# Chapter 5
# DATA AND DATA SOURCES

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The data in this chapter provide the background to all the analytical chapters (Chapters 6, 7, 8 and 9). In this chapter, data types, data sources, data treatments, and a general overview of the data are described. The data are then discussed in relation to described exports, instability and economic growth; causes of CERV; export sector performance; and sources of CERV.

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## 5.1 Introduction

Data are obviously crucial for any research study, since every study is a synthesis and analysis of data about some topic. Results of research depend on the type of data, be it primary, secondary or a combination of the two. Primary data are normally gathered from original sources while secondary data are collected from non–original sources (e.g., from previous studies and/or reports made by others). In this study, secondary data and their sources were used.

The nature of this study, which is basically historical, involving time series data, partly dictated that secondary data be employed. In addition, finding secondary data was thought to be less expensive, in terms of money and time, than primary data collection.

A consistent set of time series data were collected for four selected SPINs or the Melanesian countries[11]: Fiji, PNG, SI and Vanuatu. These data were then treated as explained below before they were used for the main analyses. The different ways of treating data depended mainly on the method of analysis to be applied to a particular data set.

The rest of this chapter is organised as follows. Types of data are described in section 5.2. Section 5.3 describes the sources of data. Data treatments are presented is section 5.4 while the general data descriptions are discussed in section 5.5. Finally, some conclusions are drawn in section 5.6.

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11 The terms 'the selected SPINs' and 'the Melanesian countries' are used interchangeably here and elsewhere in this thesis.

## 5.2 Data Sets Assembled for the Various Analyses

### 5.2.1 Data types and definitions

Data for four types of analyses were collected for this research, each type being presented in a separate chapter. They included data for the study of: export expansion, instability and economic growth relationships (presented in Chapter 6), the external and domestic causes of CERV (Chapter 7), the export sector performance (Chapter 8), and the demand and supply sources of CERV (Chapter 9). The data sets used for each analysis are defined and summarised in Tables 5.1. and 5.2, respectively.

**Table 5.1: List of definitions for the data sets used in this study**

| Abbreviation | Description |
|---|---|
| EXP | Domestic exports (gross export values) |
| EXR | Domestic nominal exchange rates |
| GDP | Gross domestic product |
| WGDP | World gross domestic product<br>WGDP is a simple weighted average of GDP for the major trading partners of the respective selected SPINs |
| WCPI | Word commodity price index for agricultural raw materials |
| WD | World demand – measured as weighted–average index of constant prices of world exports for the relevant commodities |
| CM | Competitiveness – improvement of export market shares of traditional (or principal) commodity exports |
| DV | Diversification – broadening, horizontally, of the commodity export mix |

Most of the data collected for this study were nominal, annual and free–on–board (fob) aggregate export values and individual commodity export quantities, prices and values. As shown in Table 5.2, only two data sets – fob aggregate export values and GDP – were used for export expansion and instability and economic growth relationships which are presented in Chapter 6. Five data sets – fob exports, domestic GDP, exchange rates, world GDP, and world commodity prices – were used for the analysis of the external and domestic causes of CERV, presented in Chapter 7. Presented in Chapter 8, for the export sector performance, were four data sets consisting of fob exports, world demand, competitiveness and diversification. The latter three terms are further explained in Chapter 8 and in section 5.5. Data sets for commodity exports quantities, prices and values for various individual major export commodities were assembled and used for the analysis of the demand and supply sources of CERV presented in Chapter 9.

**Table 5.2: Types of data sets used in this research**

| Chapter | | | |
|---|---|---|---|
| 6 | 7 | 8 | 9 |
| | | | Export commodity |
| EXP | EXP | EXP | quantities |
| GDP | GDP | GDP | prices |
| – | EXR | CM | values |
| – | WGDP | DV | – |
| – | WCPI | – | – |

### 5.2.2 Data sampling issues

The major trading partners of the respective selected SPINs from where WGDP data sets were computed are listed in Table 5.3. From the table, it is shown that six, seven, and five major trading partners were identified for Fiji, PNG and SI, respectively. No trading partners were identified for Vanuatu since it was not analysed in Chapter 7 due to unavailability of the data sets. In each case, the identified major trading partners import about 80 per cent of the total commodity exports of that SPIN.

**Table 5.3: List of the identified major trading partners for the selected SPINs**

| The selected SPINs | | |
|---|---|---|
| Fiji | PNG | SI |
| Canada | Federal Republic of Germany | Federal Republic of Germany |
| New Zealand | Netherlands | Netherlands |
| Australia | Australia | Australia |
| UK | UK | UK |
| Japan | Japan | Japan |
| USA | USA | – |
| – | Spain | – |

Collecting the data for this study proved to be very difficult. If available, the records kept for the secondary sources of data were often missing and variable. Data for the 1960s were most unavailable and variable. Whatever data were found, they were recorded in different units of measurements which entailed some rigorous conversions. The fundamental changes in the social and economic structures which have taken place over the years in the SPINs and in the world commodity trade could have been one reason for the different recording systems. In addition, due to budget constraints, it was not possible to travel to some of the selected SPINs to collect the required data from their data banks. Many times, the author relied on writing letters and faxes to the selected SPINs and other data sources. Often, replies were not forthcoming.

Despite these difficulties, it proved possible to assemble data covering a minimum span of about 30 years for most of the variables needed for the analysis. The sample sizes for these data sets are summarised in Table 5.4 below.

**Table 5.4: Sample sizes for the data sets used in this study**

| Country and data sets | Number of observations | Period covered |
|---|---|---|
| **Fiji** | | |
| EXP, GDP, EXR, | | |
| WGDP, WCPI | 33 | 1960–1992 |
| EXP, WD, CM, DV | 30 | 1961–1990 |
| **PNG** | | |
| EXP, GDP, EXR, | | |
| WGDP, WCPI | 33 | 1961–1993 |
| EXP, WD, CM, DV | 30 | 1961–1990 |
| **SI** | | |
| EXP, GDP, EXR, | | |
| WGDP, WCPI | 33 | 1960–1992 |
| EXP, WD, CM, DV | 30 | 1961–1990 |
| **Vanuatu** | | |
| EXP, GDP | 12 | 1979–1990 |

Data for the demand and supply sources of CERV involved various observations of the quantities, prices and values for 6, 12, 7 and 6 primary export commodities for Fiji, PNG, SI and Vanuatu, respectively. These data were gathered over different time frames for each of the four selected SPINs.

In time series econometric analysis, best results are usually expected from long data series. It seems that there is no rule about the minimum number of observations. For each analysis in this study, longer data series would have been desirable. Small sample sizes mean fewer degrees of freedom in statistical analyses, possibly weakening the credibility of the results. However, data for most variables for the selected SPINs were not available, especially for the period before 1960s. This data limitation is indicative of the data deficiencies faced in many LDCs.

Nevertheless, it has been possible to assemble one of the longest and most comprehensive data sets for the selected SPINs ever put together. It is an empirical matter whether or not these data are sufficiently significant to generate results that will shed light on the relationships that have existed in these SPINs over the past three decades between CERV and the various variables.

## 5.3 Data Sources

Various sources were identified for the data used in this research. Most of the data (both general and specific) were extracted from International Financial Statistics (IFS) Yearbook by IMF (1991–1994 and various issues), and from the Fiji, PNG, SI and Vanuatu statistical compendiums found in the South Pacific Economic and Social Databases (NCDS 1992). Data obtained from these sources include EXP, GDP, EXR, WGDP, WCPI, and the quantities and values of the principal export commodities. Data sources, principal and supplementary sources, are summarised in Table 5.5.

**Table 5.5: Sources of data sets used in this study**

| Country and data sets | Sources |
|---|---|
| **All selected SPINs** | |
| EXP, GDP, EXR, WGDP, WCPI | IFS Yearbook by IMF (1991–1994 and various issues), Fiji, PNG, SI and Vanuatu Statistical Compendium by NCDS (1992a b c d), Pacific Islands Yearbook by Tudor (1963 1968), Inder (1977 1978), Carter (1981), Morman and Ngaire (1989), and SI Development Plans (British SI Protectorate 1971). |
| **Fiji, PNG & SI** | |
| WD, CM, DV | Trade Yearbook (FAO various issues), International Trade Yearbook (United Nations various issues), Economic and Social Survey of Asia and the Pacific (UN 1992), Commodity Trade and Price Trends (World Bank 1983). |
| **All selected SPINs** | |
| For all individual commodities and to fill and join up missing data | Current Economic Statistics (Fiji Government 1982, 1991 and various issues), Fiji Old Colonial Reports (Anon. 1962–1970), Quarterly Economic Bulletin (PNG Government various issues), National Accounts Statistics (PNG Government 1974), Summary Statistics (PNG Government various issues), PNG Old Colonial Reports (Australian Government 1969–1973), Private Reports (Lam 1984), AIDAB Reports (1991a) Statistical Yearbook (SI Government 1974–1984), British SI Old Colonial Reports (SI Government 1962–1975), Quarterly Reviews (Central Bank of SI 1992), Asia–Pacific Reviews (World Information 1993), AIDAB Reports (AIDAB 1991b), New Hibrides Old Colonial Reports (Anon. 1960–1970), Vanuatu Statistical Bulletin (Vanuatu Government 1984), AIDAB Reports (AIDAB 1994). |

## 5.4 Data Treatments

### 5.4.1 Currency conversion

Since most of the collected data were in their respective local currencies, they had to be converted to a common denominator, the US dollar. The local currency/US dollar average annual exchange rates were used for conversion purposes. One reason for converting the data into one uniform currency is to ensure that there is consistency in the data before any analysis is performed. This could also permit cross country comparisons of the data and the results.

Conversion was to US dollars because the US dollar is the main currency of international trade. Moreover, a consistent set of exchange rates was available in the IFS Yearbooks, the major source of the data used in this research. Further, to allow the results to be compared with similar studies in other LDCs, it was appropriate to follow common practice and convert the data into US dollars.

### 5.4.2 Conversion to constant prices

To remove the effects of inflation, data in dollar values were deflated to constant prices, using either 1985 or 1961 as the base year. The 1985 base year was applied to all the data used in Chapters 6 and 7. The 1985 base was used in the IFS Yearbooks which were the major sources of data for these chapters. For Chapter 8 where indices were constructed from various sources, Love's (1984) suggestion that data for the indices should be deflated using the initial year (1961 for this study) as the base year was adopted.

### 5.4.3 Conversion to logarithms

For all the data used in Chapters 6, 7 and 8 (including all the data for unit roots and cointegration tests), logarithms were taken to smooth the data series prior to the analyses. Conversion to logarithms helps to avoid 'explosive' results. It also makes the data unitless thereby making interpretation of the results easier since there is no referring back to the units used.

For the demand and supply decomposition in Chapter 9, data on quantities were converted where necessary into metric tonnes and their multiples. Data in money values were not converted to US dollars but were left in the respective local currencies. Where there had been a change in the local currency units, values were converted to one current currency.

This procedure follows the practice of the previous similar demand and supply decomposition studies (Piggott 1978, Fleming and Piggott 1985 1989, Myers and Runge 1985).

## 5.5 General Overview of the Data

In this section changes over time in the data to be used in the various analytical chapters are examined. The data sets examined are for: exports, instability and economic growth, causes of CERV, export performance sector and sources of CERV.

### 5.5.1 Data for exports, instability and economic growth

The data used here consisted of only two variables, namely, the aggregate export values and GDP for each selected SPIN. The raw data, deflated to constant prices, are represented in Appendix 5.1. These deflated data in log forms are presented graphically in Figures 5.1 and 5.2 for exports and GDP, respectively.

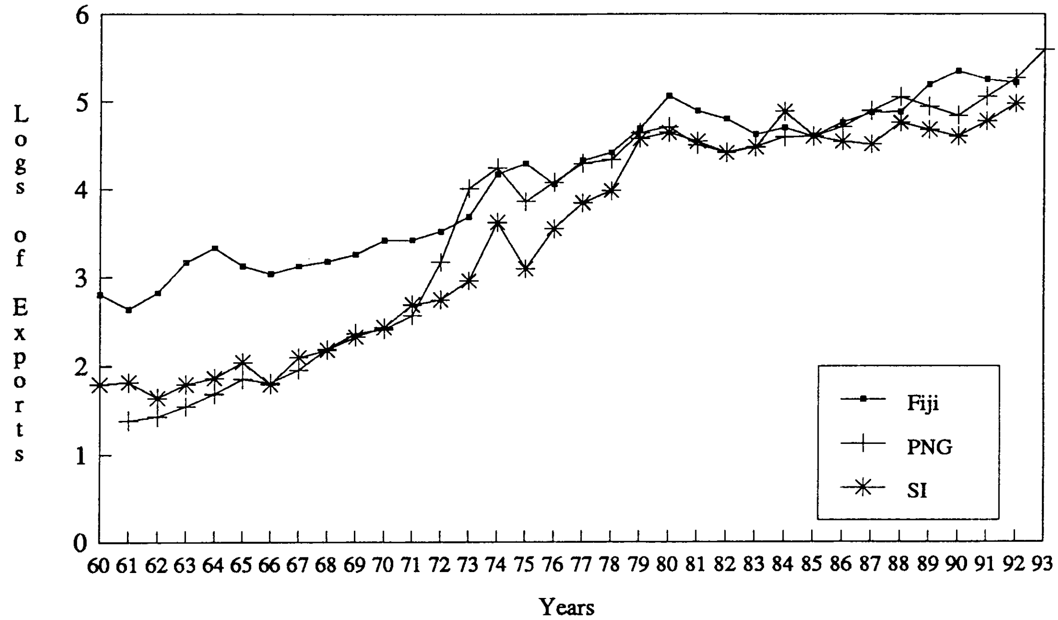
As can be seen from the figures, both the aggregate exports and GDP have grown through time. The patterns of exports and GDP growth show some similarities, suggesting associations between them for each of the selected SPINs. This possible association is analysed in Chapter 6.

### 5.5.2 Data for causes of CERV

Data for five variables – aggregate EXP values, GDP, EXR, WGDP and WCPI – are used for the analysis of the causes of CERV in Chapter 7. The first three variables relate to domestic sector while the last two variables relate to external market sector. Since the aggregate EXP values and GDP have been described in section 5.5.1, only EXR, WGDP and WCPI are discussed here.

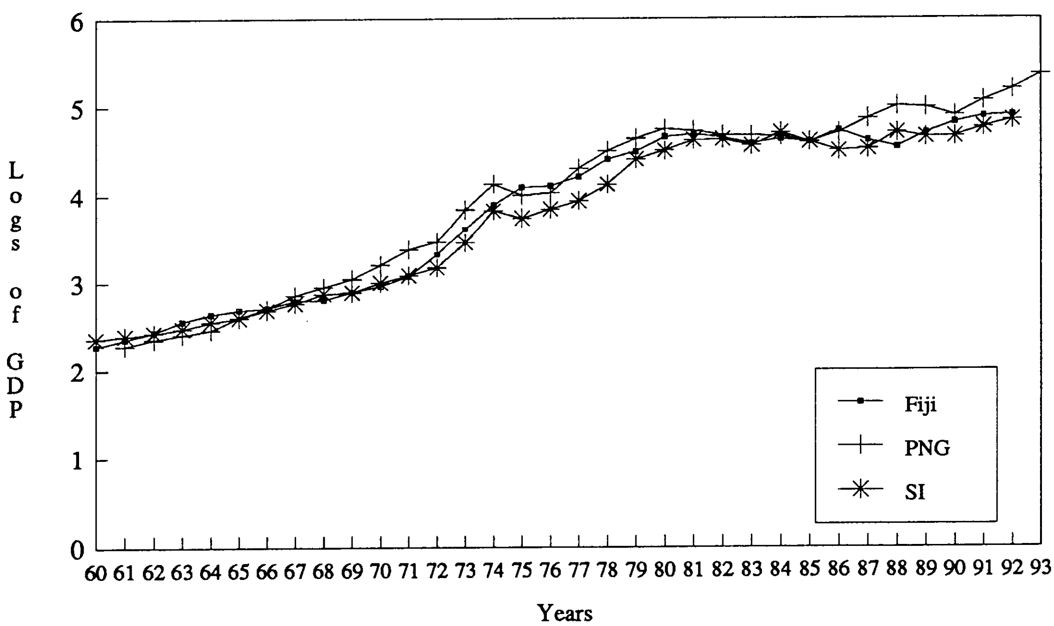
Like EXP and GDP, EXR, WGDP and WCPI variables were also deflated to constant prices. These series are tabulated in Appendices 5.2 and 5.3 for EXR, and WGDP and WCPI, respectively. These deflated data, in log forms, are presented in Figure 5.3 for EXR and 5.4 for WGDP and WCPI.

