABLE 5.20. CAUSAL IMPLICATIONS FROM VAR AND VECMs

COUNTRY	CAUSALITY	TYPE	SIGN/SIG.
Hong Kong	No Causality		
India	X → Y	Direct	(-)***
	Y → X	CR/ECT	(-)***
Israel	No Causality		
S. Korea	X → M	Direct	(+)
	Y → X	Spurious	(-)
	M → X	Direct	(-)
Malaysia	M → Y	Direct	(-)***
	Y → X	Spurious (II)	(-)
	M → X	Direct	(-)**
Pakistan	X → Y	Direct	(+)**
	M → Y	Spurious (I)	(+)*
Philippines	No Causality		
Sri Lanka	M → Y	Direct	(+)
	X → M	Direct	(-)
	Y → M	Spurious (I)	(+)
Thailand	X → Y	Direct	(+)**
	Y → M	Direct	(-)***
	X → M	Direct	(+)***
Turkey	X → Y	Direct	(+)
	X → M	Direct	(+)
	Y → X	Direct	(+)***
	M → X	Spurious	(+)**
Ethiopia	Y → X	Direct	(+)**
	M → X	Spurious	(+)
Ghana	M → X	Direct	(-)***
Ivory Coast	X → Y	Direct	(-)
	Y → M	Direct	(-)**
	M → X	Direct	(-)**
	Y → X	Indirect	(-)#
Kenya	M → Y	Direct	(+)**
Madagascar	Y → M	CR/ECT	(+)***
Senegal	No Causality		

TABLE 5.20. CAUSAL IMPLICATIONS FROM VAR AND VECMs (Continued)

COUNTRY	CAUSALITY	TYPE	SIGN/SIG.
Sudan	No Causality		
Tanzania	M → X	Direct	(+)**
	Y → X	CR/ECT	(+)***
Tunisia	M → Y	Direct	(+)*
	Y → M	Direct	(+)**
	Y → X	CR/ECT	(+)***
	M → X	CR/ECT	(-)***
Zambia	No Causality		
Argentina	M → Y	Direct	(-)***
	X → Y	Spurious (I)	(+)
Bolivia	M → Y	Direct	(-)***
	M → X	Direct	(+)
Brazil	No Causality		
Chile	No Causality		
Peru	No Causality		
Uruguay	Y → M	Direct	(+)***
	Y → M	CR/ECT	(+)***
Costa Rica	M → Y	Direct	(-)**
	X → M	Direct	(-)*
	X → Y	Indirect	(-)#
Dominican Rep.	M → Y	Direct	(-)*
	Y → X	Direct	(-)***
	M → X	Direct	(-)
El Salvador	M → Y	Direct	(-)**
Guatemala	Y → M	Direct	(+)***
	M → X	CR/ECT	(+)***
	Y → X	Indirect	(+)#
Honduras	No Causality		
Nicaragua	Y → X	Direct	(+)***
	M → X	Spurious	(-)
	M → X	CR/ECT	(+)***

N.B. The arrow (→) indicates the direct of causality. (***) indicates statistical significance at 1%, (**) indicates statistical significance at 5 % and (*) means that the causal inference is statistically significant at 10%. CR/ECT means that the causal finding and the sign of it were obtained from the cointegrating regression and the error correction mechanism.
The statistical significance of the indirect causality cases were not tested because of the nature of the relationship. The sign (#) was used instead to denote such cases.

Table 5.20 includes a causal structure called *spurious*. This causal structure is similar to Type II spurious causality, but does not fulfill all its requirements. For example, in the case of South Korea, it is found that the causal link from Y to X is spurious, but it does not satisfy the conditions of type I or type II causality. In particular, Y causes X in a bivariate model, but not in a trivariate model. Furthermore, there is a feedback between M and X (i.e., X causes M, and M causes X). However, there is no causal link from X or M to Y. Type II spurious causality would require that M causes Y. As a result, the observed causality from Y to X does not fall under any of the previously defined categories. It cannot be considered as a direct causality since Y does not cause X in a trivariate model. Therefore, this case has been referred to as *spurious* causality. A total of four cases of *spurious* causality have been detected, and this irregularity may warrant further investigation.

Table 5.20 shows three cases of Type I spurious causality, two cases of type II spurious causality, and four cases of spurious causality. In only two cases, however, do the spurious causal relationships prove to be statistically significant: from M to Y in Pakistan and from M to X in Turkey. Although Monte-Carlo studies are needed to confirm these preliminary findings, one may say that the spurious causality does not generally survive the t- or F-tests.

Indirect causality is defined as follows. If X causes M and M causes Y, then X indirectly causes Y. This is a plausible case and indeed the underlying reasoning for the "exports as a source of foreign exchange" hypothesis. In a foreign exchange constrained economy, exports may provide the needed foreign exchange for the imports of intermediate goods and raw materials, which in turn enhance the growth of real GDP. What is hypothesized is an indirect causal link from exports to real output growth. In Table 5.20, the statistical significance of the indirect causality cases were not tested because of the nature of the relationship. The sign (#) was used instead to denote such cases.

Table 5.20 indicates three cases of indirect causality, all with respect to the real exports - real output relationship. In the case of the Ivory Coast, there is an indirect (negative) causality from real output to real exports. This is compatible with an import-substitution strategy. One can see from Table 5.1 that the Ivory Coast followed a moderately outward-oriented strategy between 1965 and 1973. Subsequently, the country followed a moderately inward-oriented trade strategy.

One more insight into the negative causality found from output growth to import growth is the implementation of IMF/World Bank structural adjustment policies. Adjustment and growth policies which required import compression may be responsible for the negative causal relationship between import growth and output growth. Khan and Knight (1988) provide empirical evidence on the relationship between import compression and economic growth. A causal investigation of import compression deserves more attention and is left as a topic for future research.

CHAPTER VI.

AN EVALUATION OF THE FINDINGS

6.1. INTRODUCTION

This chapter evaluates the empirical findings of Chapter V. The analysis is based mainly on the results presented in Table 5.20. The qualitative implications of Table 5.20 are summarized in Table 6.1. In addition, two columns illustrating the trade policy followed by each country in the 1965-1973 and 1973-1985 periods are added. This enables the reader to view the causal findings in relation to each country's trade policy regime. The chapter is organized as follows. Section 6.2 reviews the findings. Section 6.3 provides a comparison to the previous literature. Section 6.4 reports the results of sensitivity analyses and the causal strength of the findings. Section 6.5 provides further economic insights in interpreting the results, while section 6.6 concludes.

6.2. A REVIEW OF THE FINDINGS

For 20 countries, no causality in any direction was found between real exports and per capita real GDP. Of the remaining 12 cases, only two of them (Pakistan and Thailand) exhibit a positive causal link from exports to output. There are six cases which fall under the internally generated exports (IGE) hypothesis. The growth-reducing exports (GRE) hypothesis finds support in the cases of India, and Costa Rica, whereas the export-reducing growth (ERG) hypothesis is supported in India, the Ivory Coast and the Dominican Republic. The results are in line with the previous findings in the literature. That is, if one considers only the export promotion (EP) cases as evidence for export-led/outward-oriented growth, very weak support is found for the export-led growth hypothesis. Thanks to the multivariate approach taken in this study and the tests for cointegration, three cases of indirect causality were detected. The cointegration analysis gives support for the IGE hypothesis for Tanzania and Tunisia. Lal and Rajapatirana (1987) argue that IGE can be interpreted as outward-oriented growth, and Suliman *et al.* (1994) argue that GRE can be considered as export-led growth in inward-oriented countries. This broader view would increase the number of export-led growth/outward-oriented growth cases to 10 in our sample. Thus, one might also argue that some evidence is found for the argument that greater openness enhances economic growth.

One should, however, keep in mind that the direct evidence for export-output causality is when export Granger-cause output with a positive sign. This case is not given much empirical support in this study.

An examination of Table 6.1 suggests that the source of positive correlation between exports and output is the causal link from the latter to the former rather than vice versa. It is also striking that the cases of GRE and ERG are only a few compared to what has been previously found in the literature. With respect to trade orientation and the directions of causal links, one can infer the following.

TABLE 6.1. CAUSAL RELATIONSHIPS BETWEEN REAL GDP AND REAL EXPORTS

		TRADE ORIENTATION	
COUNTRY	RELATIONSHIP	1965-1973	1973-1985
ASIA			
Hong Kong	No Causality	S.O.	S.O.
India	ERG, GRE	S.I.	S.I.
Israel	No Causality	M.O.	M.O.
S. Korea	No Causality	S.O.	S.O.
Malaysia	No Causality	M.O.	M.O.
Pakistan	EP	S.I.	M.I.
Philippines	No Causality	M.I.	M.I.
Sri Lanka	No Causality	S.I.	M.I.
Thailand	EP	M.O.	M.O.
Turkey	IGE	S.I.	M.O.
AFRICA			
Ethiopia	IGE	S.I.	S.I.
Ghana	No Causality	S.I.	S.I.
Ivory Coast	Indirect ERG	M.O.	M.I.
Kenya	No Causality	M.I.	M.I.
Madagascar	No Causality	M.I.	S.I.
Senegal	No Causality	M.I.	M.I.
Sudan	No Causality	S.I.	S.I.
Tanzania	IGE (CR/VECM)	S.I.	S.I.
Tunisia	IGE (CR/VECM)	M.I.	M.O.
Zambia	No Causality	S.I.	S.I.
SOUTH AMERICA			
Argentina	No Causality	S.I.	S.I.
Bolivia	No Causality	M.I.	S.I.
Brazil	No Causality	M.O.	M.O.
Chile	No Causality	S.I.	M.O.
Peru	No Causality	S.I.	S.I.
Uruguay	No Causality	S.I.	M.O.
CENTRAL AMERICA			
Costa Rica	Indirect GRE	M.O.	M.I.
Dominican Republic	ERG	S.I.	S.I.
El Salvador	No Causality	M.I.	M.I.
Guatemala	Indirect IGE	M.O.	M.I.
Honduras	No Causality	M.I.	M.I.
Nicaragua	IGE	M.I.	M.I.

N.B. S.O.: Strongly outward-oriented, M.O.: Moderately outward-oriented, M.I.: Moderately inward-oriented, S.I.: Strongly inward-oriented

First, the EP hypothesis found support in countries which either pursued a relatively outward oriented trade policies (Tunisia) or which opened up recently (Pakistan). However, it is not possible to draw general conclusions about this with only two countries at hand.

Second, the countries for which the IGE hypothesis is supported are those which followed inward-oriented trade policies in both or either half of the sample period.

Third, for the Ivory Coast, the Dominican Republic and India, the ERG hypothesis finds support. All three countries have a common trade policy orientation. India and the Dominican Republic remained strongly inward-oriented throughout the sample period. The Ivory Coast, on the other hand, became more inward-oriented after 1973. Again, the findings suggest that economic growth may hinder export growth in inward-oriented countries since import-substitution is the priority.

Fourth, in the case of India and Costa Rica, a negative causal link from export growth to economic growth is detected. This leads to a negative feedback between export growth and output growth in the case of India. The Indian case is complex and it is left as a subject of future research. The Costa Rican case is interesting. The previous research on Costa Rican export subsidy programs showed that, while export subsidies led to increased exports their fiscal costs alone were higher than the increase in exports.[55] The negative causal link from export growth to output growth detected

[55] Hoffmaister (1992).

in the present study may be due to the fiscal and welfare costs created by such subsidies. Again, more research is needed in this area, with an explicit aim of comparing the results from dynamic computable general equilibrium models and tests of Granger-causality in a larger sample of countries with similar subsidy programs.

Finally, Latin American countries do not show any causality between exports and economic growth. In African countries, there is no evidence of exports causing output. In four cases, however, a causal link from output to export growth is detected (positive in three cases and negative in one case). These findings support Ahmad and Kwan's (1991) findings. A striking result is the finding of no-causality in any direction in the case of Hong Kong and South Korea. The previous literature produced mixed results in the case of South Korea, including no-causality findings.[56] For Hong Kong, Chow (1987) indicated a feedback between manufactured exports and manufacturing GDP. The differences in the results may be due to different data definitions, differences in sample size, or there may not actually be any causality at all.[57]

6.3. A COMPARISON OF THE FINDINGS WITH THE LITERATURE

In this section, the results of the previous chapter are compared with what has been previously found in the literature. The causal

[56] ***Add the literature on export-output causality in S. Korea.***

[57] Chow's (1987) study was strongly criticized by Sephton (1989).

findings from the existing literature on the 32 countries investigated in this dissertation are presented in Table 6.2. This Table shows four studies which covered a large number of countries in their samples. It can be seen from Table 6.2 that the only agreement between the present study's results and the previous literature is over some of the non-causality cases. In cases where there is a causal link between real GDP and real exports, the present study produced different results than the previous literature.[58]

A common ground shared by the previous literature is the lack of causality (especially a positive one) from exports to output growth. The findings are in accordance with Ahmad and Kwan's (1991) results using African countries.