**Figure 5.1: Aggregate export trends, 1960–1993**



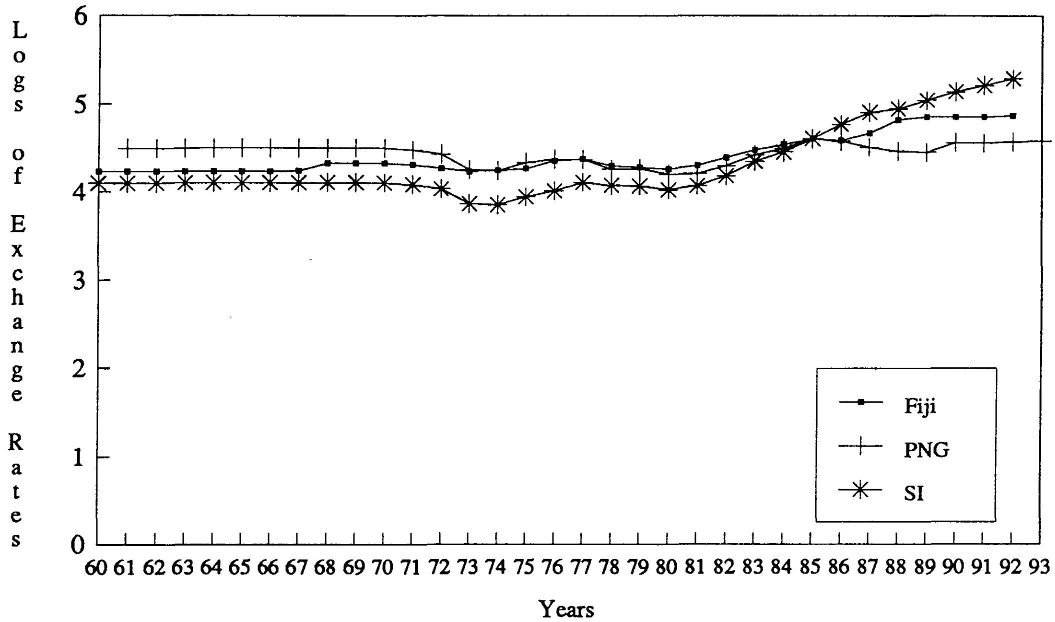

Notes: Exports deflated to 1985 prices, and logs of deflated data are plotted.
Source: Computed from Appendix 5.1.

**Figure 5.2: GDP trends, 1960–1993**



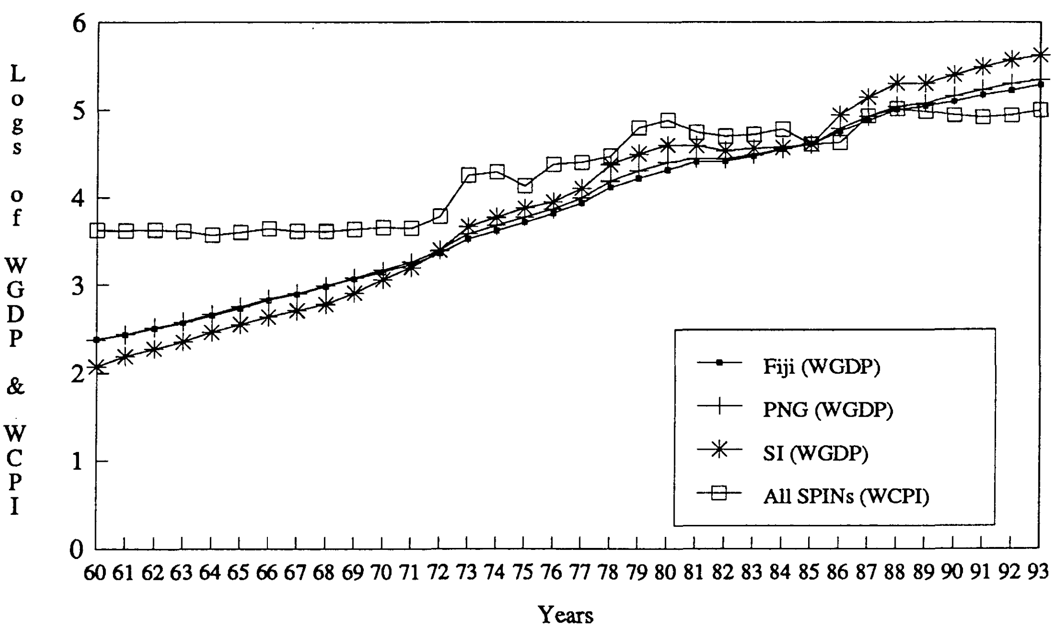

Notes: GDP deflated to 1985 prices, and logs of deflated data are plotted.
Source: Computed from Appendix 5.1.

**Figure 5.3: Exchange rate trends, 1960–1993**




Notes: Exchange rates deflated to 1985 prices, and logs of deflated data are plotted.
Source: Computed from Appendix 5.2.

**Figure 5.4: WGDP and WCPI trends, 1960–1993**




Notes: WGDP and WCPI deflated to 1985 prices, and logs of deflated data are plotted.
Source: Computed from Appendix 5.3.

Interestingly, until 1986/87, changes in the exchange rates for the selected SPINs (Figure 5.3) show similar patterns over time. The nominal exchange rates for the three SPINs were apparently fixed until about 1971/72 when some flexibility was introduced. The rate began to change more rapidly from about 1986/87.

Through time, the external market factors (WGDP and WCPI) seem to have moved somewhat together for the three selected SPINs, as illustrated in Figure 5.4. WGDP had grown continuously over time. This was not the case with WCPI. During the initial years, until about 1972, the log graph of WCPI did not seem to have any noticeable trends. However, from 1973 to 1993, more variable trends are noticed, probably reflecting more hostile world market situations during this period.

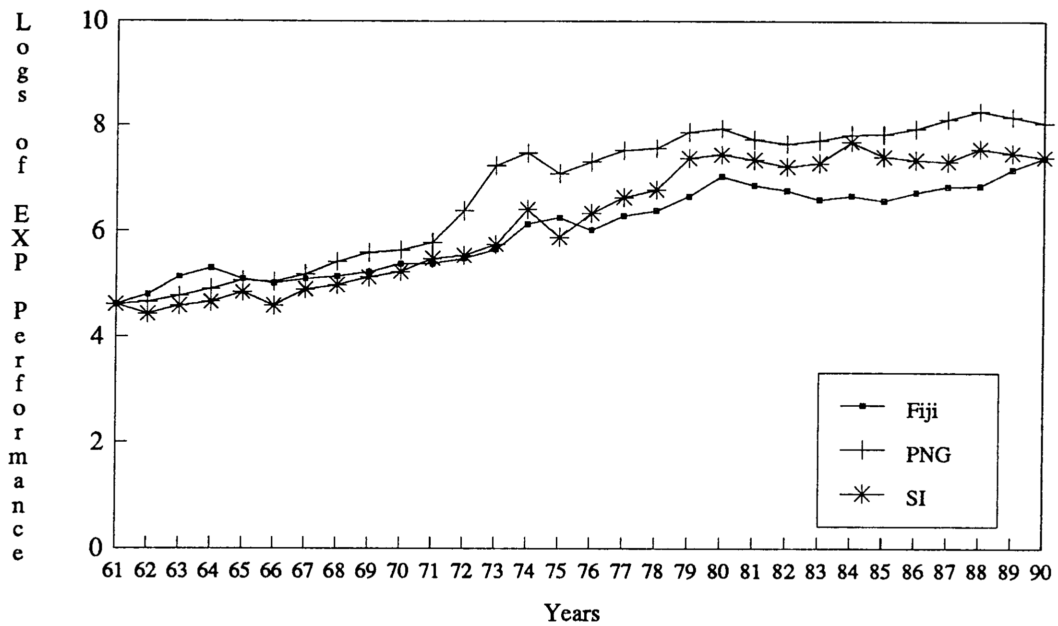
### 5.5.3 Data for exports sector performance

Four variables (EXP, WD, CM and DV) were constructed as indices and were used for the assessment of export sector performance in the selected SPINs. The construction of these variables is explained in Chapter 8. Like the variables in the previous subsections, the exports sector performance variables were deflated to constant prices and are tabulated in Appendices 5.4 and 5.5 for EXP and WD, and CM and DV, respectively, for the selected SPINs. The logarithms of these variables are graphed in Figure 5.5 for EXP, 5.6 for WD, 5.7 for CM and 5.8 for DV.

Export sector performance, as reflected by the trend of aggregate exports for the three SPINs (Figure 5.5), has expanded through time. The patterns of this expansion are approximately similar and they seem to be moving together. Although the moving together of world demand for PNG and SI were closer to each other than with that of Fiji, the expansion of this demand for the three countries had generally been realised (Figure 5.6). This figure shows that the trends of world demand for the three selected SPINs had been generally expanding over time. This trend seems to have slowed down after the 1970s, particularly after 1980. This slow–down is more visible for Fiji and PNG.

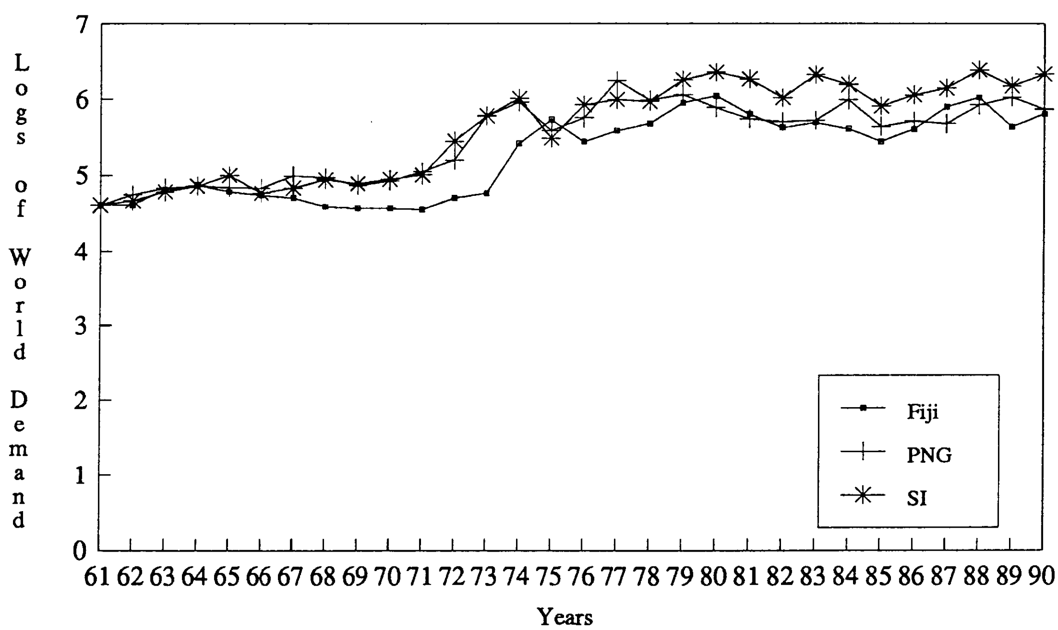
The trend for competitiveness improved modestly for the three SPINs. With variations, SI and PNG showed more improvement than Fiji. In all these cases, but more especially Fiji, competitiveness started to decline from the mid 1960s to the early 1970s, and towards the mid 1980s and more seriously toward the end of 1980s (Figure 5.7). Diversification increased a little towards the mid 1960s (Figure 5.8). Immediately thereafter, diversification fell towards, and up to, the end of the 1960s, rising again from the early to mid 1970s. After about 1975 and, throughout the remaining period, diversification started diminishing.

**Figure 5.5: Export performance trends, 1961–1990**



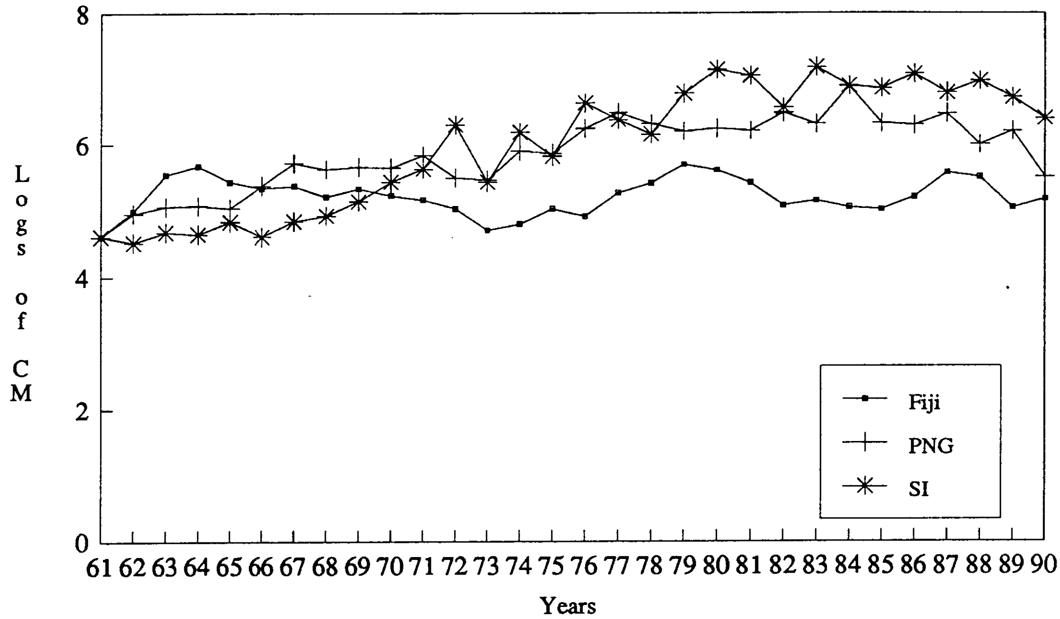

Notes: Exports deflated to 1961 prices, and logs of deflated data are plotted.
Source: Computed from Appendix 5.4.

**Figure 5.6: World demand trends, 1961–1990**



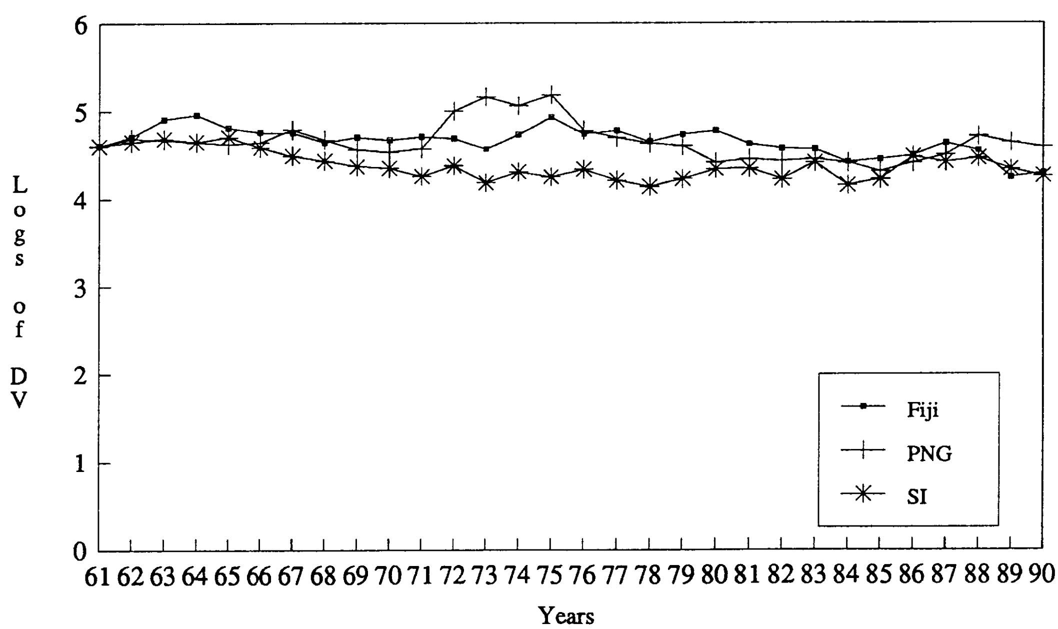

Notes: World demand values deflated to 1961 prices, and logs of deflated data are plotted.
Source: Computed from Appendix 5.5.

**Figure 5.7: Competitiveness trends, 1961–1990**




Notes: Competitiveness values deflated to 1961 prices, and logs of deflated data are plotted.
Source: Computed from Appendix 5.6.

**Figure 5.8: Diversification trends, 1961–1990**




Notes: Diversification values deflated to 1961 prices, and logs of deflated data are plotted.
Source: Computed from Appendix 5.7.

### 5.5.4 Data for sources of CERV

Data for the sources of CERV include fob export quantities, prices and values of individual principal commodities. Most of these data covered a period of 30 years, approximately from 1961 to 1990, although some data were available for less than 30 years. Export quantities and values of the principal individual export commodities were gathered for the four Melanesian countries. Data on fob export prices for all the commodities were not collected, but were generated by dividing the annual fob export values by the respective export quantities. As mentioned, the data for the sources of CERV were utilised without adjustment for inflation or conversion to logarithms.

To study the sources of CERV in the selected SPINs, data were assembled covering the most important primary export commodities of these SPINs. These main commodities were thus identified, and data about them (quantities, prices and values) were put together (see Appendices 5.6 – 5.9).

Six commodities (sugar, molasses, coconut oil, gold, forestry and marine) were selected for Fiji. Data for sugar, molasses, coconut oil and gold were available for 30 years (1961–1990) while those of forestry were available for 28 years (1963–1990) and those of marine exports for 16 years (1975–1990).

PNG data covered the greatest number of commodities – twelve (coffee, cocoa, copra, coconut/copra oil, rubber, tea, palm oil, logs, forestry, marine, gold and copper). Coffee, cocoa, copra, copra oil, rubber, logs, forestry, marine and gold data were available for 30 years (1961–1990). Tea data were available for 28 years (1963–1990) while data for palm oil and copper were available for 20 years (1971–1990).

SI data covered seven commodities (copra, forestry, cocoa, marine, fish, gold, and palm oil and kernel). Copra, cocoa, timber, marine and gold were available for 30 years (1961–1990) while fish export data were available for 20 years (1971–1990) and palm oil and kernel for 15 years (1976–1990).

Lastly, Vanuatu data covered six commodities (copra, cocoa, coffee, beef, fish, and timber). All these commodities, except beef and timber, were available for 30 years (1961–1990). Beef was available for 27 years (1964–1990) while timber was available for 13 years (1978–1990). Selected individual commodities are described in Appendix 5.12.

# Chapter 6

# AN ASSESSMENT OF EXPORT EXPANSION AND INSTABILITY AND ECONOMIC GROWTH RELATIONSHIPS

In this chapter[12], a null hypothesis is tested, namely that export expansion and instability have no significant causal relationships to economic growth and instability in selected SPINs. The hypothesis has been tested by using cointegration, Granger causality, error correction mechanisms, forecast error variance decomposition, and impulse response analysis. It was found that various causal relationships existed between export growth and instability and GDP growth and instability in the selected SPINs. But, since the time series data used were short, the conclusions and implications of this analysis should be treated with caution.

## 6.1 Introduction

There are two goals in this chapter. The first is to investigate whether expansion of export revenues positively influences economic growth. The second is concerned with whether CERV affects economic growth and instability in three Melanesian countries: Fiji, PNG and SI. Due to data limitations, Vanuatu is omitted. These goals, which are investigated simultaneously, were motivated by both the controversies the issues have generated and their importance to strategic planning in Melanesia. The motivation was also influenced by mixed evidence from other parts of the world on the contentious but often–made assumption that exports have long–run relationships with economic growth.

The general objective of this chapter is to find some empirical evidence either to support or refute the proposition that both expansion of exports and CERV have positive influences on economic growth of the selected SPINs. The study is focused on both short– and long–run relationships between exports and GDP, changes in both being used as proxy measures for both growth and instability.

Using data from three Melanesian countries, investigations are accomplished by applying cointegration analysis for long–run relationships. Granger causality tests, FEDA and IRA, based on both VAR models and ECMs, are employed for dynamic short–run analysis. While the VAR models were applied to the three countries, ECMs were applied to only two countries (PNG and SI) where at least moderate cointegration was detected.

12 The author's contributions to Onchoke and In (1992), In, Onchoke and Fleming (1994), Onchoke and In (forthcoming) and Onchoke (forthcoming) form the bases of parts for this chapter.

In extending this type of empirical analysis to the Melanesian countries using the techniques mentioned above, an attempt is made to differentiate this study from many similar previous studies in three novel ways:

- First, this study employs some of the relatively more recent Granger causality developments in that various unit roots tests and cointegration tests are incorporated as pre–test requirements prior to the actual Granger causality tests. To supplement Granger causality testing, FEDA and IRA are also employed, all integrated as a single analytical package. The time series properties of the variables of interest are evaluated empirically. Some of the relatively new testing procedures by Phillips (1987), Phillips and Perron (198), Park and Choi (1988) and Park, Ouliaris and Choi (1988) are employed to evaluate the properties of the variables. Two empirical tests by Akaike (1974) and Schwarz (1978) are also employed for finding optimal lag lengths for the data series under investigation.

- Second, it is likely that this study may be one of the first applications of contemporary time series econometrics in the SPINs.

- Third, and perhaps most importantly, this study demonstrates that it is possible to support causality tests with FEDA and IRA applications. This helps to shed more light on the consistency of the short–run relationships between exports and GDP.

This chapter is structured as follows. An overview of primary export development in Melanesia is given first. Following this is a brief background to the debate on export–economic growth relations (presented as the role of exports in economic growth). Theoretical issues in export–GDP interactions are then presented which provide the basis for the analytical methods[13], which are then explained. Results are presented and discussed, and finally a summary is provided and conclusions are drawn.

## 6.2. Primary Export Development in Melanesia – An Overview

The first outside contacts for people in the South Pacific were with the early European explorers and travellers. This early contact opened the doors for the beginning of export trade in the region. The initial export commodities traded were copra and coconut oil. The

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[13] The presentation of analytical methods in this chapter forms the major reference for the methods used in Chapters 7 and 8 as well.

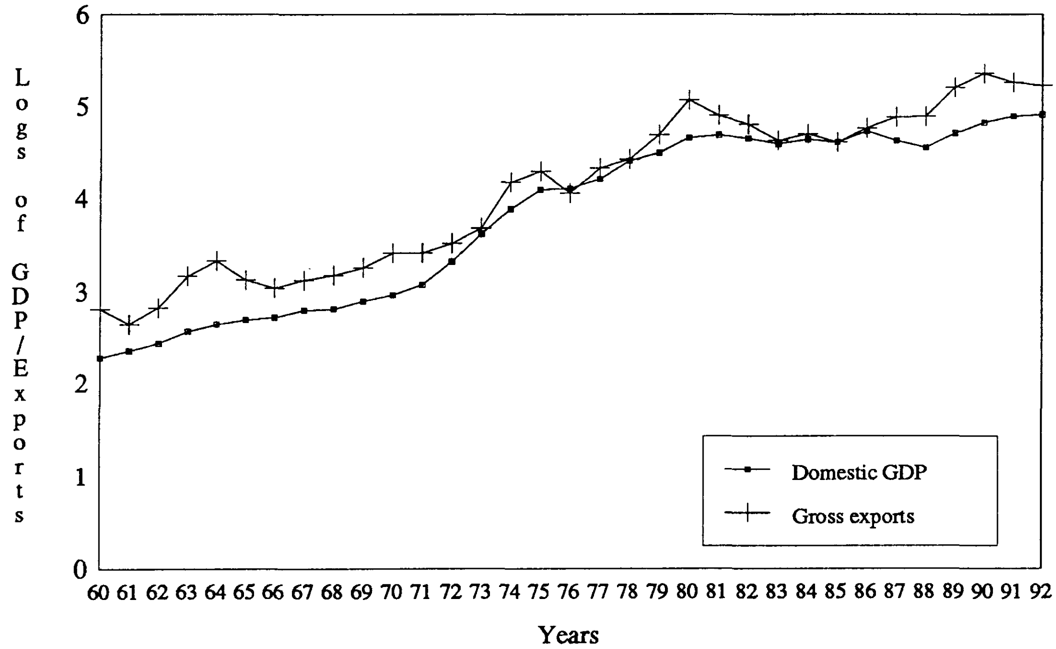
first plantations in the South Pacific were established not in Melanesia but in Polynesia – in Western Samoa in the 1850s. In Melanesia, they were established in Fiji in the 1870s, and New Guinea, Solomon Islands and New Hebrides (now Vanuatu) towards the end of the 19th century. Their establishment laid the foundations for export industries which were to make an indelible mark on Melanesian economies that can be seen to this day. After coconut products, cocoa was among the first established crops grown on plantations. Other crops such as sugar, coffee and oil palm followed later (Antony and Fleming 1992).

The establishment of an agricultural research system and extension services by the Australian administration in PNG in the late 1920s gave a major impetus to export crop development in Melanesia. It was aimed mainly at improving export opportunities in plantation crops, and laid the cornerstones of a resilient and thriving agricultural export sector (ISNAR 1982, Antony and Fleming 1992). Prospecting for gold and other minerals began in the 1920s in what was then New Guinea. Discovery of minerals, especially from the 1960s onwards, gave rise to an export economy of enviable strength and distinguished the export structure of PNG from other Melanesian countries. The mineral sector developed much more along the lines of an enclave sector than did the plantation sectors in PNG and other Melanesian countries.

Despite participation by village–based small–scale producers in copra export production throughout Melanesia in the 19th and early 20th centuries, Solomon Islands and Vanuatu generally lagged behind in opening up their subsistence agriculture for export trade. With the exception of Western Samoa, it was not until after the 1960s (i.e., after political independence) when the dominant economic activity, subsistence agriculture, truly became an integral part of the agricultural export sector. Thus, with independence, profound changes occurred in economic activities characterised by an increasing dependence on foreign exchange earnings from exports of agricultural commodities, and an increasing reliance on smallholders to deliver those exports. From the late 1950s onwards and especially following political independence, small–scale farmers in Melanesia, who had until then been predominantly subsistence producers, were allowed, on a limited scale and experimental basis, to become involved in production for exports. To the surprise of many, these small farmers thrived to the extent that they overtook the plantation sector in the production of most export commodities.

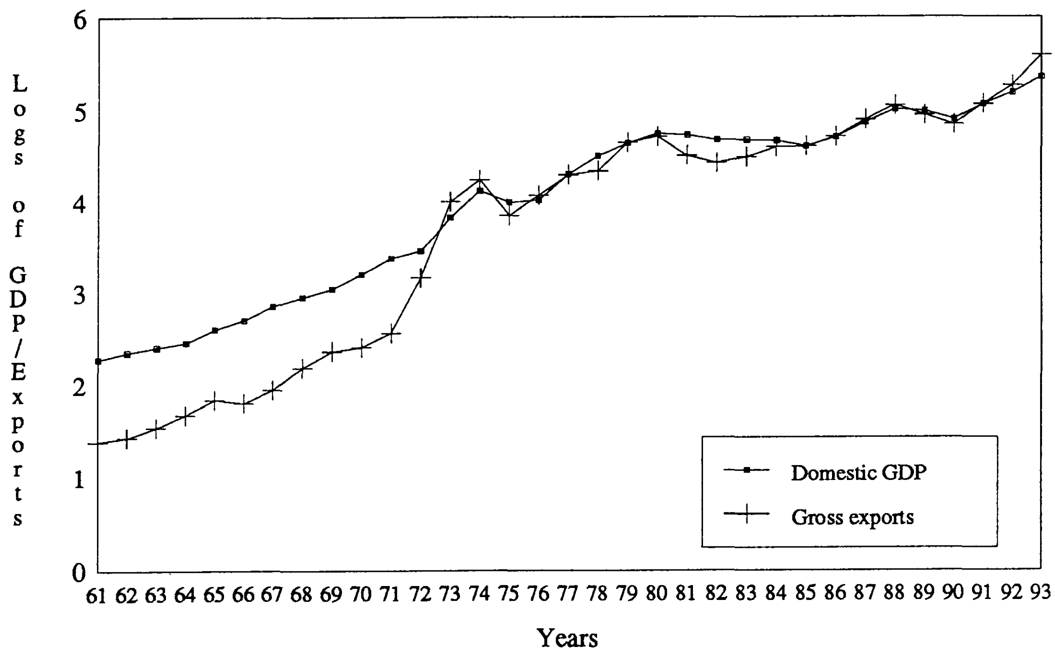
In overall terms, the given graphical descriptions represented in Figures 6.1a, b, c and d for Fiji, PNG, SI and Vanuatu, respectively, clearly depict the trends in logarithmic forms of the aggregate export revenues in relation to GDP.

**Figure 6.1a: GDP–export trends (deflated to 1985 prices), Fiji, 1960–1992**



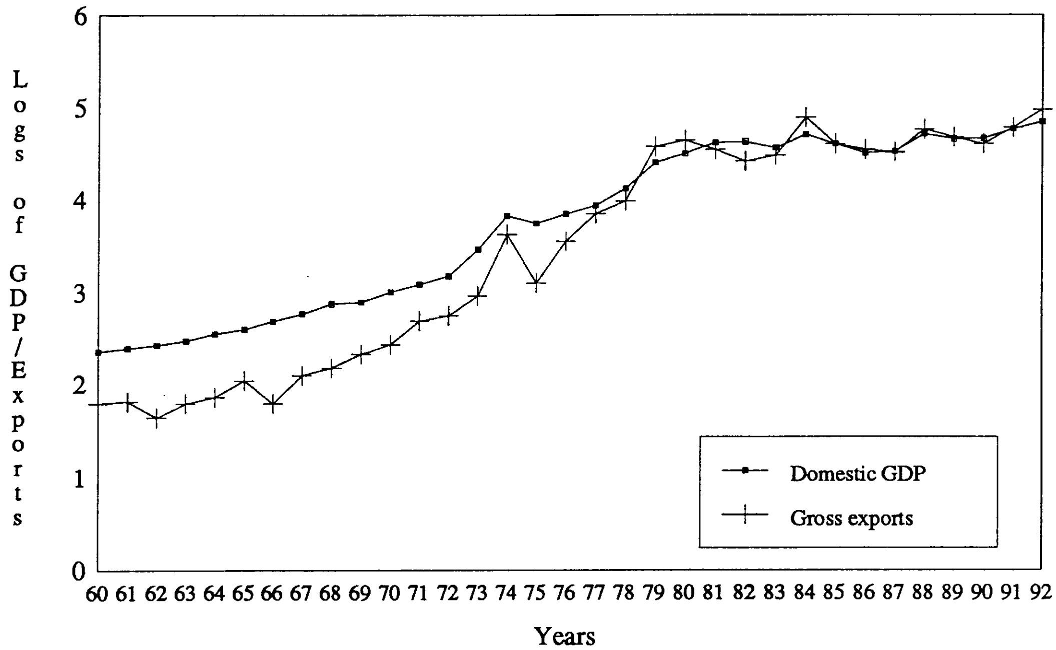

Source: Chapter 5.

**Figure 6.1b: GDP–export trends (deflated to 1985 prices), PNG, 1961–1993**



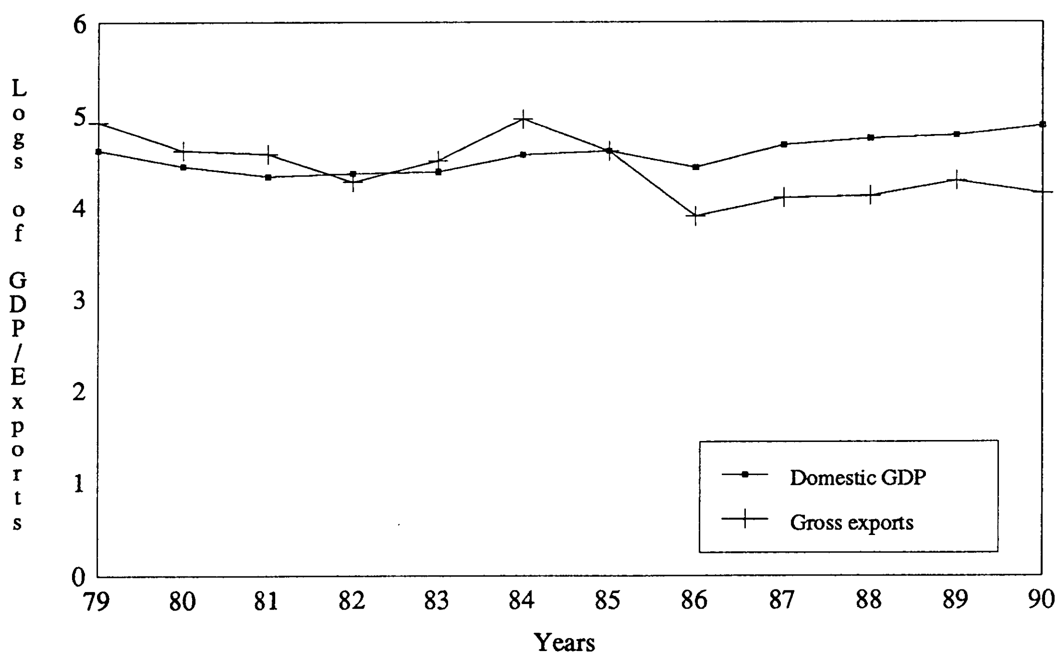

Source: Chapter 5.

**Figure 6.1c: GDP–export trends (deflated to 1985 prices), SI, 1960–1992**




Source: Chapter 5.

**Figure 6.1d: GDP–export trends (deflated to 1985 prices), Vanuatu, 1979–1990**




Source: Chapter 5.

Evidence from these figures reveals a marked export expansion for the past three decades for Fiji, PNG and SI and one decade for Vanuatu[14]. However, periodic fluctuations are observed to have been inherent in the export expansion. The fluctuations became more conspicuous towards the mid 1970s, around the time of political independence for most of the Melanesian nations. And as the GDP and export growth expanded over time, the observed fluctuations continued over the period under review.

For instance, more substantial expansion in growth occurred in the late 1960s to early 1970s than occurred in the later half of the 1970s and the 1980s. The slow–down in the observed growth, particularly towards and after mid the 1970s and early to mid 1980s could be attributed partly to disturbed expectations and uncertainties from transitions to political independence, and unfavourable world market positions, respectively.

## 6.3 Role of Exports in Economic Growth

The idea that foreign (export) trade generates economic growth is not recent. It can be traced back to the classical economists. As documented by Thoburn (1977), Smith (1776) and Mill (1848) were some of the first economists to advocate that foreign trade provided a crucial stimulus to economic growth.

Smith (1776) contended that foreign trade was important in that the domestic market surplus, which might not be cleared due to small domestic demand, could be cleared in the external markets. In return, other goods useful to the domestic economies could be imported from external sources. By opening up to more extensive external markets, use of domestic productive resources could be optimised, with increased division of labour, to expand national output to the utmost. This would thereby increase the real revenues and wealth of the societies.