It should be emphasized that each study in the literature uses a different sample period, and the definition of the variables may differ. Moreover, even when the same data set is used, different results may be obtained from different filters, a different model selection procedure, and methodology. What is important is that the causal approach to the study of exports and growth relationship is unable to confirm the results of the cross-country production function approach. This is a robust result in the face of many studies by different authors using different methodologies. In interpreting this non-causality, one must note the recent contributions of Levine and Renelt (1992) and Greenaway and Sapsford (1994a,b) to the study of cross-country and time series

[58] Two exceptions are: EP for Thailand, and IGE for Nicaragua.

TABLE 6.2. A COMPARISON OF THE RESULTS WITH THE PREVIOUS LITERATURE

COUNTRY	Present Study	Jung and Marshall (1985)	Chow (1987)	Bahmani-Oskooee, et al. (1991)	Dodaro (1993)
ASIA					
Hong Kong	NC	---	EP,IGE	---	NC
India	ERG, GRE	NC	---	---	NC
Israel	NC	ERG,GRE	EP,IGE	---	EP,IGE
S. Korea	NC	ERG	EP,IGE	EP,IGE	NC
Malaysia	NC	---	---	---	GRE
Pakistan	EP	ERG	---	---	NC
Philippines	NC	NC	---	NC	NC
Sri Lanka	NC	NC	---	NC	NC
Thailand	EP	IGE	---	EP,IGE	NC
Turkey	IGE	NC	---	---	ERG
AFRICA					
Ethiopia	IGE	---	---	---	NC
Ghana	NC	---	---	---	IGE
Ivory Coast	Ind. ERG	---	---	---	NC
Kenya	NC	IGE	---	---	NC
Madagascar	NC	---	---	---	NC
Senegal	NC	---	---	---	NC
Sudan	NC	---	---	---	NC
Tanzania	IGE (CR)	---	---	---	NC
Tunisia	IGE (CR)	NC	---	NC	NC
Zambia	NC	---	---	---	IGE
SOUTH AMERICA					
Argentina	NC	NC	NC	---	NC
Bolivia	NC	ERG	---	---	NC
Brazil	NC	NC	EP,IGE	NC	NC
Chile	NC	NC	---	---	IGE
Peru	NC	ERG	---	GRE	NC
Uruguay	NC	NC	---	---	NC
CENTRAL AMERICA					
Costa Rica	Ind. GRE	EP	---	---	EP
Dominican R.	ERG	NC	---	EP,IGE	NC
El Salvador	NC	NC	---	GRE	GRE
Guatemala	Ind. IGE	NC	---	---	NC
Honduras	NC	NC	---	NC	NC
Nicaragua	IGE	---	---	---	IGE

N.B. NC stands for "No Causality". (---) indicates that the study did not cover the country. "Ind." stands for "indirect".

production functions. Levine and Renelt (1992) undertook a sensitivity analysis of cross-country regressions. As discussed in Chapter II, their findings, based on Leamer's (1983) extreme bounds analysis indicate that the production function approach, taking exports as a factor of production, does not produce robust results with respect to the export variable. Furthermore, Greenaway and Sapsford (1994a,b) examined the robustness of the results from cross-section and time series production functions for developing countries. These studies produced results similar to Renelt and Levine. These sensitivity analyses of production functions, therefore, produced evidence compatible with the causal findings presented in this dissertation. All these weaken the empirical case for policies aiming at export-led growth. One must, however, keep in mind Bhagwati's (1988) distinction between export promotion (a policy) and export-led growth (an empirical outcome).

6.4. SENSITIVITY ANALYSES

In this section, two forms of sensitivity analyses are undertaken. The first analysis simply asks and empirically answers the question: What results would be obtained if one simply tested for the causality between *export growth* and *output growth* in a bivariate model without paying attention to unit roots and breaking trends? In addition, the sensitivity of the results to the model (lag) selection criteria used is evaluated. The second analysis examines the decisiveness of the causal evidence in view of Poskitt and Tremayne's (1987) R-ratios, as described in Chapter III.

6.4.1. RESULTS FROM BIVARIATE MODELS

The results from bivariate causality tests will be presented. First, the tests were conducted using Akaike's FPE criterion and the Schwarz criterion. Tables 6.3 and 6.4 show the VAR models selected by each criterion and their causal implications. It is striking that one now finds more cases of EP in both Tables. For ease of comparison, the results from this exercise are put together with the results presented in Table 5.21. Table 6.5 shows the combined results.

The FPE criterion selected generally longer lags than the Schwarz criterion, as expected theoretically. The results from both criteria are broadly compatible, although there are some differences. The FPE and Schwarz criteria produced the same causal inferences in 27 of the 32 cases considered. However, there is an important difference when the bivariate models are compared with the trivariate models. Note that the trivariate models may use different residual series due to breaking trends or trend stationary processes. The number of EP cases (seven under the FPE criterion and five under the Schwarz criterion) is reduced to only two. This indicates that the support for the EP hypothesis is indeed even weaker than what the literature suggests. The bivariate EP findings not supported by the trivariate analysis may be regarded as spurious causality cases.

Overall, the findings support the theoretical reasoning that causal inferences are sensitive to the filter, model selection criteria, and the model used. Further analysis of the specification problems in export-economic growth causality tests are left as part of a future research agenda.

TABLE 6.3 GRANGER-CAUSALITY TESTS BETWEEN EXPORT GROWTH AND OUTPUT GROWTH: Results from the Schwarz Criterion