Mill (1848) suggested that by opening up the markets beyond the domestic frontiers, a nation could improve its production processes. Because the country could be producing for larger external markets, there would be greater likelihood of making inventions and improvements in production processes. Opening up of foreign trade could open new frontiers and promote the attainment of new commodities, ideas and opportunities. New wants and the energy and ambitions in people could be stimulated, inducing those who previously were satisfied with scanty comforts from little effort, to work harder. Trade would gratify their

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14 Since it was not possible to obtain at least 30 years of consistent data for Vanuatu, its graph shows only those years in which data were available. Lack of data for Vanuatu means that much of the empirical analysis is confined to the other three Melanesian nations – Fiji, PNG and SI.

new tastes and induce them to save and accumulate capital for still more complete fulfilment of those tastes in the future.

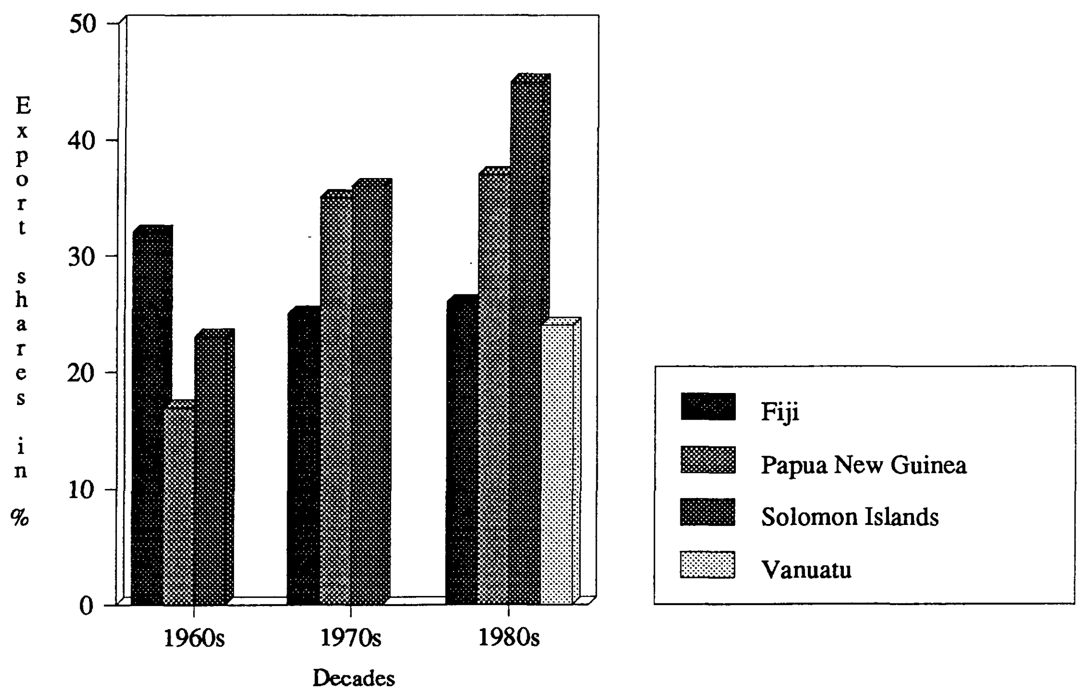
In theory, export–based economies experience capital formation through the operation of disaggregated multiplier–accelerator mechanisms. That is, export expansion raises incomes through multiplier processes with linkages that work through acceleration principles. Export trade can be a means of spreading advanced technology by offering opportunities for new economic activities which embody more advanced techniques. Domestic economies are conditioned to these opportunities by the growth of their export sectors (Thoburn 1977).

Thoburn emphasised that particular export commodities were developed in the LDCs following the principle of comparative advantage which took into account factor movements. In their search for new sources of raw materials and abundant cheap labour, and new markets for manufactures, the colonial powers exploited the natural resources found in the colonies. Given that the colonies were also endowed with favourable climate, this led to the establishment of export enterprises that were intensive users of the natural resources and of unskilled labour. As a key part of this process, plantations were established for export crop production. Such plantations thrived for a long period and still exist in most LDCs today, although, with the advent of political independence, their ownership might have changed hands. The plantations required large amounts of capital to exploit newly established economies of scale, and small numbers of technical and managerial staff, which were mainly imported, to complement the abundant unskilled labour and natural resources used in the production processes.

In most LDCs, including the SPINs, there exists great economic dependence on exports of primary commodities. For instance, it has been estimated by Adams and Behrman (1982) that exports from primary commodities account for up to about 80 per cent of total export earnings in the LDCs, while most rely on imported processed commodities and capital goods. This implies that the maintenance and further improvement of export performance is crucial to sustainable economic growth.

For the Melanesian countries, the primary commodity export sector has been, and continues to be, an important source of foreign exchange earnings as well as cash incomes (Antony and Fleming 1992). Figure 6.2 shows exports in the Melanesian economies as a proportion of GDP for the past three decades (10–year averages).

**Figure 6.2: Percentage export share in GDP for selected SPINs**

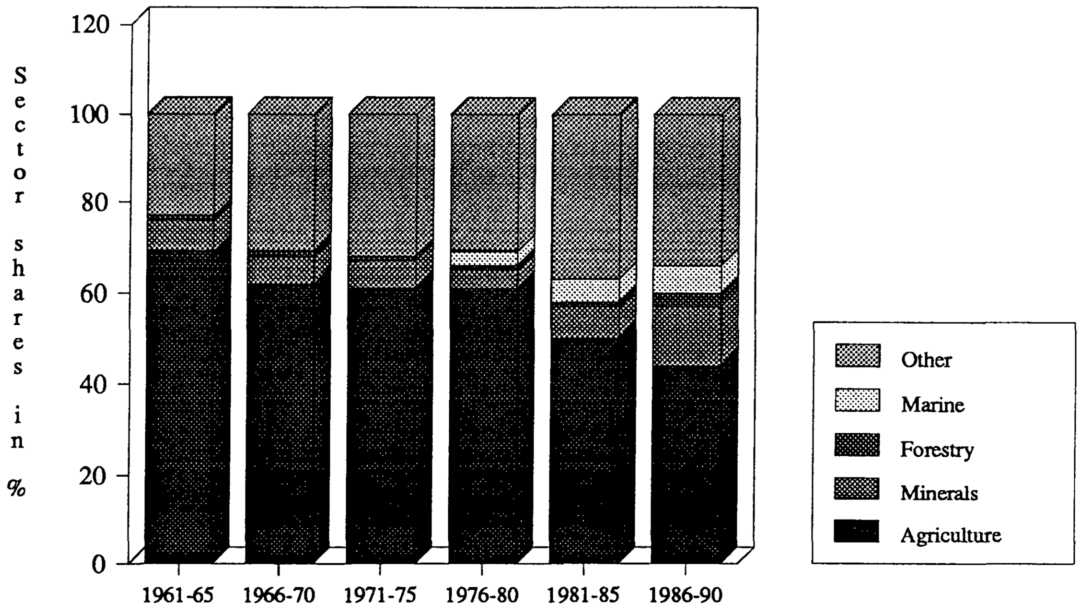



Source: Drawn from Appendix 6.1.

Clearly, these economies are fairly open, although in no period was the proportion of exports to GDP greater than 45 per cent in any country; only Solomon Islands reached this level in the 1980s. The share in Fiji declined over time while shares in PNG and SI about doubled due to rapid expansion in mineral exports and forestry and marine exports, respectively. For the first two decades (1960s and 1970s), data could not be obtained for Vanuatu, but the proportion of exports to GDP in the 1980s was estimated to be about 24 per cent.

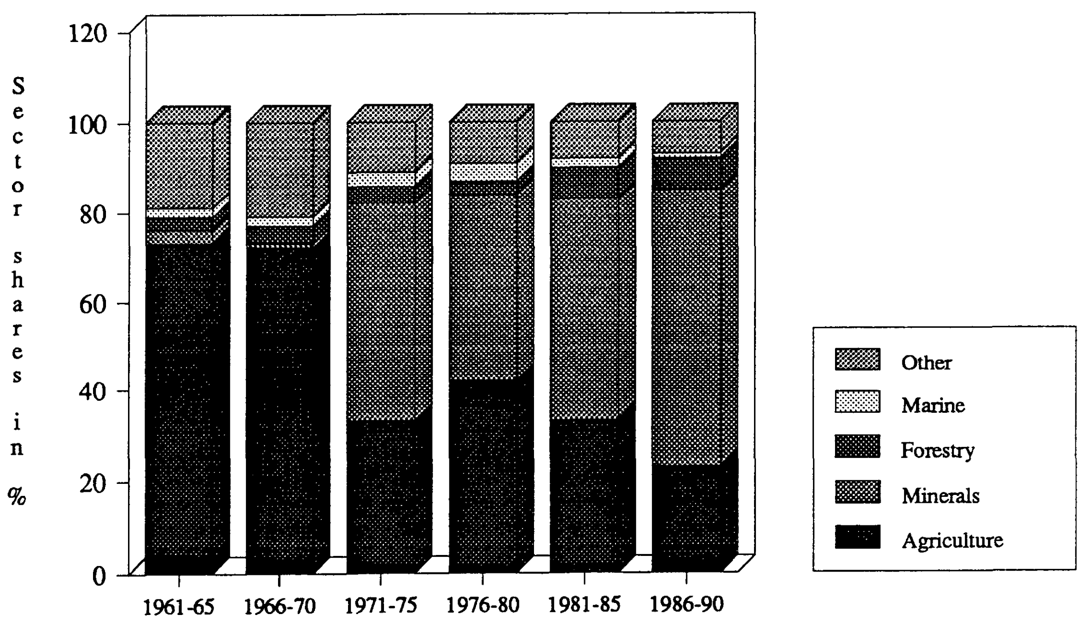
The composition of total exports by major commodity sectors (agriculture, minerals, forestry, marine and other) for the Melanesian countries reveals drastic changes over time (see Figures 6.3a, b, c and d). From these figures, which are based on 5–year averages, it is clear that the predominance for agricultural exports during the 1960s diminished in the 1970s to 1980s in most of the Melanesian countries.

**Figure 6.3a: Export composition (% sector share in total exports, 5–year averages), Fiji**



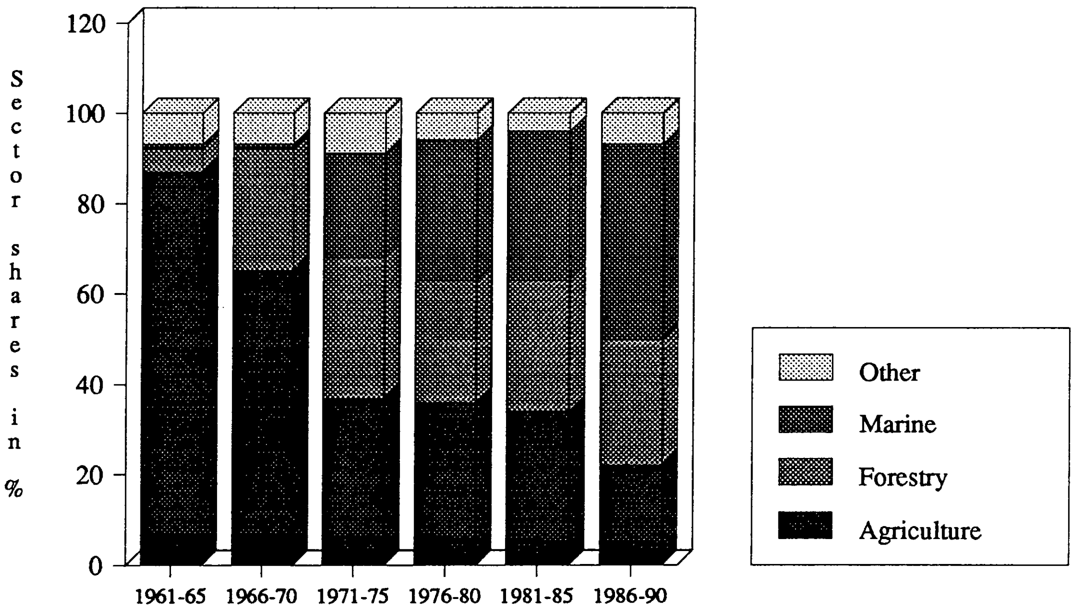

Source: Drawn from Appendix 6.2a.

**Figure 6.3b: Export composition (% sector share in total exports, 5–year averages), PNG**



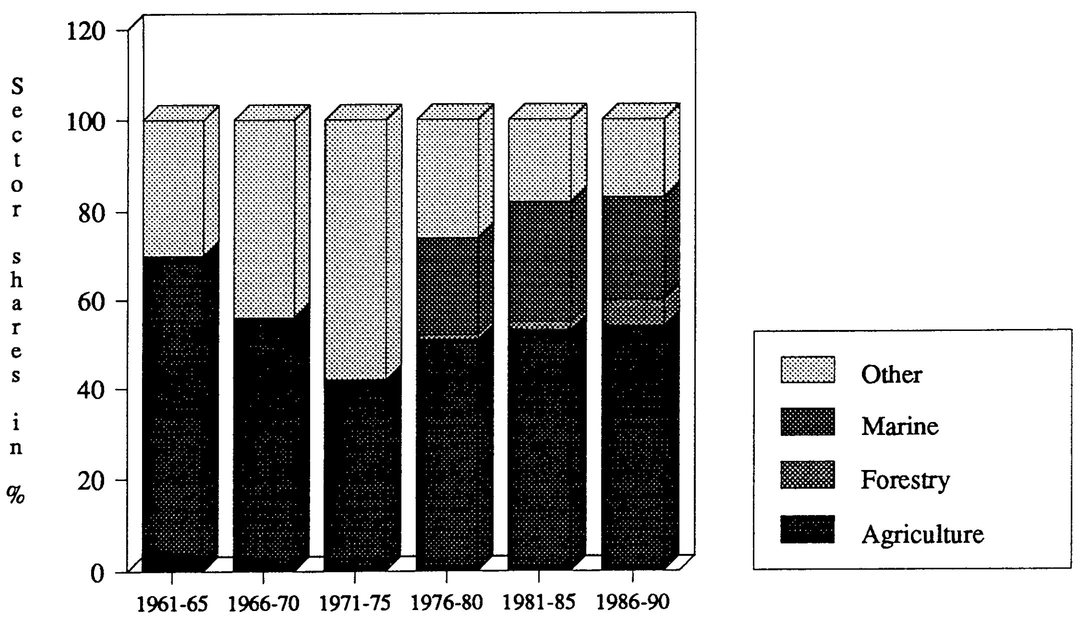

Source: Drawn from Appendix 6.2b.

**Figure 6.3c: Export composition (% sector share in total exports, 5–year averages), SI**




Source: Drawn from Appendix 6.2c.

**Figure 6.3d: Export composition (% sector share in total exports, 5–year averages), Vanuatu**




Source: Drawn from Appendix 6.2d.

As Figure 6.3a shows, agriculture's contribution to the total exports declined by around one–third in Fiji, from the early 1960s to the latter half of the 1980s. While minerals maintained almost a steady share throughout most of the period, their share increased during the 1980s. In the 1980s, marine and forestry products increased their shares of total exports. Over the period, there was also a large increase in shares from other commodities. From the 1960s to the 1970s and 1980s, agricultural export share declined by more than half in PNG (Figure 6.3b). Its place was taken by dramatic increases in mineral exports. Forestry products were also important in PNG. During the same period, agriculture's share more than halved in SI as the forestry and marine exports expanded (Figure 6.3c). In Vanuatu, although the contribution of agricultural exports declined from the 1960s to the 1970s and 1980s, its contribution picked up from the later half of the 1970s to 1980s (Figure 6.3d). From the late 1970s and during the whole of the 1980s, exports of marine products expanded substantially. Exports of forestry products were also becoming important towards the late 1980s.

Over the past three decades, then, the primary role of agriculture as a source of foreign exchange earnings has clearly been challenged, and its share of foreign exchange earnings is now small in all the Melanesian countries. This challenge has arisen mainly from several sources, the main two of which could be attributed to:

- Diversification into other primary industries, such as forestry and fisheries, and minerals (especially in PNG) has reduced agriculture's relative importance in the commodity export sector.
- Non–commodity exports such as tourism, remittances from expatriate populations, foreign investment, financial services (more important in Vanuatu) and aid funds have dwarfed earnings from commodity exports in many SPINs and are now considerable in all the Melanesian countries.

## 6.4. Theoretical Issues in Export–GDP Interactions

The hypothesis tested here - that export growth and instability do not cause economic growth and instability - may appear to be straightforward and easily testable. But in reality, this hypothesis embodies many theoretical and empirical questions which still remain unresolved. This section deals with some of the theoretical issues surrounding the subject of this hypothesis with regard to LDCs in general and the SPINs in particular.

Early empirical work on export–GDP relationships used simple methods such as the conventional Spearman's rank correlation and ordinary least squares (OLS) regression analysis (see, for example, Emery 1967, Michaely 1977, Feder 1983). These studies provided some evidence of a positive association between exports and GDP and were taken at the time to imply a causal relationship, although they did not show the direction of the relationship. This failure to distinguish between statistical association and statistical causality motivated others to explore this relationship further using more sophisticated methods that could test for causality (Giles et al. 1992).