	X Causes Y			Y causes X			
COUNTRY	Lag on (Y,X)	$\Sigma\beta_i X_i$	F- or t-test	Lag on (X,Y)	$\Sigma\delta_i Y_i$	F- or t-test	Conclusions
ASIA							
Hong Kong	(2,0)	---	---	(1,0)	---	---	NC
India	(0,3)	-0.1127	(F) 7.60**	(1,0)	---	---	GRE
Israel	(0,0)	---	---	(0,0)	---	---	NC
Korea, S.	(0,1)	0.1732	(t) 2.41*	(3,0)	---	---	EP
Malaysia	(1,0)	---	---	(0,1)	-0.0073	(t) 4.89**	ERG
Pakistan	(1,(2,4))	0.1742	(F) 4.96**	(0,0)	---	---	EP
Philippines	(2,1)	0.1137	(t) 2.67***	(0,0)	---	---	EP
Sri Lanka	(1,0)	---	---	(2,3)	1.8167	(F) 4.20**	IGE
Thailand	(0,0)	---	---	(0,0)	---	---	NC
Turkey	(1,0)	---	---	(0,3)	-2.6184	(F) 4.75**	ERG
AFRICA							
Ethiopia	(0,0)	---	---	(0,3)	-0.2642	(F) 0.28	NC
Ghana	(0,0)	---	---	(1,(2))	3.6932	(t) 2.32***	IGE
Ivory Coast	(0,2)	0.0903	(F) 2.55*	(0,0)	---	---	EP
Kenya	(0,0)	---	---	(0,0)	---	---	NC
Madagascar	(0,2)	0.1817	(F) 3.20*	(2,0)	---	---	EP
Senegal	(0,1)	-0.0933	(t) -2.21*	(1,0)	---	---	GRE
Sudan	(0,0)	---	---	(0,0)	---	---	NC
Tanzania	(0,0)	---	---	(0,1)	0.7391	(t) 1.29	NC
Tunisia	(1,0)	---	---	(0,0)	---	---	NC
Zambia	(0,0)	---	---	(1,0)	---	---	NC
SOUTH AMERICA							
Argentina	(0,0)	---	---	(0,0)	---	---	NC
Bolivia	(3,0)	---	---	(3,0)	---	---	NC
Brazil	(0,0)	---	---	(0,0)	---	---	NC
Chile	(0,0)	---	---	(0,0)	---	---	NC
Peru	(1,0)	---	---	(0,0)	---	---	NC
Uruguay	(1,0)	---	---	(0,0)	---	---	NC
CENTRAL AMERICA							
Costa Rica	(1,0)	---	---	(1,0)	---	---	NC
Dom. Rep.	(0,0)	---	---	(0,0)	---	---	NC
El Salvador	(1,0)	---	---	(1,0)	---	---	NC
Guatemala	(1,0)	---	---	(0,1)	1.4106	(t) 2.00**	IGE
Honduras	(0,0)	---	---	(0,(3,4))	0.0218	(F) 5.63***	IGE
Nicaragua	(0,0)	---	---	(0,3)	1.6112	(F) 7.60***	IGE

N.B. (*): significant at 10 %, (**): significant at 5 %, (***): significant at 1%.

TABLE 6.4 GRANGER-CAUSALITY TESTS BETWEEN EXPORT GROWTH AND OUTPUT GROWTH: Results from the FPE Criterion

	X Causes Y			Y causes X			
COUNTRY	Lag on (Y,X)	$\Sigma\beta_i X_i$	F- or t-test	Lag on (X,Y)	$\Sigma\delta_i Y_i$	F- or t-test	Conclusions
ASIA							
Hong Kong	(2,0)	---	---	(1,0)	---	---	NC
India	(0,3)	-0.1127	(F) 7.60**	(1,0)	---	---	GRE
Israel	(1,1)	0.0714	(t) 0.73	(0,0)	---	---	NC
Korea, S.	(0,4)	0.1281	(F) 3.23**	(3,0)	---	---	EP
Malaysia	(1,0)	---	---	(0,1)	-0.0073	(t) 4.89**	ERG
Pakistan	(1,(2,4))	0.1742	(F) 4.96**	(0,0)	---	---	EP
Philippines	(2,1)	0.1137	(t) 2.67***	(2,0)	---	---	EP
Sri Lanka	(1,1)	0.1864	(t) 1.79*	(2,4)	2.5519	(F) 3.88**	EP,IGE
Thailand	(0,1)	0.0370	(t) 0.70	(0,0)	---	---	NC
Turkey	(1,0)	---	---	(0,3)	-2.6184	(F) 4.75**	ERG
AFRICA							
Ethiopia	(0,0)	---	---	(4,3)	3.0205	(F) 1.20	NC
Ghana	(0,0)	---	---	(1,(2))	3.6932	(t) 2.32***	IGE
Ivory Coast	(0,3)	0.2860	(F) 2.39*	(0,0)	---	---	EP
Kenya	(0,0)	---	---	(0,0)	---	---	NC
Madagascar	(0,2)	0.1817	(F) 3.20*	(2,0)	---	---	EP
Senegal	(1,1)	-0.0934	(t) -1.81*	(1,0)	---	---	GRE
Sudan	(0,3)	-0.3478	(F) 2.86*	(2,1)	1.1249	(t) 1.63	GRE
Tanzania	(0,0)	---	---	(0,2)	1.5238	(F) 1.45	NC
Tunisia	(1,0)	---	---	(0,0)	---	---	NC
Zambia	(0,0)	---	---	(1,0)	---	---	NC
SOUTH AMERICA							
Argentina	(0,4)	-0.0388	(F) 2.27*	(0,4)	-0.7008	(F) 2.00	GRE
Bolivia	(3,0)	---	---	(3,0)	---	---	NC
Brazil	(0,0)	---	---	(0,0)	---	---	NC
Chile	(0,0)	---	---	(0,0)	---	---	NC
Peru	(3,0)	---	---	(0,0)	---	---	NC
Uruguay	(1,0)	---	---	(4,0)	---	---	NC
CENTRAL AMERICA							
Costa Rica	(1,0)	---	---	(1,1)	0.5506	(t) 1.01	NC
Dom. Rep.	(0,4)	0.4133	(F) 2.48*	(1,(3))	-1.2277	(t) -2.79***	EP,ERG
El Salvador	(2,0)	---	---	(2,1)	0.9326	(t) 1.86*	IGE
Guatemala	(1,0)	---	---	(0,1)	1.4106	(t) 2.00**	IGE
Honduras	(1,0)	---	---	(0,(3,4))	0.0218	(F) 5.63***	IGE
Nicaragua	(0,0)	---	---	(0,3)	1.6112	(F) 7.60***	IGE

N.B. (*): significant at 10 %, (**): significant at 5 %, (***): significant at 1%.

TABLE 6.5 CAUSAL RELATIONSHIPS BETWEEN REAL GDP AND REAL EXPORTS UNDER DIFFERENT SPECIFICATIONS

COUNTRY	Trivariate with UR and BTs.	Bivariate (FPE)	Bivariate (Schwarz)
ASIA			
Hong Kong	No Causality	No Causality	No Causality
India	ERG, GRE	GRE	GRE
Israel	No Causality	No Causality	No Causality
S. Korea	No Causality	EP	EP
Malaysia	No Causality	ERG	ERG
Pakistan	EP	EP	EP
Philippines	No Causality	EP	EP
Sri Lanka	No Causality	EP, IGE	IGE
Thailand	EP	No Causality	No Causality
Turkey	IGE	ERG	ERG
AFRICA			
Ethiopia	IGE	No Causality	No Causality
Ghana	No Causality	IGE	IGE
Ivory Coast	Indirect ERG	EP	EP
Kenya	No Causality	No Causality	No Causality
Madagascar	No Causality	EP	EP
Senegal	No Causality	GRE	GRE
Sudan	No Causality	GRE	No Causality
Tanzania	IGE (CR/VECM)	No Causality	No Causality
Tunisia	IGE (CR/VECM)	No Causality	No Causality
Zambia	No Causality	No Causality	No Causality
SOUTH AMERICA			
Argentina	No Causality	GRE	No Causality
Bolivia	No Causality	No Causality	No Causality
Brazil	No Causality	No Causality	No Causality
Chile	No Causality	No Causality	No Causality
Peru	No Causality	No Causality	No Causality
Uruguay	No Causality	No Causality	No Causality
CENTRAL AMERICA			
Costa Rica	Indirect GRE	No Causality	No Causality
Dominican Republic	ERG	EP, ERG	No Causality
El Salvador	No Causality	IGE	No Causality
Guatemala	Indirect IGE	IGE	IGE
Honduras	No Causality	IGE	IGE
Nicaragua	IGE	IGE	IGE

N.B. UR stands for "Unit Root tests". Bts stands for "Breaking Trends tests."

6.4.2. THE DECISIVENESS OF THE EVIDENCE

The R-ratios from the minimum Schwarz values obtained in trivariate models are also calculated. The relevant Schwarz statistics, the effective sample size after allowance for the lags involved, and the resulting R-ratios are shown in Table 6.6. If the critical value of the R-value is taken as 10, only four causal findings are decisive. These are GRE in India, IGE in Tanzania, ERG in the Dominican Republic, and IGE in Nicaragua. If one tries to eliminate only the closely competing models, but not the competing cases, the square root of 10 can be used as the cut-off point. Table 6.7 shows the results from this critical value. The results under the column ($X \rightarrow Y$) show whether the support for the causal finding reported from X to Y is strong or not. The results under the column ($Y \rightarrow X$) show the strength of the reported causal relationship from Y to X. For example, the GRE hypothesis is decisive for India, whereas the no causality model is as good as the ERG hypothesis. Overall, 42 out of 64 causal inferences were found to be decisive. The effective sample size, of course, is the key factor here. In the remaining 22 cases, the causal link from X to Y is not decisive in 14 cases, whereas the causal link from Y to X is not decisive in 8 cases. Indeed, these non-decisive cases may point out a problem of insufficient observations. The difference, in terms of the Schwarz criterion, between causality and non-causality models is just not large enough. Referring to Tables 5.19, 5.20, and 6.1, one can construct a table where all possible causal relationships, weak or decisive, are shown. Table 6.8 shows the results of this exercise.

TABLE 6.6 POSKITT-TREMAYNE R-RATIOS BETWEEN REAL GDP AND EXPORTS

COUNTRY	T	Y	X → Y X	'R' Ratio	X	Y → X Y	'R' Ratio
ASIA							
Hong Kong	18	-6.1438	-5.9844	4.20	-4.7245	-4.8641	3.51
India	26	-6.3496	-6.6845	77.77	-4.8440	-4.7678	2.69
Israel	26	-6.0598	-6.0201	1.68	-5.3721	-5.2613	4.22
S. Korea	19	-7.5593	-7.4405	3.09	-5.4632	-5.3274	3.63
Malaysia	26	-6.1477	-6.1197	1.43	-5.4763	-5.3553	4.82
Pakistan	24	-6.6749	-6.7845	3.73	-3.1944	-3.0776	4.06
Philipns.	28	-8.3670	-8.3204	1.92	-4.1451	-4.0310	4.94
Sri Lanka	24	-6.9985	-6.9037	3.12	-4.9608	-4.8402	4.25
Thailand	27	-7.1696	-7.2395	2.57	-4.8042	-4.7427	2.29
Turkey	18	-7.4162	-7.5203	2.55	-4.0231	-4.2518	7.83
AFRICA							
Ethiopia	22	-7.4944	-7.3779	3.60	-3.8302	-3.9883	5.69
Ghana	24	-7.0135	-6.9044	3.70	-1.5915	-1.4736	4.12
Ivory C.	20	-6.6928	-6.6988	1.07	-4.2593	-4.1394	3.74
Kenya	28	-5.5251	-5.4067	5.25	-4.3501	-4.2557	3.75
Madagscr.	24	-6.3026	-6.2696	1.49	-3.5815	-3.5232	2.01
Senegal	24	-6.7620	-6.6869	2.46	-3.2701	-3.1560	3.93
Sudan	21	-4.7778	-4.6583	3.51	-4.2218	-4.0773	4.56
Tanzania	24	-5.9156	-5.7916	4.43	-4.0824	-3.8357	19.31
Tunisia	22	-6.4959	-6.3787	3.63	-4.6677	-4.5311	4.49
Zambia	21	-6.0770	-6.0633	1.15	-3.7892	-3.7041	2.44
SOUTH AMERICA							
Argentina	23	-6.8882	-6.9100	1.28	-4.6625	-4.5337	4.40
Bolivia	23	-6.2791	-6.1742	3.34	-4.2170	-4.0874	4.44
Brazil	22	-5.9814	-5.8616	3.74	-4.5737	-4.4432	4.20
Chile	24	-5.3693	-5.2850	2.75	-3.9123	-3.8426	2.31
Peru	24	-6.3949	-6.2783	4.05	-3.7510	-3.6696	2.66
Uruguay	24	-5.7059	-5.5774	4.67	-3.3883	-3.2607	4.62
CENTRAL AMERICA							
C. Rica	24	-7.8826	-7.7541	4.67	-4.4467	-4.3146	4.88
Dom. Rep.	24	-5.4664	-5.3340	4.90	-4.0744	-4.5783	403.43
El Slvdr.	23	-6.4958	-6.4231	2.31	-4.9912	-4.9905	1.01
Guatemala	24	-7.4698	-7.3468	4.38	-4.9084	-4.8417	2.23
Honduras	24	-6.3650	-6.2440	4.27	-4.0259	-3.9398	2.81
Nicaragua	24	-3.9465	-3.8288	4.11	-3.8244	-4.0621	17.33