Studies in which various causality tests have been applied include Jung and Marshall (1985) for 37 LDCs, Ahmad and Kwan (1991) for 47 African countries, Serletis (1992) for Canada and Giles et al. (1992) for New Zealand. All used Granger causality tests (Granger 1969). Studies employing both Granger and Sims causality tests (Sims 1972) include Hsiao (1987) for four NICs in Asia and Love (1992) for 20 trade–dependent countries. Sims causality tests were used by Chow (1987) for eight NICs.

The empirical results from most of these studies have remained controversial, contradictory and mixed (Ahmad and Kwan 1991), and largely inconclusive. Their interpretation is difficult because it is not certain whether findings of no evidence of causality are due to shortcomings in technique or data, or because there is a real lack of relationships. Questions of causality are, therefore, still largely unresolved and this has perpetuated the controversy of whether export growth actually determines economic growth.

### 6.4.1 Export/GDP nexus

GDP is defined as a sum of consumption, investment, government expenditure and net exports (exports less imports). Since exports are components of GDP, it can be postulated that a rise in exports will obviously increase GDP. It is also true, in theory, that export growth contributes to domestic capital formation and generates investment demand in both export and related industries. And through importation, export trade is usually accompanied by introduction of new technologies from external markets. More advanced technology should ultimately raise labour productivity and generate higher returns to capital.

In spite of the above, it is conjectured here that the aforegoing theoretical arguments need not be true in the case of many LDCs and the selected SPINs in particular. On the one hand, the open nature of Melanesian economies and their heavy dependence on imports of processed products and capital goods (which have ranged between 40 and 70% of GDP) and high import propensity (Skully 1985, p. 247, Browne and Scott 1989, p. 13, Antony and Fleming 1992, p. 45), combined with their small domestic markets, suggest that they are prime candidates for reliance on exports for economic growth. But on the other hand, there is no guarantee that imports have been or will be used for productive purposes since it has been observed (see, for example, Browne and Scott 1989) that Melanesian countries tend to import luxury and other non–productive consumption goods. The bulk of the typical composition of these imports has been represented mainly by food and beverages and finished consumer goods. Thus, a substantial proportion of the imports might not have contributed directly to capital formation and enhanced productive capacity in the Melanesian countries. Nor is it inevitable that the other favourable 'knock–on' effects will eventuate.

Sheehey (1990, 1992) has argued that, as a result of the weight of exports in GDP, the results of studies measuring the relationships between GDP growth and export growth are statistical artefacts. He suggested that a more appropriate measure is GDP net of exports and showed that the use of (GDP – EXP) in place of GDP changed quite substantially the results obtained. In this study, however, it is argued that the use of unadjusted GDP may be legitimate since, as shown in sections 1.1 and 6.3, the export share in GDP of the SPINs has been relatively low, ranging from 17 to a maximum of 45 per cent over the period studied. On the other hand, import dependence has ranged from 40 to 70 per cent of GDP, implying that net exports in GDP may have been negative in many years.

Two other common arguments are often put forward on why export orientation might in fact reduce economic growth. First, export instability could have a negative impact on economic growth in Melanesian countries with small foreign reserves and underdeveloped financial markets although the evidence to support this proposition is not convincing. Second, secular declines in terms of trade in the industries producing commodities typically exported by countries, such as those in Melanesia, reduce the value of their exports over time – again, a proposition with mixed support.

In practice, then, an increase in exports could occur at the expense of equally valuable production for the domestic market (and consumption) with none of the compensating advantages mentioned above. Consequently, this implies that increased exports might not lead to a higher GDP and could conceivably lower it. So whether exports increase GDP is an empirical question to be tested. It is thus not only appropriate and interesting but also timely to test the export/GDP nexus for the Melanesian countries.

Different export products produce different stimuli. Beyond primary increases in export output using different input coefficients, some commodities require value–adding processing and marketing activities prior to export. The extent of value–adding is largely dictated by the learning process[15] of the economies. In particular, the processing of primary export commodities using modern techniques should benefit other activities across the economy by, for example, spreading technical knowledge, training labour, the demonstration effect of new techniques, allocational gains, increased capital formation, higher factor productivity, foreign exchange earnings, and acquisition of management and supervisory skills (Thoburn 1977, Kavoussi 1985). Learning processes are facilitated – and differentiated between countries – by the generation of new skills, technical change, and innovations in export and export related sectors.

According to Thoburn (1977), more favourable linkages are likely to stem from exports that require more skilled than unskilled labour. Processing of primary products that provide forward linkages is also important in stimulating economic activity, as are backward linkages to industries supplying inputs to export firms that generate derived demand by export industries for goods and services.

Research by Meier (1976) and Thoburn (1977) shows that many LDCs have experienced long periods of export growth. This is partly because, after a country is exposed to external economic influences, its exports are diversified and grow markedly in volume for reasons which have already been discussed. Yet, in some cases, such sustained growth of exports has failed to propel the economies forward. This is contrary to the traditional belief that economic growth is propelled through foreign trade.

For exports to be a propelling force in economic growth, the export sectors should not remain enclave[16] entities. Instead, export processes should be integrated into the economies. This simply implies export sectors diffusing stimuli and creating positive responses to the

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15 Expansion of export growth has a learning effect on the exporting economies. This is usually in terms of acquiring new skills which come as a result of exposure to external trade and these skills help increase productivity.

16 This implies that exports need not expand separately from the rest of the economy.

other sectors of the economies. In brief, well–established commodity export sectors should spur and maintain sustained and well–balanced economic growth through the maintenance of a combination of the following factors: foreign exchange receipts, steady employment, real incomes and government revenues, continuous capital formation, optimum resource allocation, and a reasonable capacity to import.

### 6.4.2 Export instability

If export instability adversely affects economic growth of the LDCs, they might need to build up large foreign reserves to be used as a short–run strategy to cushion fluctuations in export earnings. A long–run strategy of reducing instability in export earnings could involve the liberalisation of trade and exchange rate management and measures to diversify the range of products exported. If, however, export instability has few adverse effects on economic growth in the LDCs, then the efforts to stabilise export earnings are misplaced. Resources for stabilisation should then better be used to increase productive capacity and improve general economic management (Gyimah–Brempong 1991).

Gyimah–Brempong has suggested that instability could have adverse effects on the economic growth of the LDCs. Partly, this is because LDCs import most of their capital goods. Technical progress in the LDCs generally, but particularly in the SPINs, tends to be embodied in the imports. Therefore, sustained ability to import, which is mainly a function of stable export earnings, becomes crucial in supporting sustained economic growth. Most of the crucial production inputs are also imported. Diminished, or instability in, export earnings could thus impair the ability to import the production inputs. This impairment could also be in terms of inability to import the inputs at the time they are most needed during the peak of the production processes. In addition, large shares of government revenues to finance economic growth are derived from export taxes. Instability in export earnings could therefore imply instability in government revenues which could affect adversely the implementation of plans and projects, delaying their completion. For all these reasons, stability and growth of export earnings may strongly affect patterns of economic growth. Therefore, it appears timely and justifiable to undertake an economic assessment to find out whether export growth and instability influence economic growth and instability in the selected SPINs.

## 6.5. Analytical Methods

In this section, the analytical methods employed in this chapter, and Chapters 7 and 8, are presented. In the presentation, model specification tests of the methods are discussed. While conducting the standard procedures for the model specification tests, $Y_t$ is used to denote a generic univariate time series. In the empirical analysis $Y_t$ represents, in turn, GDP, EXP and other series of interest for the selected SPINs. Briefly, the reviews of the model specification tests consist of the steps of testing for: (1) unit roots, (2) cointegration, (3) ECMs representation, (4) Granger causality, and (5) FEDA and IRA.

It would have been desirable to have accounted in the analysis for any effects of the price stabilisation schemes, described in Chapter 2, in breaking, to various degrees, the connection between world market receipts and payments to domestic producers. Unfortunately, no means could be devised to measure the extent of the effectiveness of the various schemes over time. Consequently, a limitation of the methods used is that any such impact of the schemes is not accounted for.

### 6.5.1 Unit roots testing procedures

Before any economic variables such as exports and GDP are tested for their relationships, it is important to find out about the statistical properties of the variables. If these statistical properties are unknown and data are not transformed accordingly, the standard statistical tests performed on the data are normally considered spurious (Granger and Newbold 1974). Innovations in examining the statistical properties of variables have been introduced by Dickey and Fuller (1979, 1981), Said and Dickey (1984), Phillips (1987), Phillips and Perron (1988), Perron (1988), Park and Choi (1988) and are reviewed briefly. These new tests are particularly important for the time series data which usually suffer from some statistical problems such as serial correlation.

Unit roots can be defined in terms of stationarity (see Chapter 4 (subsection 4.3.2) for details) which refers to the order of intergration of variables. For the test of the unit roots, three distinct methods were applied, namely, the augmented Dickey–Fuller (ADF) test (Dickey and Fuller 1981), Phillips and Perron (PP) (1988) test, and Park and Choi (PC) (1988) test. Since the basic statistical procedures for the ADF and PP are now relatively well known, only brief explanations on them are provided. More complete information is presented on the PC and Park–Ouliaris–Choi (POC) (1988) tests for unit roots and cointegration, respectively.

### (a) ADF test

The most commonly used unit roots test is the ADF test. The ADF test is an extension of the Dickey–Fuller test which is based on equation (6.1) for which m = 0. Equation (6.1) is an autoregressive process of variable differences, expressed as:

$$\Delta Y_t = \upsilon_0 + \alpha Y_{t-1} + \alpha_1 \text{trend} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + u_t \qquad (6.1)$$

where: $\Delta Y_t$ = difference in current value of $Y_t$, $\upsilon_0$ = constant value, $\alpha$ = parameter of first lagged difference in $Y_t$, $Y_{t-1}$ = first lagged values of $Y_t$, $\alpha_1$ = parameter of the trend value, $\beta_1$ = parameter of the lagged differences (t–i) of Y, m = order of the autoregressive process, $u_t$ = white noise random error term, with mean = 0, constant, variance, and covariance = 0.

An extension of m to a positive number in the ADF test is to accommodate a richer dynamic structure that may govern the innovation sequence. Put differently, the motivation for the augmentation of the lagged differences is to ensure that the errors are uncorrelated and, therefore, 'to whiten $u_t$' in (6.1). The null hypothesis of the unit roots is given by Ho: $\alpha = 0$ and $\alpha_1 = 0$ while the alternative hypothesis is Ha: $\alpha < 0$. If the computed statistics are negative and 'large' in absolute values, compared with the critical values, the null hypothesis of the unit roots is rejected in favour of the alternative. The distribution of the estimator of $\alpha$ is non–standard and the values for the ADF and PP tests do not come from the normal t or F–distributions. Instead, the critical values are found in tables which were obtained by simulations and published by Fuller (1976). The unit roots test results below report critical values for ten per cent significance levels for the ADF and PP tests as computed by SHAZAM (White, Wong, Whistler and Haun 1990). The SHAZAM program for the ADF and PP tests computes a lag identification procedure which provides and automatically includes the critical values for the tests, including a constant term and a time trend.

### (b) PP test

The second unit roots test used for the SPINs data, which also tackles the autocorrelation problems, is the PP test. This test is basically a transformed regression and is a non–parametric procedure. Essentially, the PP test is an attempt to remove the nuisance parameters which are associated with serial correlations in the Dickey–Fuller regressions. These nuisance parameters can be represented by the following:

$$1/T * \sum_{t=1}^{T} u_t^2 + 2/T \sum_{s=1}^{l} w(s,l) \sum_{t=s+1}^{T} u_t u_{t-s} \qquad (6.2)$$

where: $u_t$ = estimated residual from the ADF equations where m = 0, $l$ = truncation lag parameter, $w(s, l) = (1-s)/(l+1)$ = window. This is a window choice used by the SHAZAM application package.

As discussed in Phillips (1987) and Perron (1988), it is important to consider the selection of proper truncation lags. The transformed test statistics are listed by Perron (1988, Table 1, pp. 308–9). The $\alpha$ of the transformed regression is then tested following the usual ADF procedure.

### (c) PC test

The third unit roots test applied is the PC test. The PC test is fundamentally different from previous methods (the ADF and PP tests) in the sense that the autoregressive root is not determined directly. This approach has some intuitive merits and notable simplicity. Instead of the autoregressive root, the PC test deploys a *spurious* feature of a regression that involves integrated processes where polynomial terms are added. The test procedure utilises two OLS regressions:

$$Y_t = \sum_{k=0}^{p} \gamma_k t^k + u_t \qquad (6.3)$$

$$Y_t = \sum_{k=0}^{q} \gamma_k t^k + u_t \qquad (6.4)$$

While regression (6.3) has no or fewer time polynomials than regression (6.4), the latter has superfluous time polynomial terms, i.e., $t^{p+1}, \ldots, t^q$ (q>p). The test statistic for the PC test is defined by:

$$J_2(p, q) = (RSS_p - RSS_q)/RSS_q$$

where $RSS_p$ and $RSS_q$ are residual sums of squares from regressions (6.3) and (6.4), respectively.

The critical values at five per cent significance level are 0.330 and 0.295 for a random walk with constant [$J_2(1, 3)$] and random walk with constant and trend [$J_2(1, 5)$], respectively. Hence, calculated values greater than the critical $J_2(1, 3)$ and $J_2(1, 5)$ values indicate presence of unit roots. When a time series variable is stationary around a deterministic trend, the standard F–test for the superfluous time polynomial terms should approach zero. However, this is not the case if a unit root is present because the regression becomes spurious in the sense of Granger and Newbold (1974) and Phillips (1986).

Essentially, the statistic tests the null hypothesis Ho: $= \gamma_{p+1} = ... = \gamma_q = 0$ against the alternative hypothesis that at least one of the redundant $\gamma \neq 0$. For the $J_2$ test, the finite sample power can be computed using the standard F tables when the residual $u_t$ is a Gaussian i.i.d.[17] process and $(n-q)/n(q-p)\ F(\gamma_p, q) = (n-q)/(q-p)\ J_2(p, q)$ has an F distribution with degrees of freedom q–p and n–q for a sample size, n. Under the null hypothesis that $Y_t$ is a non–stationary time series, $J_2(p, q)$ has a stable distribution and the critical values are tabulated following Park and Choi (1988). The null hypothesis of a unit root in $Y_t$ is accepted if $J_2(p, q)$ is greater than the relevant critical value, and rejected if it is smaller.

### 6.5.2 Cointegration testing procedures

Cointegration, as originally defined by Granger (1981), simply implies the existence of a long–run equilibrium relationship between two or more variables. Thus, two variables are said to be cointegrated if their data series have a linear combination which is stationary, even though the individual series are non–stationary or have unit roots (Hallam, Machado and Rapsomanikis 1992). Using cointegration theory as developed by Granger (1986), Engle and Granger (1987), Johansen (1988) and Stock and Watson (1988), it is possible to test for long–run equilibrium relationships between variables such as exports and GDP.

If exports and GDP are each I(1), for example, it is typically true that any linear combination of these variables in a bivariate representation may also be I(1). However, if the linear combination is I(0), then exports and GDP are said to be cointegrated. In other words, for instance, if $Y_t$ is a vector of economic variables (i.e., EXP and GDP) or $Y_t = EXP_t$ and

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17 i.i.d. means independent and identically distributed

$GDP_t$, we can say that there is a permanent, historical or a long–run relationship that binds the components of $Y_t$ ($Y_{1t}$ and $Y_{2t}$) when a special linear constraint holds:

$$\alpha' Y = 0, \quad \text{for } \alpha \neq 0 \tag{6.5}$$

where vector $\alpha$ is of the same size as $Y_t$.

Moreover, we need to characterise situations which occur more frequently than not, namely, short–run deviations from the long–run relationships:

$$\alpha' Y_t = Z_t \tag{6.6}$$

where the univariate quantity $Z_t$ is called the equilibrium error. The idea of a long–run, permanent relationship between components of $Y_t$ makes sense only if $Z_t$ is a stationary time series, else it is not the case that there are forces (other factors) that operate in the long run and bind components of $Y_t$, and hence there is no historical equilibrium, or long–run relationships among the variables.

To test for the long–run relationships or cointegration between export and GDP variables, two tests of cointegration (ADF and PP) based on residuals and a third test by variable addition (POC), are introduced and compared[18]. The residual–based cointegration tests follow the standard Engle–Granger two–step test. First, estimates of static regression are conducted, and secondly, unit roots tests are performed on the estimated residuals, $\hat{u}_t$ (Rayner and Cooper 1994). That is, the ADF and PP tests are tests for no cointegration.

### (a) ADF test

The ADF test examines the least squares residuals from the following cointegration regression:

$$Y_t = \beta_0 + \beta_1 \text{trend} + \beta X_t + u_t \tag{6.7}$$

In order to test for cointegration between $EXP_t$ and $GDP_t$ series, which is expected to be I(1), by the unit roots tests, first, we run the regression $GDP_t$ on $EXP_t$ and get the

[18] These residual–based tests have been shown to be free of nuisance parameters. But there can arise a potential pitfall if the test statistics from these tests suffer from size distortion in a finite sample. This is especially true if the tests are based on the null hypothesis of no cointegration, where instability of the statistics across different data–generating process can make the results unreliable. This problem is well treated in Park et al. (1988).

computed $\hat{u}_t$. If the residuals have a unit root, the regression model is not cointegrated and there is thus no cointegration between $GDP_t$ and $EXP_t$. As Phillips and Ouliaris (1987) have shown, the ADF and PP unit roots tests can be used to test for no cointegration between variables, e.g., $GDP_t$ and $EXP_t$. More precisely, the ADF test for no cointegration follows the procedure below:

(a) First, compute the residuals $\hat{u}_t$ from the regression of $GDP_t$ on $EXP_t$ based on equation (6.7).