TABLE 6.7 DECISIVENESS OF THE CAUSAL RELATIONSHIPS BETWEEN REAL GDP AND REAL EXPORTS

COUNTRY	Causal Relationship	Decisiveness of Evidence $X \rightarrow Y$	$Y \rightarrow X$
ASIA			
Hong Kong	No Causality	Decisive	Decisive
India	ERG, GRE	Decisive	Weak
Israel	No Causality	Weak	Decisive
S. Korea	No Causality	Weak	Decisive
Malaysia	No Causality	Weak	Decisive
Pakistan	EP	Decisive	Decisive
Philippines	No Causality	Weak	Decisive
Sri Lanka	No Causality	Weak	Decisive
Thailand	EP	Weak	Weak
Turkey	IGE	Weak	Decisive
AFRICA			
Ethiopia	IGE	Decisive	Decisive
Ghana	No Causality	Decisive	Decisive
Ivory Coast	Indirect ERG	Weak	Decisive
Kenya	No Causality	Decisive	Decisive
Madagascar	No Causality	Weak	Weak
Senegal	No Causality	Weak	Decisive
Sudan	No Causality	Decisive	Decisive
Tanzania	IGE (CR/VECM)	Decisive	Decisive
Tunisia	IGE (CR/VECM)	Decisive	Decisive
Zambia	No Causality	Weak	Weak
SOUTH AMERICA			
Argentina	No Causality	Weak	Decisive
Bolivia	No Causality	Decisive	Decisive
Brazil	No Causality	Decisive	Decisive
Chile	No Causality	Weak	Decisive
Peru	No Causality	Decisive	Weak
Uruguay	No Causality	Decisive	Decisive
CENTRAL AMERICA			
Costa Rica	Indirect GRE	Decisive	Decisive
Dominican Republic	ERG	Decisive	Decisive
El Salvador	No Causality	Weak	Weak
Guatemala	Indirect IGE	Decisive	Weak
Honduras	No Causality	Decisive	Weak
Nicaragua	IGE	Decisive	Decisive

N.B. the cut-off point for decisive versus non-decisive evidence is taken as R = 3.1623, i.e., the square root of 10.

TABLE 6.8 CAUSAL RELATIONSHIPS BETWEEN REAL GDP AND REAL EXPORTS

COUNTRY	Causal Relationship
ASIA	
Hong Kong	**No Causality**
India	**GRE**
Israel	X
S. Korea	X
Malaysia	X
Pakistan	**EP**
Philippines	X
Sri Lanka	X
Thailand	EP, Y
Turkey	**IGE**, EP
AFRICA	
Ethiopia	**IGE**
Ghana	**No Causality**
Ivory Coast	**Indirect ERG**, GRE
Kenya	**No Causality**
Madagascar	X,Y
Senegal	X
Sudan	**No Causality**
Tanzania	**IGE (CR/VECM)**
Tunisia	**IGE (CR/VECM)**
Zambia	X,Y
SOUTH AMERICA	
Argentina	EP
Bolivia	**No Causality**
Brazil	**No Causality**
Chile	X
Peru	Y
Uruguay	**No Causality**
CENTRAL AMERICA	
Costa Rica	**Indirect GRE**
Dominican Republic	**ERG**
El Salvador	X,Y
Guatemala	Indirect IGE,X
Honduras	Y
Nicaragua	**IGE**

N.B. 'X' indicates that there may be a causal link from X to Y. 'Y' indicates that there may be a causal link from Y to X. Bold cases indicate that the evidence is decisive.

The non-causality findings turn out to be decisive for Hong Kong, Ghana, Kenya, Sudan, Bolivia, Brazil, and Uruguay. These constitute only 7 cases out of 20 reported in Table 6.1. That the observed non-causality between exports and economic growth lacks decisiveness in many cases is an important finding.

6.5. FURTHER EXPLANATION OF NON-CAUSALITY FROM EXPORT GROWTH TO OUTPUT GROWTH IN DEVELOPING COUNTRIES

Levine and Renelt (1992), Greenaway and Sapsford (1994a,b), and Kirkpatrick (1995) found that earlier results suggesting that exports enhance economic growth were not robust. Their studies used data that extended into the 1980s and employed cross-section and time-series production functions. Indeed, the results of Levine and Renelt (1992), Greenaway and Sapsford (1994a,b), and Kirkpatrick (1995) might be reflecting the effects of debt-crisis and structural adjustmnent policies (SAPs) in developing countries. During the 1980s, many developing countries underwent SAPs as prescribed by the IMF and the World Bank. Table 6.9 shows the countries studied in this dissertation and the years they received IMF structural adjustment loans.

The structural adjustment policies involve monetary and fiscal restraint, export promotion, and import compression, among others.[59] Structural adjustment programs typically led to output contractions, reductions in public and private investment,

[59] See Kirkpatrick (1995, Tables 1 to 4) for the elements of structural adjustment policies and their degree of implementation by developing countries.

TABLE 6.9 IMF ASSISTANCE RECEIVED BY EACH COUNTRY: Breakdown by Years

COUNTRY	YEARS	TOTAL (Years)
ASIA		
Hong Kong	-	0
India	1980-1983	4
Israel	1975,1976	2
S. Korea	1980,1981,1983-1986	6
Malaysia	-	0
Pakistan	1973,1977,1980-1982	5
Philippines	1973,1976,1979-1981,1983-1986	9
Sri Lanka	1974,1977,1979,1981,1983	5
Thailand	1981,1982,1985,1986	4
Turkey	1978-1984	7
AFRICA		
Ethiopia	1981	1
Ghana	1979,1983-1987	5
Ivory Coast	1981-1986,1988	7
Kenya	1975,1979,1980,1982-1985,1988	8
Madagascar	1980-1983,1985,1986,1988	7
Senegal	1980-1987	8
Sudan	1973,1979,1980,1982-1984	5
Tanzania	1975,1980,1986	3
Tunisia	1986,1988	2
Zambia	1976,1978,1979,1981,1983,1984,1986	7
SOUTH AMERICA		
Argentina	1976,1977,1979,1983-1987	8
Bolivia	1973,1980,1986	3
Brazil	1983,1984,1988	3
Chile	1974,1975,1983-1986	6
Peru	1977-1980,1982-1984	6
Uruguay	1983,1985,1986	3
CENTRAL AMERICA		
Costa Rica	1980-1982,1985,1987,1988	6
Dominican R.	1983,1985	2
El Salvador	1982	1
Guatemala	1983,1988	2
Honduras	1979,1981,1982	3
Nicaragua	1979	1

Source: Khan (1990, Table 7, pp. 227-228).

increases in exports, and decreases in imports in many developing countries. These issues are well captured in the studies of Harrigan and Mosley (1991), Serven and Solimano (1993), and Kirkpatrick (1995). Harrigan and Mosley (1991) used a *with/without approach* to compare the macroeconomic effects of the World Bank's structural adjustment loans (SAL) programme. Their study indicated (p. 63) that:

> ...[t]he rate of return on World Bank programme aid, measured in terms of the impact of GDP growth rates, is found to have been disappointing. The study also identifies a negative correlation between Structural Adjustment Loans and investment. It was also found that the Bank programme aid's strongest beneficial effect has been on the balance of payments current account, both via the stimulation of exports, and via the curbing of imports.

In other words, structural adjustment policies brought about an increase in exports accompanied by stagnating output levels during the 1980s. This may also help explain the findings of this dissertation.

Serven and Solimano (1993) specifically evaluate the relationship between structural adjustment policies and capital formation in developing countries. The authors used pooled time series - cross section data on 15 countries for the period 1976-1988. Their estimation of the investment equations yielded the following results (p. 137). First, output growth and public investment have a significant positive impact on private investment. This also points to the complementarity between public and private investment. Second, the foreign debt burden, macroeconomic instability (measured by the variability of inflation and of the real exchange rate), and the deterioration of world economic conditions after 1982 influence private investment negatively. Third, the foreign debt burdens and adverse external conditions played the largest role in the decline in investment levels as a percentage of real GDP.

Thus, Serven and Solimano (1993) emphasize the effects of macroeconomic stability, policy credibility and some debt relief measures as a way to revive investment in developing countries. From the perspective of this dissertation, therefore, it is not surprising to see that the export promotion policies pursued by many developing countries could not be translated into *export-led growth* in empirical terms. This specifically points to the fact that export-led growth policies need pre-requisites and co-requisites to act as catalysts.[60]

A similar view is shared by Kirkpatrick (1995). Using with/without, before-after, and simulation studies for 80 low and middle income developing countries, Kirkpatrick (1995) showed that trade liberalization did not contribute to productivity growth in the 1980s. As a result, the author concludes that (p. 32) "...trade liberalisation alone does not provide the key to more rapid economic development."

Returning to the results of this dissertation, the causal relationships between imports and output growth can be examined in Table 5.20.

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[60] Suliman *et al.* (1994) show that the level of financial development is a catalyst for Granger-causality from export growth to economic growth to hold.

A reexamination of these results reveals that, first, there is a positive causal link from output growth to import growth in Madagascar, Tunisia, Uruguay, and Guatemala. This is consistent with a Keynesian import function.

Second, imports cause output growth in Pakistan, Kenya, and Tunisia. This is consistent with the hypothesis that intermediate and capital goods imports enhance economic growth. Indeed, the causal findings between imports and economic growth are compatible with those between exports and economic growth.

Making an analogy with Levine and Renelt's (1992) study, if one were to replace the exports variable with imports (as a proxy for openness), one would obtain a positive causal relationship from this variable to economic growth in only three cases. Also, the finding of this positive causality (even in three cases) shows that Granger-causality tests do not suffer from an accounting identity effect, since this would require a negative relationship for imports.

Third, it is found that there is a negative causal relationship from output growth to import growth in Thailand and the Ivory Coast. This can be interpreted as an increase in output growth causing a decrease in imports. Thus, it is consistent with the import compression hypothesis.

Fourth, in the cases of Malaysia, Argentina, Bolivia, Costa Rica, the Dominican Republic, and El Salvador, the direction of causality is from imports to output growth, the sign being negative. Again, this is consistent with import compression policies.

The World Bank's (1993) The East Asian Miracle: Economic Growth and Public Policy studied the underlying factors behind the economic growth success of eight high performing Asian economies (HPAEs), namely, Japan, Hong Kong, South Korea, Singapore, Indonesia, Malaysia, and Thailand.[61] The policies followed by these HPAEs were classified into two groups - fundamentals and selective interventions. "Fundamentals" are macroeconomic stability, high investments in human capital, stable and secure financial systems and openness to foreign technology. "Selected interventions", on the other hand, are mild financial repression, directed credit policies, selective industrial policies, and export-push trade policies.

The World Bank's study acknowledges that it is difficult to establish links between economic growth and a specific intervention, and even more difficult to establish causality. The study concludes that credibly pursued policies and a stable macroeconomic environment were responsible for the higher growth performance in the HPAEs.

The study also emphasizes that institutional and political circumstances, and the capacity of the government institutions matter. Stern (1991) and Öniş (1995) emphasize the same point.

The above preconditions for the success of export-promotion policies also relate to endogenous growth theory. One of the key

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[61] See also Page (1994) for a summary of The East Asian Miracle.

feature of this theory is its emphasis on human capital formation. Endogenous growth models have rich implications for economic growth in developing countries. As discussed in Chapters I and II, the new growth models do not necessarily assign a growth-enhancing role to openness.[62] The sectoral specialization of trading partners is important in explaining growth rate differentials. For example, as a result of international specialization, if a country specializes in the production of goods with low human capital intensity, its stock of human capital grows more slowly, leading to a slower growth rate for the economy. The de-industrialization process and shifting of traditional manufacturing to developing countries should also be evaluated in this respect.

It is argued in Chapter I that most of the hypothesized links between exports and output growth are microeconomic in nature. The indirect macro-oriented link, (i.e., that exports may act as a foreign exchange source for intermediate/capital and raw material imports), is not given support by the findings of this dissertation. Thus, the study of linkages between exports and productivity growth becomes more important. This requires empirical investigations at a more disaggregated level, such as sector specific data and exports at SITC sub-categories. The study by Giles, Giles, and McCann (1992) is one of the first to examine causality at a disaggregated level. The extension of their study to LDC economies is required. For example, Eswaran and Kotwal (1993) demostrate that if the developing South specializes in primary

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[62] See also Pio (1994).

goods production, trade with the developed North will decrease the South's well-being through depressed real wages.