(b) Second, run a residual regression based on equation (6.8).

$$\Delta \hat{u}_t = \gamma \hat{u}_{t-1} + \sum_{i=1}^{p} \delta_i \Delta \hat{u}_{t-i} + e_t \tag{6.8}$$

(c) Third, check the coefficient of $u_{t-1}$. If $\gamma = 0$, $\hat{u}_t$ will be an I(1) series.

Therefore, the hypothesis of cointegration corresponds to $\gamma$ being significantly negative (a positive value would imply that $\hat{u}_t$ is non–stationary). If the negative value is less than the critical value, which is also negative, then it supports cointegration between $GDP_t$ and $EXP_t$.

### (b) PP test

Following similar principles, the PP test is also performed on the series of the OLS residuals $u_t$ in equation (6.7). Failure to reject the null hypothesis that $u_t \approx I(1)$ is taken to imply that $GDP_t$ and $EXP_t$ are not cointegrated. The critical values for the ADF and PP tests of cointegration are tabulated by Engle and Yoo (1989).

### (c) POC test

Finally, the POC test for cointegration is briefly described. Here, a superfluous time polynomial is added to the model. The test is carried out to find out whether the coefficients of the added polynomial are zero or not. If the test shows the coefficients of the added polynomial are zero, stationary errors are implied, meaning that cointegration exists. Two equations are postulated for the POC test:

$$Y_t = \alpha_1 + \beta_1 X_t + \gamma_1 \text{trend} + u_{1t} \tag{6.9}$$

$$Y_t = \alpha_2 + \sum_{k=1}^{p} \rho_k t^k + \beta_2 X_t + u_{2t} \tag{6.10}$$

The POC test statistic for models (6.9) and (6.10) is defined by:

$$J_2(1, 5) = (RSS_1 - RSS_2)/RSS_2.$$

Where $RSS_1$ = residual sum of squares from regression (6.9) and $RSS_2$ = residual sum of squares from equation (6.10). The critical value for this test is 0.330 and 0.295 at five per cent significance level for $J_2(1, 3)$ and $J_2(1, 5)$ models, respectively, and any observed values less than these figures support the existence of cointegration.

### 6.5.3 ECMs representation

Since the ECMs have been dealt with at length in Chapter 4, only a cursory treatment is given here. Recall the ECM representation of equation (4.23) in Chapter 4:

$$\Delta X_t = c + \sum_{i=1}^{m} \alpha_i \Delta X_{t-i} + \sum_{j=i}^{n} \beta_j \Delta Y_{t-j} + \theta \varepsilon_{t-1} + e_t \tag{6.11}$$

where: $\Delta$ denotes the first–order time difference (i.e., $\Delta X_t = X_t - X_{t-1}$) and $e_t$ is a sequence of i.i.d. random errors with mean zero and variance $\sigma_e^2$ [i.e., $e_t \approx$ i.i.d. $(0, \sigma_e^2)$].

Equation (6.11), which implies that $X_t$ and $Y_t$ are cointegrated, is an ECM representation in the Engle–Granger (1987) sense. This has also been discussed well by others (see for example, Dolado et al. 1990, Shoesmith 1992).

The term $\varepsilon_{t-1}$ in equation (6.11) represents the extent (deviation) of the disequilibrium[19] between levels of X and Y in the previous period. What the ECM says here is that changes in $X_t$ depend not only on changes in $Y_t$, but also on the extent of the disequilibrium between the levels of X and Y. The ECM formulation is appealing in that it combines flexibility in dynamic specification with desirable long–run properties. In this sense, the ECM captures the dynamics of the system. It also incorporates the equilibrium suggested by economic theory (for more treatment of this subject, see Hendry and Richard 1983, Dolado et al. 1990).

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19 Disequilibrium (sometimes referred to as equilibrium error) could be interpreted, in the simplest form, as the distance the system is away from the equilibrium at any point in time (Dolado et al. 1990).

The term $\varepsilon_{t-1}$ was incorporated in all the estimations of causality, FEDA and IRA where cointegration was found and considered to be adequate. The ECM term was computed in two steps. First, the variable coefficients from the cointegrating regressions were calculated. Second, these coefficients were then incorporated in a second regression where the disequilibrium errors were actually determined.

### 6.5.4 Granger causality testing procedure

Granger causality has also been discussed in detail in Chapter 4. However, in brief, there are several ways in which causality among variables is estimated. Some analysts have adopted either the standard Granger (1969) tests [with modified recent developments (Granger 1988)], Sims (1972) causality tests or the Geweke, Meese and Dent (1983) procedure. Others have used combined procedures for comparison purposes. However, the simulation and analytical research presented by Guilkey and Salemi (1982), Nelson and Schwart (1982) and Geweke et al. (1983), suggests that, in the commonly used finite sample sizes, the OLS version of the Granger causality test is more powerful than many of the other available procedures. Therefore, the Granger causality procedure is applied in this study.

A test of Granger causality utilises OLS regression in a bivariate system of dynamic equations. In order to achieve stationarity, the equations are specified in first–difference forms (also referred to as distributed lag regressions). For a pair of variables in two equations, these equations (same equations as (4.25) and (4.26) in Chapter 4), which also allow for the convenience of computing the F–statistics, can be represented as follows:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i \Delta X_{t-i} + \sum_{j=i}^{n} \beta_j \Delta Y_{t-j} + u_t \qquad (6.12)$$

$$\Delta Y_t = \delta_0 + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \sum_{j=i}^{q} \gamma_j \Delta X_{t-j} + u_t \qquad (6.13)$$

where: $\Delta X_t$ and $\Delta Y_t$ = $\log(X_t) - \log(X_{t-1})$ and $\log(Y_t) - \log(Y_{t-1})$ are approximately stationary X and Y time series, respectively; $DY_{t-i/j}$ and $DX_{t-i/j} = \log(Y_{t-2}) - \log(Y_{t-1})$ and $\log(X_{t-2}) - \log(X_{t-1})$, respectively, (these actually depend on lag lengths); $\alpha_0$ and $\delta_0$ = model constants; m, n, p and q = series lag lengths; $\alpha_i$, $\beta_j$, $\delta_i$ and $\gamma_j$ = model parameters; and $u_t$ and $v_t$ = uncorrelated (white noise) residual terms.

The direct Granger test of no causality by $Y_t$ based on equation (6.12) is equivalent to testing the following null hypothesis: $\beta_1 = \beta_2 = \ldots \beta_i = 0$, against the alternative hypothesis that some of the $\beta_j$'s $\neq 0$. Similarly, a Ho: $\gamma_1 = \gamma_2 = ... \gamma_i = 0$ against Ha: that some of $\gamma_j$'s $\neq 0$ is testable for equation (6.13). If it happens in equations (6.12) and (6.13) that Y causes X since some of the $\beta_j$'s are not zero and X causes Y since some of the $\gamma_j$'s are non zero, then there is feedback causality.

The above Granger causality test with two equations is based on an F–statistic distribution. This statistic is computed by estimating the above expressions in both unconstrained and constrained forms (full and reduced models). The F–statistics can then be expressed as:

$$F = \frac{(SSR_r - SSR_f)/m}{SSR_f/(T - m - n - 1)}$$

where $SSR_r$, $SSR_f$ = residual sum of squares of the reduced and full models, respectively; m = numerator degrees of freedom; T – m – n – 1 = denominator degrees of freedom; T = total number of observations; m, n = represent number of lags, 1 = subtracted out to account for the constant term.

In Granger causality tests, if it is found that Y causes X and X does not cause Y, it implies that there is uni–directional causality running from Y to X. This also means that some $\beta_j$ coefficients are significantly different from zero. If, on the other hand, there exists bidirectional (or feedback) causality between the two variables, some of both $\beta_j$ and $\gamma_j$ coefficients are significantly different from zero. Finally, if Y does not cause X and X does not cause Y, either Y and X are statistically independent or they are contemporaneously related, but they may not be related in any other way (Giles et al. 1992).

### 6.5.5 FEDA and IRA

Forecast error decomposition and impulse response analyses are tools which can be used to analyse data in terms of dynamic relationships among variables in a given estimated system. The interpretation of the error terms in VAR models is crucial in trying to analyse relationships of economic fluctuations, particularly those related to market stituations. Interactions among variables in the VAR models can be assessed by investigating the effects of errors on the subsequent movements of all the variables in the model.

In other words, FEDA and IRA are two related ways of quantifying relationships, for example relationships from causality results. If causality is observed, it is possible to make inferences as to magnitudes and persistence of the causality effects (Baffes and Shah 1994), Normally, FEDA and IRA are accomplished by transforming the estimated VAR equations to derive a moving average representation of the VAR model. Through the moving average representations, the FEDA and IRA techniques are used to examine the dynamic relationships among variables in the VAR models. For a more thorough treatment of FEDA and IRA, see, for example, Bessler (1984a), Ford (1986), Orden (1986a b), Doan (1990), Tegene (1990), and Myers et al. (1990).

### (a) The VAR representations

The VARs (discussed in detail in Chapter 4) have become popularly preferred procedures for various reasons. These include the fact that VARs are relatively easy to specify and estimate, their structural shocks are not usually correlated, thus simplifying the interpretation of the results, and they focus on fluctuations that are unpredictable *ex ante* (Myers et al. 1990).

Most importantly, VAR models can be used to find out short–run dynamic relationships among variables through manipulation of their moving average representations. This is the situation exploited in this thesis where the VAR moving average representations are formulated into the impulse response functions and forecast error variance decomposition proportions.

The VAR model used herein generally follows the VARs described by Litterman (1979) and developed by Sims (1980). Thereafter, they have been widely applied, e.g., Trevor and Donald (1986), Tegene (1990) and Myers et al. (1990). These VAR models may be represented in the following form:

$$Y_t = \sum_{j-1}^{m} B_j \; Y_{t-j} + \varepsilon_t \qquad (6.14)$$

where: $Y_t$ = n x 1 vector of endogenous variables, (i.e., $Y_t$ = [$EXP_t$, $GDP_t$ and other variables]), $B_j$ = n x n matrices, $\varepsilon_t$ = n x 1 vector of multivariate white noise residuals.

Equation (6.14) is specified as an unrestricted reduced form equation and can be estimated easily by OLS. Although it is rather difficult to describe model (6.14) in terms of $B_j$ coefficients, the IRA and FEDA, as described by Litterman (1979) and suggested for application by Sims (1980), unrestricted reduced form equations are useful devices in the VAR framework for testing the relationships among variables.

In order to understand how the IRA and FEDA work, a MA representation of model (6.14) is considered in the first place. This is obtained by repeated substitutions of $Y_{t-j}$. This becomes:

$$Y_t = \sum_{j=0}^{\infty} M_j \ \varepsilon_{t-j}$$

$$= M_0 \ \varepsilon_t + M_1 \ \varepsilon_{t-1} + \ldots = M(L) \ \varepsilon_t \qquad (6.15)$$

These Ms are a sequence of matrices, $M_0, \ M_1, \ M_2, \ldots$, with $M_0 = I$. Note that the εs represent the innovations in the Y process.

The impulse response of the ith variable to a unit innovation in the jth variable K periods earlier is given by the ijth element of $M_k$. The matrices of the moving average representation could thus provide impulse response functions that trace the responses over time of the variables in the model to a one–standard deviation shock in one of the variables (Trevor and Donald 1986, Tegene 1990, Myers et al. 1990). The effects of an unexpected shock to a system are thus traced through deviations of the shocked time paths from the expected time paths given by the impulse responses.

Impulse response analysis could thus be used to predict the responses of exports, and other variables, to an unexpected initial shock (such as an unexpected boom) in the export revenues. On the other hand, it is sometimes of interest to partition the variance of the forecast errors into proportions attributable to innovations in each variable in the system. Sources of variability of a particular variance in a system are traced and their contributions computed and attributed to other variables in the system. In brief, this describes exactly what FEDA does.

To evaluate the effects of shocks among the variables of interest in a system, therefore, FEDA and IRA were conducted for estimated VAR models and ECMs. Like IRA, FEDA is embodied within the MA representations of the VAR models.

One disadvantage that arises from the use of both FEDA and IRA is the occurrence of contemporaneous correlation of forecast errors. This implies that the covariance matrices (i.e., $\Sigma = E \ \varepsilon_t \ \varepsilon_t'$) of the error terms are not diagonal. Therefore, one way to take account of this problem is to orthogonalise the innovations (Ford 1986).

It is often useful to look at the moving average representations with orthogonalised innovations. In general, such a situation can be defined that $U_t = G \ \varepsilon_t$ where G depends on a particular ordering of the variables, if the matrix G above is chosen such that $E(U_t U_t') = E[G \varepsilon_t \varepsilon_t' G'] = G \Omega G' = \phi$. Note that $\phi$ is diagonal by construction and its diagonal elements give the variances of the orthogonal components of the residuals.

If the contemporaneous innovations in different variables were orthogonal, the decompositions of the variance of forecast errors would be straightforward. Thus, such an arrangement can be defined so that the (n x 1) vectors $L_i = (0, 0, \ldots, 0, 1, 0, \ldots, 0)$, where the one is in the ith position. Then the k–step forecast of variable i can be written as:

$$E_t Y_{it+k} = Y_{it+k} - L_i \varepsilon_{t+k} - L_i M_1 \varepsilon_{t+k-1} - \ldots - L_i M_{k-1} \varepsilon_{t+1} \quad (6.16)$$

Rearranging equation (6.16), the k–step error is derived as:

$$Y_{t+k} - E_t \; Y_{t+k} = \varepsilon_{t+k} + M_1 \; \varepsilon_{t+k-1} + \ldots + M_{k-1} \; \varepsilon_{t+1} \quad (6.17)$$

Substituting for the εs leads to:

$$Y_{t+k} - E_t Y_{t+k} = IG^{-1} U_{t+k} + M_1 G^{-1} U_{t+k-1} + \ldots + M_{k-1} G^{-1} U_{t+1} \quad (6.18)$$

The variance matrix of the k–step forecast error is given by:

$$E[(Y_{t+k} - E_t Y_{t+k})(Y_{t+k} - E_t Y_{t+k})']$$

$$= G^{-1}\phi G^{-1\prime} + M_1 G^{-1}\phi G^{-1\prime} M'_1 + \ldots + M_{k-1} G^{-1}\phi G^{-1\prime} M'_{k-1}$$

$$= \Omega + M_1 \Omega M'_1 + \ldots + M_{k-1} \Omega M'_{k-1} \quad (6.19)$$

Then define $H_k = M_k G^{-1}$ and let $h_k(ij)$ be the ijth element of $H_k$. The k–step forecast variance of the ith variable is expressed as:

$$\sum_{k=0}^{k-1} \sum_{j} h_k \; (ij)^2 \; \phi_{jj} \quad (6.20)$$

Therefore, the percentage of the k–step forecast variance in variable i accounted for by the component of innovations in variable J is:

$$100 \bullet \frac{\sum_{k=0}^{k-1} h_k \ (iJ)^2 \ \phi_{JJ}}{\sum_{k=0}^{k-1} \sum_{j} h_k \ (ij)^2 \ \phi_{jj}} \qquad (6.21)$$

The RATS statistical application package (Doan 1990) was applied for this analysis and the orthogonalisation was done in the order of GDP and exports using a Choleski factorisation. For Chapter 7, variable orthogonalisation was done in the order of world GDP, world agricultural prices, GDP, exchange rates and exports while those of Chapter 8 were orthogonalised as world demand, competitiveness, diversification and exports. Further specific details of FEDA and IRA techniques are presented here below.

### (b) Testing for FEDA

Following Ford (1986), FEDA can also be based on a moving average transformation of an autoregressive model such as:

$$Z_t = Hv_t + \sum_{j=1}^{m} \Delta_j \ z_{t-j} \qquad (6.22)$$

where Z is an M–variate stochastic process, $Hv_t$ is the deterministic part of $Z_t$, and $z_t$ is an N–variate white noise process – if t is not equal to j and $z_t$ and $z_j$ are uncorrelated.

From (6.22), the moving average representation for the decomposition becomes:

$$Z_t = \sum_{j=0}^{\infty} H_j \ S \ V_{t-j} \qquad (6.23)$$

where the $H_j$ are the moving average parameters.

The K–step ahead forecast error variance is:

$$\text{var} \ (Z_{t+k} - E_t[z_{t+k}])$$

$$= \sum_{k=j=0}^{k-1} (H_k S) \ (H_k S)' \qquad (6.24)$$

Let $h_k s_{ij}$ be the ijth element of $H_k S$, then $(h_k s_{ij})^2$, j = 1,..., m is the ith diagonal of $H_k S(h_k S)'$. The k–step ahead forecast variance of the ith variable is then given by:

$$\sum_{k=0}^{k-1} \sum_{j} (h_k \ s_{ij})^2 \tag{6.25}$$

and the percentage of that variance from equation (6.23) accounting for variable i by variable J is:

$$100 \bullet \frac{\sum_{k=0}^{k-1} (h_k \ s_{iJ})^2}{\sum_{k=0}^{k-1} \sum_{j=1}^{m} (h_k \ s_{ij})^2} \tag{6.26}$$

The decomposed variance depends strongly on the ordering of the variables prior to the decomposition.

### (c) Testing for IRA

Based on the same moving average transformation of the autoregressive model in equation (6.22), Ford (1986) represents the moving average of IRA as:

$$Z_t = \sum_{j=0}^{\infty} H_j \, v_{t-j} \tag{6.27}$$

## 6.6 Results and Discussion

This section covers data and data sources and results on unit roots, cointegration, ECMs, Granger causality, forecast error variance decomposition analysis and impulse response analysis.

### 6.6.1 Data and data sources

Data and data sources are discussed in Chapter 5, so there is no need to discuss them here. It should, however, be repeated that Vanuatu is excluded from the empirical analysis of this chapter because adequate data were not available to warrant any time series statistical analysis.

### 6.6.2 Unit roots test results

For the test of the unit roots, three methods (ADF, PP and PC) were employed. These methods were described in section 5 of this chapter. These tests, specifically the PP and PC tests, have been found to perform better than other standard tests (In, Mehta and Doran 1992). However, it is known that in some cases with short time series, the ADF and PP tests can yield distorted results.

The SHAZAM statistical application package (White et al. 1990) was used to carry out these tests (for a sample of SHAZAM instructions for unit roots, see the program in Appendix 7.1). Using three specified univariate models for the exports and GDP, all three tests were applied for comparison and supplementary purposes. The three univariate models are: (a) no constant and no trend model, (b) constant and no trend model, and (c) constant and trend model. The results of the unit root tests for these univariate time series models of the three selected SPINs are given in Table 6.1.

**Table 6.1: Unit roots test results of exports and GDP for selected SPINs, in both level and first difference models**

| | Test Statistics | | | | | |
|---|---|---|---|---|---|---|
| | ADF | | PP | | PC | |
| | VARL[a] | VARD[b] | VARL[a] | VARD[b] | VARL[a] | VARD[b] |
| | | | **FIJI** | | | |
| (1) GDP | | | | | | |
| Model 1 | 1.50 | −2.34* | 3.27 | −2.26* | – | – |
| Model 2 | −1.30 | −3.15* | −1.33 | −3.16* | 33.79 | 0.23** |
| Model 3 | −1.22 | −3.28* | −0.72 | −3.29* | 31.49 | 0.27** |
| (2) Exports | | | | | | |
| Model 1 | 2.12 | −1.61 | 2.00 | −4.34* | – | – |
| Model 2 | −0.80 | −2.75* | −0.81 | −5.05* | 16.85 | 0.04** |
| Model 3 | −2.19 | −3.34 | −2.38 | −5.01* | 3.94 | 0.11** |
| | | | **PNG** | | | |
| (3) GDP | | | | | | |
| Model 1 | 4.24 | −1.67* | 3.63 | −2.72* | – | – |
| Model 2 | −1.19 | −2.59* | −1.13 | −4.07* | 40.97 | 0.32** |
| Model 3 | −1.13 | −3.71* | −1.30 | −4.10* | 30.05 | 0.26** |
| (4) Exports | | | | | | |
| Model 1 | 2.21 | −1.64* | 2.29 | −3.15* | – | – |
| Model 2 | −1.25 | −2.69* | −0.98 | −3.95* | 19.39 | 0.15** |
| Model 3 | −1.22 | −3.73* | −1.60 | −3.92* | 19.62 | 0.24** |

Notes: [a] VARL = VAR in levels, [b] VARD = VAR in first differences, Model 1 = No constant, no trend; Model 2 = Constant, no trend; Model 3 = Constant, trend.
ADF and PP critical values at 10% significance levels for models 1, 2 and 3 are −1.62, −2.57 and −3.13, respectively, while those of the PC test at 5% level for models 2 and 3 are 0.330 and 0.295, respectively.
* Significant at 10% level, ** Significant at 5% level.

**Table 6.1: continued (unit roots test results)**

| | Test Statistics | | | | | |
|---|---|---|---|---|---|---|
| | ADF | | PP | | PC | |
| | VARL[a] | VARD[b] | VARL[a] | VARD[b] | VARL[a] | VARD[b] |
| | | | **SOLOMON ISLANDS** | | | |
| (5) GDP | | | | | | |
| Model 1 | 3.65 | −1.75* | 3.29 | −3.25* | – | – |
| Model 2 | −0.93 | −2.64* | −0.92 | −4.58* | 54.35 | 0.31** |
| Model 3 | −0.88 | −3.70* | −1.04 | −4.60* | 34.55 | 0.24** |
| (6) Exports | | | | | | |
| Model 1 | 1.89 | 0.97 | 2.25 | −6.06* | – | – |
| Model 2 | −0.67 | −2.62* | −0.60 | −7.29* | 33.22 | 0.12** |
| Model 3 | −2.02 | −3.79* | −1.89 | −7.19* | 25.72 | 0.14** |

Notes: [a] VARL = VAR in levels, [b] VARD = VAR in first differences, Model 1 = No constant, no trend; Model 2 = Constant, no trend; Model 3 = Constant, trend.
ADF and PP critical values at 10% significance levels for models 1, 2 and 3 are −1.62, −2.57 and −3.13, respectively, while those of the PC test at 5% level for models 2 and 3 are 0.330 and 0.295, respectively.
* Significant at 10% level, ** Significant at 5% level.

### (a) Results for VAR models in levels

All three tests reported in Table 6.1 indicate that the observed values are greater than the critical values for the VAR models in levels. Therefore, at 10 and five per cent significance levels for ADF and PP, and PC tests, respectively, all fail to reject the null hypothesis that $\alpha = 0$ and $\alpha_1 = 0$ of equation (6.1). This implies that the export and GDP variables are non-stationary. These data series are probably integrated of order one or two, i.e., I(1) or I(2). For them to be stationary, they will have to differenced at least one time. To confirm the order of intergration of these data, they were tested in the first difference form and the results are discussed in the next subsection.

### (b) Results for VAR models in first differences

To confirm the order of integration, the data series of exports and GDP for the VAR models in first difference form were also tested for unit roots using the same three tests (see Table 6.1). Most results for the unit roots testing in the first differences were found to be stationary, i.e., they are integrated of order zero, I(0). Although the ADF test results are mixed, they nevertheless confirm that most series are stationary in their first difference.[20] The results from the PP and PC tests confirm that all the three models for the exports and GDP data series, for the three selected SPINs, are I(1). Thus, in general, these data series were treated, henceforth, as I(1).

In support of these unit roots test results, recent empirical evidence suggests that it is now becoming increasingly clear that most economic variables such as exports and GDP are I(1). Kugler (1991) for USA, Japan, Switzerland, West Germany, UK and France, Serletis (1992) for Canada and Giles et al. (1992) for New Zealand, have all found unit roots for export and GDP data series. Clearly, these results lend some credibility to the conclusion that the tested export and GDP series for the selected SPINs are I(1).

### 6.6.3 Cointegration test results

On finding that the export and GDP data series for the selected SPINs were I(1), the next logical step was to investigate whether the bivariate representation series have long–run equilibrium relationships. In other words, cointegration means finding out whether the two series have a linear combination series which is stationary I(0). In Stock and Watson's (1988) terms, finding whether a bivariate series is driven by common trends is equivalent to identifying their long–run equilibrium relationships.

The SHAZAM package was again applied in conducting the three tests (ADF, PP and POC) described in section 5 for cointegration testing (for a sample of SHAZAM instructions for cointegration, see the program in Appendix 7.1). In cointegrating regressions, the ADF, PP and POC are normally called residual–based tests because the emphasis here is to test whether the errors are I(0). If the errors are stationary then a cointegration relation exists between the variables in question.

The null hypothesis for cointegration is to test whether Ho: $\gamma_t = 0$ vs the alternative hypothesis Ha: $\gamma_t \neq 0$. Cointegrating OLS regressions for equations (6.7) and (6.8) were used for ADF and PP unit roots of $u_t$ while equations (6.9) and (6.10) were used to test for POC unit roots of the same $u_t$. Cointegration results from these tests are presented in Table 6.2.

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20 The mixed results may reflect the substantial finite sample size distortion of the ADF test. The ADF test tends to indicate low powers in small finite sample sizes such as the one used in this analysis.

**Table 6.2: Cointegration test results of exports and GDP for the selected SPINs**

| | Test Statistics | | |
|---|---|---|---|
| | ADF | PP | POC |
| | | **FIJI** | |
| (1) GDP = f(EXP) | | | |
| Model 2 | –2.81 | –2.94 | 2.08 |
| Model 3 | –2.24 | –2.37 | 7.09 |
| (2) EXP = f(GDP) | | | |
| Model 2 | –2.79 | –2.93 | 0.58 |
| Model 3 | –3.68* | –3.55* | 0.47 |
| | | **PNG** | |
| (3) GDP = f(EXP) | | | |
| Model 2 | –1.87 | –2.89 | 1.38 |
| Model 3 | –3.76* | –3.95* | 0.88 |
| (4) EXP = f(GDP) | | | |
| Model 2 | –1.90 | –2.90 | 0.16** |
| Model 3 | –2.61 | –3.11 | 0.15** |
| | | SOLOMON ISLANDS | |
| (5) GDP = f(EXP) | | | |
| Model 2 | –4.40* | –5.25* | 0.27** |
| Model 3 | –3.89* | –4.33* | 0.21** |
| (6) EXP = f(GDP) | | | |
| Model 2 | –4.30* | –5.24* | 0.11** |
| Model 3 | –4.27* | –5.18* | 0.14** |

Notes: Model 2 = Drift, no trend; and Model 3 = Constant, trend. Critical values for ADF and PP at 10% significance levels are: –3.04 and –3.50 for model 2 and model 3, respectively. Those for POC are 0.330 and 0.295 for models 2 and 3, at 5% significance level. Test statistics greater than critical values support no cointegration hypothesis.
* Significant at 10% level, ** Significant at 5% level.

While both ADF and PP tests support cointegration for model three of Fiji and PNG for only relations (2) and (3), respectively, POC tests support cointegration of both model 2 and 3 for relation (4) in PNG. All the three tests support cointegration for both models in both relations (5) and (6) for the Solomon Islands case.

Since in cointegration tests observed values smaller than critical values support the cointegration relations, it seems safe to conclude that there is moderately sufficient and sufficient cointegration in PNG and Solomon Islands, respectively. Following Granger (1988, p. 203), if a set of variables is stationary and cointegrated, the model should be estimated on the basis of ECMs modelling. And if the variables are not cointegrated, a VAR model in the first difference form is the most suitable representation for such variables (for more details see, for instance, Engle and Granger 1987, Granger 1988, Shoesmith 1992).

The aforegoing statements imply that ECMs and VAR models in levels could be misspecified for non–cointegrated systems, because using the same methods in non–cointegrated systems might yield inconsistent and/or spurious regression results in the Granger sense. On the other hand, some practitioners, for example, Naylor, Seaks and Wichern (1972), Cooper (1972), Doan (1990), and Ramachandran and Kamaiah (1992) suggested that differencing (non–stationary and non–cointegrated) variables prior to statistical estimations throws away vital information embodied in variable levels. Further, differencing cointegrated series could produce non–invertible moving average errors in the regression models. In other situations, differencing may also lead to spurious co–movement between variables.

Given the above arguments, most statistical estimations (for causality, FEDA and IRA) in this thesis are conducted in VAR models in both levels and first differences, and also in ECMs for the cases in which cointegration is obtained. In addition to the risk of losing information, the VAR models were estimated in levels because the sample sizes used in this thesis are relatively small.

### 6.6.4 Empirical estimations for ECMs

The main difference between the ECMs and VAR models in first differences is the inclusion of the disequilibrium errors in the ECMs. This discussion is therefore confined to the question of how to compute the ECM disequilibrium errors, especially for PNG and SI where a reasonable number of variables were found cointegrated. Since the main hypothesis in this chapter is to test that exports do not cause GDP, the discussion is centred mainly on the relation where GDP is a function of exports.

Using the Engle–Granger two–step standard procedure (Engle and Granger 1987) (discussed in depth in Chapter 4), the ECMs for PNG and SI were estimated. This procedure involves estimating the long–run parameter $\beta_i$ (the cointegrating coefficient) first from the cointegrating regressions (of equations (6.7) which in this case is $Y_t = \beta_0 + \beta_1 trend + \beta_i X_t + u_{it}$). Second, the ECMs for the two countries were fitted using the estimated long–run parameters. Thus, the disequilibrium errors on the ECMs to the long–run equilibrium, $\varepsilon_{1,t-1}$, as expressed in equation (6.11) for PNG and SI, were computed as follows:

$$\text{PNG } \varepsilon_{1,t-1} = GDP_{t-1} - 0.211 * EXP_{t-1} \qquad (6.28)$$

$$\text{SI } \varepsilon_{2,t-1} = GDP_{t-1} + 0.033 * EXP_{t-1} \qquad (6.29)$$

Note that the long–run parameters can also be interpreted directly as long–run elasticities since the cointegrating regressions were estimated in logarithmic forms. Hence, the estimated long–run elasticity of exports for PNG is 0.211 while that of SI is –0.033 (see Table 6.3). The estimated long–run elasticity for PNG is statistically significant at the 10 per cent level and has the expected positive sign. But that of SI is not statistically significant and has the unexpected negative sign. The SI results raise doubts on the validity of the long–run equilibrium relationships between exports and GDP in SI. Even though the SI results were not significant, their negative sign implies that the past values of exports have an inverse effect on GDP.

Having computed the $\varepsilon_{i,t-1}$ as shown in equations (6.28) and (6.29) above, the next step was the fitting of the actual ECMs. The ECMs for the two countries are expressed as:

$$\Delta\, GDP^i_t = constant + \theta_i\, \varepsilon^i_{t-1} + lagged\ \{GDP^i_t,\ EXP^i_t\} + error\ terms \qquad (6.30)$$

where: i = PNG and SI.

Applying OLS on equation (6.30), coefficients of the disequilibrium errors were estimated. These coefficients, along with the parameter estimates of the long–run relationships, are presented in Table 6.3.

**Table 6.3: Estimates of the long–run parameters and coefficients of the disequilibrium error terms**

| | Parameter estimates for: | |
|---|---|---|
| Country | Cointegration ($\beta_i$) | Disequilibrium errors ($\theta_i$) |
| **PNG** | | |
| | 0.211 | –0.029 |
| | (1.96)* | (–1.13) |
| **SI** | | |
| | –0.033 | –0.021 |
| | (–0.22) | (–0.97) |

Notes: t-statistics are in the parentheses, * Significant at least at 10% level.

As shown in Table 6.3, the ECM results estimated by OLS (indicated by the estimated disequilibrium errors) are not statistically significant, even at the 10 per cent level. However, the parameter signs of the disequilibrium errors ($-\theta_i$ (i = PNG and SI)) for both countries are negative as expected. Although the negativity of the coefficients of the disequilibrium errors could be reflecting signals for positive relations of the presence of cointegration, this by itself is not sufficient to establish firmly these relationships. The presence of cointegration should be established in conjunction with the statistical significance of the disequilibrium error coefficients. Hence, on the basis of OLS estimations, the statistical insignificance of the parameters for the disequilibrium errors suggests that the presence of cointegration between exports and GDP is doubtful for the two country cases. Nevertheless, the computed coefficients of the disequilibrium errors were incorporated as one of the ways to estimate causality, FEDA and IRA.

### 6.6.5 Empirical evidence for causality

Before causality models can be estimated, optimal lag lengths had to be determined empirically for each data series. This is because results of causality tests are quite sensitive to model specification when appropriate lags are not included. It is therefore crucial to determine empirically the appropriate distribution of lags to avoid misspecifying the lengths by assigning arbitrary values for the lags.

Some of the previous studies (Hsiao 1979, 1981, Ahmad and Kwan 1991, Bahmani–Oskooee and Sohrabian 1992, Giles et al. 1992) have determined empirically optimal lag lengths using the AIC and Akaike's final prediction error (FPE). Other studies (Jung and Marshall 1985, Chow 1987, Hsiao 1987) have arbitrarily assigned lag values a priori. Such a priori assignment of lags might give rise to misleading results for causality tests, mainly due to misspecification of the order of the autoregressive process (Giles et al. 1992).

In addition to cointegration tests, distributed lags with empirically determined optimal lags are particularly useful for cases such as the selected SPINs where relatively short time series data are deployed. Appropriate lags improve the validity of the statistical inferences, especially for short time series. In normal circumstances, various statistical tests may not be very convincing because very short time series are not particularly well suited to asymptotic validity tests (Giles et al. 1992).

For the above reasons, optimal lag lengths for all the involved series of each selected SPIN were tested for up to a maximum of four lags using AIC and SC. These tests are discussed further in Chapter 4. A RATS application package was used to conduct the lag length tests (for the lag length tests, see the RATS program in Appendix 7.2).

Lag length test results are presented along with those of causality tests in Table 6.4. In some cases, especially for SI, the optimal lag length test results indicate that a one–year lag is optimal. However, the AIC test alone showed two–year lags to be optimal for the export–GDP regressions for Fiji. On the other hand, various combinations of the export–GDP and GDP–export regressions produced various optimal lags, which ranged from one to four years (see regressions (3) and (4) in Table 6.4).