Furthermore, studying export-output causality at the disaggregated level may have implications for testing endogenous growth theory. One may, for example, take exports from human capital-intensive sectors, manufacturing sectors, and primary goods sectors, and evaluate their causal impact on economic growth. Endogenous growth theory implies that research and development (R&D) and human capital are key determinants in explaining economic growth. Specialization in low human capital manufacturing industries may indeed place an economy on a low growth trajectory. Goel and Ram (1994) attempt to integrate R&D activity into a cross-country production function for developing countries. Their results indicate positive effects of R&D activity on the growth of developing countries. Lack of data, especially time series data, may prohibit Granger-causality tests between R&D and economic growth in developing countries. However, foreign trade data are available at a disaggregated level, providing an indirect link in the test for a human capital-intensive exports and economic growth relationship. This is left as a part of future research agenda.

6.6. CONCLUSIONS

This study is a modern multiple time series analysis of the causal relationships between exports, imports and economic growth in 32 developing countries. The approach makes allowances for unit roots, breaking trends, and error correction models, where applicable. The results show that, with the exception of Pakistan and Thailand, no further support can be given to the export-led growth hypothesis. This is in line with the findings of the previous literature, and sensitivity analyses of the cross-section and time-series production functions undertaken by Levine and Renelt (1992), Greenaway and Sapsford (1994a,b) and Kirkpatrick (1995).

The results indicate that no indirect causality from exports to output growth through increased imports is observable. These observations suggest that the empirical case for export-led policies is rather weak and that export growth is not a sufficient condition for economic growth in developing countries.

CHAPTER VII.

CONCLUSIONS

7.1. SUMMARY

This dissertation studies the causal relationships between exports, imports and economic growth in 32 developing countries in the light of recent developments in time-series econometrics. In particular, tests for unit roots, breaking trends, and cointegration are applied, and vector autoregressive (VAR) or vector error correction (VEC) models are specified. The findings are subjected to two forms of sensitivity analyses. First, a procedure for testing the strength (decisiveness) of Granger-causality tests is developed. The procedure is Bayesian in nature, and is based on the Schwarz criterion and the sample size. The idea is to compare the proximity of the posterior odds of a model where 'X Granger-causes Y' to a model where 'X does not Granger-cause Y', where X and Y are two distinct random variables. This test is applied to test for the strength of the causal findings of the dissertation. Second, the results are compared to those that would be obtained from a simple bivariate Granger-causality test using VAR models - an approach very commonly used in the literature. This comparison highlights the advantages of the methodology applied in this dissertation. The empirical findings are summarized below.

Breaking trends occur frequently in macroeconomic time series. In the sample used in this study, 38 out of 96 series were found to have breaking trends, some of which were previously indicated as a difference stationary process by the augmented Dickey-Fuller and/or Phillips-Perron tests. The breaks occur around 1973 or 1979 in most cases, corresponding to the oil price shocks. While tests for breaking trends were undertaken in the literature, this dissertation is the first to extend the analysis to developing countries. These findings raise the question of spurious cointegration. Spurious cointegration may arise if two or more variables are found to be cointegrated, when at least one of them is indeed trend stationary around a break point. Failure to test for breaking trends may lead to spuriously cointegrating relationships.

Exports and per capita real GDP are cointegrated only for India, Tanzania, and Tunisia. Imports and per capita real GDP are cointegrated in the cases of Madagascar, Tunisia, and Uruguay. Exports and imports are cointegrated in Tunisia, Guatemala, and Nicaragua.

Exports Granger-cause economic growth in India, Thailand, Pakistan, and Costa Rica. However, the sign of causality is positive only for Thailand and Pakistan. This evidence indicates that the empirical case for export-led growth is weak.

Nevertheless, the causal findings lack decisiveness in 15 out of 32 countries. There are an additional 13 cases where a causal relationship between exports and imports (in either direction) is suggested, but not detected at conventional significance levels.

The results from the benchmark bivariate vector autoregressions indicate positive causality from export growth to output growth for South Korea, Pakistan, the Philippines, Sri Lanka, the Ivory Coast, Madagascar, and the Dominican Republic. However, these cases, except Pakistan, should be regarded as spurious since the findings have not been confirmed in a trivariate model after allowing for breaking trends. Interestingly, no causal relationship between exports and economic growth is found for Thailand under the benchmark VAR models.

There is no evidence of indirect causality from exports to output growth via the real imports variable. Thus, no causal evidence is found for the "exports as a source of foreign exchange" hypothesis.

Overall, the evidence in this dissertation is in line with the previously reported non-causality from export growth to output growth. In explaining this non-causality, a parallel to the trade liberalization and economic growth literature is drawn, and the effects of structural adjustment programs on output and investment in the LDCs are considered. The importance of testing for export-output causality using data at a finer level of disaggregation is emphasized.

7.2. DIRECTIONS FOR FUTURE RESEARCH

The role of the structural adjustment policies and policies in relation to the linkages between exports and economic growth deserve further attention. Pooled cross section - time series data can be used, similar to that employed by Ahmad and Kwan (1991), to compare the causal structure between export growth and output growth *before and after* the beginning of the structural adjustment era. The pooled data approach could provide more data for estimation and other variables like debt burden, public and private investment levels, macroeconomic stability (measured as inflation and/or real exhange rate variability), capital and intermediate goods imports, which could be incorporated into the causal analysis.

One other possible extension is to use a *with/without* approach, following the cross-section study of Harrigan and Mosley (1991). The idea is to compare the patterns of Granger-causality between countries which underwent structural adjustment programs and those that did not. The choice of the control group would be very important in this approach. In the first instance one could use the sample of countries studied in Harrigan and Mosley (1991).

Finally, a natural extension is to test for export-output causality at a more disaggregated level. As argued in Chapter I, most of the hypothesized links between exports and economic growth are microeconomic in nature. Therefore, an industry-level analysis of productivity growth and export growth is recommended. This approach has the further advantage of providing insights about the implications of endogenous growth theory, e.g., whether the production and export of human capital-intensive goods lead to higher growth rates or not.

As far as econometric methodology is concerned, the model portfolio approach has appealing extensions in VAR modelling and forecasting. One possible extension is the identification of subset autoregressions and subset transfer functions. The forecasting extension of the model portfolio approach can be accomplished by combining the forecasts from competing models. The literature on the combination of forecasts indicates that combined forecasts can outperform the forecasting ability of the individual components.[63] Thus, the model portfolio approach can be extented to improve the forecasting performance of time series models.

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[63] The seminal work on the combination of forecasts is Bates and Granger (1969). See also Granger and Ramanathan (1984), and the special issues of the International Journal of Forecasting (1989, November), and the Journal of Forecasting (1989, July).

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