After the lag length tests, causality estimations based on equations (6.12) and (6.13) were conducted. In addition to VAR models, causality tests were conducted in ECMs for PNG and SI where cointegration was achieved. Their computed respective disequilibrium errors were incorporated in the causality equations.

A summary of the Granger causality test results is given in Table 6.4. For each country, the results are reported in VAR models in levels and first differences. For PNG and

SI, causality test results based on ECM formulations are also reported alongside those of the VAR models.

As evident from Table 6.4, various types of Granger causality results were established in at least one direction and one specification case in each of the three selected SPINs. Results are discussed in more specific terms in the subsections that follow.

### (a) Causality results for Fiji

In Fiji, only one case of Granger causality from GDP to exports is detected for both lags one and two of the VAR models in levels (see model (2) in Table 6.4). In both cases (lags one and two), the detected causality is statistically significant at the 5 per cent level. No causality of any type was found in any case for the VAR models in first differences. Neither was causality detected running from exports to GDP.

Causality was detected running in the opposite direction (GDP to exports) for the VAR models in levels, contrary to the main hypothesis of this chapter. Based on this result, then, the case in Fiji seems to imply that the past expansion in economic growth has enhanced expansion in export growth. This could also be interpreted to imply that the past instability in economic growth has caused export revenue instability.

### (b) Causality results for PNG

Causality results for PNG show that not only is the main hypothesis of this chapter refuted by the empirical results, but also that causality from GDP to exports exists (see the various specifications of models (3) and (4) in Table 6.4).

Causality from exports to GDP was established for all the specified lags in all the three model specifications (VAR models in levels and first differences and ECMs). Strong evidence of causality is found for lags one and two of the VAR models in first differences and lag one of the ECMs – whose estimated coefficients are all statistically significant at one per cent level. Other specifications with significant estimated coefficients for the causality from exports to GDP were the VAR model in levels where lags one and three are statistically significant at 10 and five per cent levels, respectively. For the same model specification, lag two of the ECMs is statistically significant at the five per cent level.

**Table 6.4: Granger causality test results of exports and GDP for selected SPINs**

| No causality from | For models in VARL[a], VARD[b] and ECMs[c] | | | | |
|---|---|---|---|---|---|
| | Model Type | Optimal lags AIC[d] | SC[e] | F–Test statistics | Remark |
| | | **FIJI** | | | |
| (1) Exports to GDP | | | | | |
| | VARL | 1 | 1 | 0.72 | No causality |
| | VARD | 1 | 1 | 0.02 | No causality |
| (2) GDP to exports | | | | | |
| | VARL | – | 1 | 6.25** | Causality |
| | VARL | 2 | – | 3.83** | Causality |
| | VARD | 1 | 1 | 0.62 | No causality |
| | | **PNG** | | | |
| (3) Exports to GDP | | | | | |
| | VARL | 1 | 1 | 3.86* | Causality |
| | VARL | – | 3 | 4.17** | Causality |
| | VARL | 4 | – | 2.90** | Causality |
| | VARD | 1 | 1 | 11.88*** | Causality |
| | VARD | 2 | 2 | 5.68*** | Causality |
| | ECMs | 1 | 1 | 6.64*** | Causality |
| | ECMs | 2 | 2 | 4.38** | Causality |
| (4) GDP to exports | | | | | |
| | VARL | 1 | 1 | 0.08 | No causality |
| | VARL | 3 | 3 | 2.35* | Causality |
| | VARD | 1 | 1 | 3.80* | Causality |
| | VARD | 2 | 2 | 3.83* | Causality |
| | ECMs | 1 | 1 | 1.24 | No causality |
| | ECMs | 2 | 2 | 0.19 | No causality |

Notes: [a] VARL is VAR in levels, [b] VARD is VAR in differences, [c] ECMs are error correction models, [d] AIC is Akaike information criterion, and [e] SC is Schwarz criterion.
Test statistics are based on critical values of F–distributions whose degrees of freedom are listed in Appendix 8.10.
* , ** , and *** causality significant at 10%, 5% and 1% levels, respectively.

**Table 6.4: continued (causality test results)**

| No causality from | Model Type | Optimal lags AIC[d] | SC[e] | F–Test statistics | Remark |
|---|---|---|---|---|---|
| | For models in VARL[a], VARD[b] and ECMs[c] | | | | |
| | | SOLOMON ISLANDS | | | |
| (5) Exports to GDP | | | | | |
| | VARL | 1 | 1 | 0.05 | No causality |
| | VARD | 1 | 1 | 0.46 | No causality |
| | ECMs | 1 | 1 | 0.70 | No causality |
| (6) GDP to exports | | | | | |
| | VARL | 1 | 1 | 9.31*** | Causality |
| | VARD | 1 | 1 | 1.01 | No causality |
| | ECMs | 1 | 1 | 0.72 | No causality |

Notes: [a] VARL is VAR in levels, [b] VARD is VAR in differences, [c] ECMs are error correction models, [d] AIC is Akaike information criterion, and [e] SC is Schwarz criterion.
Test statistics are based on critical values of F–distributions whose degrees of freedom are listed in Appendix 8.10.
* , ** , and *** causality significant at 10%, 5% and 1% levels, respectively.

Evidence for causality from GDP to exports was detected at lower levels (10 per cent) of statistical significance in the VAR models in levels and first differences. In both cases, these were found in lag three and lags one and two for the VAR models in levels and first differences, respectively. The coefficients of the ECM specifications were not significant for the causality running from GDP to exports.

The PNG results imply feedback (bidirectional) Granger causality between exports and GDP. It appears that past expansion in export growth has caused economic growth which, in turn, has also enhanced the expansion of exports. Hence, in the past, a complementary relationship has existed between exports and GDP. Further, it can also be inferred that past export instability has caused instability in economic growth, while, at the same time, economic growth instability has also caused export instability in PNG.

### (c) Causality results for SI

The Solomon Islands causality results have some similarities with those of Fiji. Causality running from GDP to exports was found in only one case, the VAR models in levels (see model (6), Table 6.4). At lag one, the estimated coefficient of this case was highly significant at the one per cent level. Estimated coefficients of all the remaining specifications, including the ECMs, for models (5) and (6) were found to be statistically insignificant.

As in Fiji, the causality results for SI seem to imply that past expansion in economic growth has enhanced export growth. In addition, instability in economic growth also seems to have caused export instability in the past.

### (d) Evidence of causality results from other studies

Despite the open nature of the economies of the selected SPINs, it is not surprising that such types of empirical causality results emerged. These results seem to be fairly consistent with causality findings in previous studies. For instance, out of the 37 developing countries tested for causality (Jung and Marshall 1985), there was evidence of Granger causality from export to economic growth in only four countries. Out of eight NICs, evidence of uni–directional Sims causality from manufactured exports to manufactured output was found in only one country and a bidirectional Sims causality in six countries (Chow 1987). In another study of four NICs in Asia, Hsiao (1987) detected evidence of opposite uni–directional Granger causality from GDP to exports for only one country while bidirectional Sims causality was found in two countries.

More recently, however, limited to no evidence of Granger causal linkage between exports and economic growth was found in 47 African countries (Ahmad and Kwan 1991). By using a very long time series from 1887 to 1985 for Canada, evidence of uni–directional Granger causality was found running from exports to GDP (Serletis 1992). And in New Zealand, there was little evidence for Granger causality between exports and GDP at the aggregate level, but mixed evidence was detected in certain disaggregated export groups (Giles et al. 1992).

### 6.6.6 Forecast error variance decomposition results

Since the above causality results might appear not to be conclusive on their own, mainly because the causality tests were based on short time series, a need arose to supplement them. One way to do this was to quantify the patterns of causality test results in terms of magnitudes and persistence over time (Baffes and Shah 1994). In this way, more information about the relationships between variables can be gained.

The methods of FEDA and IRA were employed for the quantification of the causality test results and they were estimated by the use of RATS application package (the sample RATS program for executing FEDA and IRA tests is listed in Appendix 7.2). The results that were obtained for the forecast error variance decomposition of GDP for the three selected SPINs are presented in Table 6.5.

**Table 6.5: Variance decompositions (in %) of GDP for selected SPINs**

| | GDP decompositions in % | |
|---|---|---|
| Period | Exports | GDP |
| | **FIJI** | |
| | VAR in Levels | |
| 1 | 65.7 | 34.3 |
| 3 | 49.2 | 50.8 |
| 5 | 39.3 | 60.7 |
| 8 | 32.2 | 67.8 |
| 10 | 29.6 | 70.4 |
| 15 | 26.1 | 73.9 |
| 20 | 24.3 | 75.7 |
| Average | 38 | 62 |
| | VAR in 1st Differences | |
| 1 | 35.7 | 64.3 |
| 3 | 34.7 | 65.3 |
| 5 | 34.7 | 65.3 |
| 8 | 34.6 | 65.4 |
| 10 | 34.6 | 65.4 |
| 15 | 34.6 | 65.4 |
| 20 | 34.6 | 65.4 |
| Average | 35 | 65 |

Note: Over 20 years, about 38 and 62, and 35 and 65 per cent of GDP for the VAR in levels and VAR in first differences are attributable to exports and GDP, respectively, in Fiji.

**Table 6.5: continued (variance decompositions)**

| | GDP decompositions in % | |
|---|---|---|
| Period | Exports | GDP |
| | **PNG** | |
| | VAR in Levels | |
| 1 | 39.8 | 60.2 |
| 3 | 37.5 | 62.5 |
| 5 | 36.1 | 63.9 |
| 8 | 35.0 | 65.0 |
| 10 | 34.5 | 65.5 |
| 15 | 34.1 | 65.9 |
| 20 | 33.6 | 66.4 |
| Average | 36 | 64 |
| | VAR in 1st Differences | |
| 1 | 44.2 | 55.8 |
| 3 | 58.6 | 41.4 |
| 5 | 58.7 | 41.3 |
| 8 | 58.7 | 41.3 |
| 10 | 58.7 | 41.3 |
| 15 | 58.7 | 41.3 |
| 20 | 58.7 | 41.3 |
| Average | 57 | 43 |
| | ECMs | |
| 1 | 41.9 | 58.1 |
| 3 | 56.7 | 43.7 |
| 5 | 56.5 | 43.5 |
| 8 | 56.5 | 43.5 |
| 10 | 56.5 | 43.5 |
| 15 | 56.5 | 43.5 |
| 20 | 56.5 | 43.5 |
| Average | 54 | 46 |

Note: On the average, about 36 and 64, 57 and 43, and 54 and 46 per cent of GDP over 20 years for the VAR in levels, VAR in first differences, and ECMs are attributable to exports and GDP, respectively, in PNG.

**Table 6.5: continued (variance decompositions)**

| Period | GDP decompositions in % | |
|---|---|---|
| | Exports | GDP |
| | **SOLOMON ISLANDS** | |
| | VAR in Levels | |
| 1 | 68.8 | 31.2 |
| 3 | 66.3 | 33.7 |
| 5 | 65.7 | 34.3 |
| 8 | 65.4 | 34.6 |
| 10 | 65.3 | 34.7 |
| 15 | 65.2 | 34.8 |
| 20 | 65.1 | 34.9 |
| Average | 66 | 34 |
| | VAR in 1st Differences | |
| 1 | 59.6 | 40.4 |
| 3 | 57.7 | 42.3 |
| 5 | 57.7 | 42.3 |
| 8 | 57.7 | 42.3 |
| 10 | 57.7 | 42.3 |
| 15 | 57.7 | 42.3 |
| 20 | 57.7 | 42.3 |
| Average | 58 | 42 |
| | ECMs | |
| 1 | 60.3 | 39.7 |
| 3 | 60.6 | 39.4 |
| 5 | 60.6 | 39.4 |
| 8 | 60.6 | 39.4 |
| 10 | 60.6 | 39.4 |
| 15 | 60.6 | 39.4 |
| 20 | 60.6 | 39.4 |
| Average | 61 | 39 |

Note: In SI, about 66 and 34, 58 and 42, and 61 and 39 per cent of GDP over 20 years for the VAR in levels, VAR in first differences, and ECMs are attributable to exports and GDP, respectively.

### (a) Fiji FEDA results

The results in Table 6.5 shows that, in Fiji, for example, where exports and GDP were not cointegrated and causality was detected in only one case involving VAR models in levels, it can now be seen that there existed some kind of relationship (a contemporaneous one at least) between the two variables. For the VAR models in levels, past GDP instability is mainly explained by GDP itself, whose contribution is about 35 per cent in year one but increases continuously to about 76 per cent by year 20. The variance decomposition of GDP is also substantially explained by exports with about 66 per cent contribution in year one, decreasing to about 24 per cent in year 20. Over 20 years, therefore, about 38 and 62 per cent of GDP decomposition were accounted for by exports and GDP, respectively.

For VAR models in first differences, in the short run (one to three years), decomposition of about 64–65 per cent of GDP instability is attributed to the forecast error variance of the GDP itself, while 36–35 per cent was due to export forecast error variance. The contribution from the exports stabilised at about 35 per cent in by year eight. This could be interpreted to imply that about 35 per cent of the forecast error variance of the export growth was positively associated with the forecast error variance of the GDP growth in Fiji, as explained by the VAR model in first differences.

Compared with the VAR models in first differences (35 per cent), exports contribution to GDP decomposition was about 38 per cent in the VAR models in levels, higher than that of the VAR models in differences. This could explain, at least partially, why causality was detected in VAR models in levels. Hence, the results appear fairly consistent for Fiji.

### (b) PNG FEDA results

In PNG where moderate cointegration and bidirectional causality were found, different patterns of result for GDP decomposition were obtained for the VAR models in levels and in first differences and ECMs. For the VAR models in levels, the contribution of exports to GDP instability is about 40 per cent in year one and about 34 per cent by year 20. During the corresponding periods, 60 per cent and 66 per cent contributions are accounted for by GDP itself (see Table 6.5). On the average over the 20 years, therefore, about 36 and 64 per cent of GDP instability is accounted for by exports and GDP, respectively, for the VAR models in levels.

For the VAR in first differences, about 43 per cent of the GDP and 57 per cent of the export forecast error variance explain the sources of and contributions to the forecast error variance of the GDP instability and growth. The export and GDP contributions started stabilising at year five.

For the ECMs, the average contributions from exports and GDP are 54 and 46 per cent to GDP instability and growth. As in VAR in first differences, the exports and GDP contributions started stabilising in a short period of five years in ECMs. This casts further doubt as to the validity of the moderate cointegration found for PNG.

The FEDA results for the PNG case seem to make some sense because the quantification of the export contributions to GDP instability and growth are quite consistent with the causality results. The causality test results were significant at five per cent level for the VAR in levels whose corresponding export contribution to GDP was about 36 per cent. Similarly, the export contribution to GDP instability was about 57 and 54 per cent for the VAR in first differences and ECMs, respectively. Their causality test results were significant at one per cent level for both models. The FEDA results, therefore, seem to confirm the results found by causality tests in PNG.

### (c) SI FEDA results

In the SI case it can be recalled that, even though cointegration was found, only one case of Granger causality in VAR models in levels was detected as highly significant. For FEDA results based on VAR models in levels, about 69 per cent of GDP instability and growth are accounted for by exports in year one. By year 20, the contribution of exports has decreased to about 65 per cent. At the same time, GDP contribution to GDP instability increased from about 31 per cent in year one to about 35 per cent in year 20. On the average over the 20 years, 66 and 34 per cent of GDP growth and instability are accounted for by exports and GDP, respectively. This appears to contradict the causal relationship which was found to exist from GDP to exports.

For the VAR models in differences, the GDP growth and instability within the SI system were accounted for by about 58 and 42 per cent of exports and GDP, respectively. These contributions started stabilising at year three. In SI, only cointegration but not causality was detected for the VAR models in first differences. And yet, about 58 per cent of GDP growth and instability is positively associated with export growth and instability.

In terms of ECMs, about 61 and 39 per cent of GDP growth and instability are accounted for by exports and GDP, respectively, over the 20 year period. However, the export and GDP contributions started stabilising from year three onwards. This could indicate that the integrity of the long–run equilibrium relationships detected in SI is rather shaky. Nevertheless, contrary to the results from causality, FEDA has shown that exports contribute quite substantially to GDP growth and instability in SI. In fact, across all the countries, it has been shown that export forecast error variance has contributed substantially to variations in GDP.

### 6.6.7 Results of impulse response analysis

IRA is another useful but related technique well suited for shock evaluation. Usually, the shocks are manifested also in terms of magnitudes and persistence over time where they are portrayed in terms of either transitory or permanent relationships towards long–term equilibrium.

For example, IRA could be used to predict what happens to GDP if there is an unexpected positive[21] shock (e.g., an unexpected boom) in export revenues. This technique is thus quite useful in analysing the dynamic inter–relationships among variables in a system (Ford 1986). Like FEDA, IRA technique was conducted by using the RATS program. The IRA results for the export/GDP system of the three SPINs under study are presented in Figures 6.4a, b and c.

#### (a) IRA results for VAR models in levels

Figure 6.4a portrays an explicit picture of the results of the VAR model in levels for the selected SPINs. The graph depicts and compares the GDP impulse responses to unexpected export shocks for the selected SPINs for a span of about 20 years. It can be seen that the responses do not subside nor do they tend towards converging. This behaviour should be an additional indication that the data used here were not stationary. Results based on VAR models in levels could thus be spurious in the Engle–Granger (1987) sense and any inferences based on these results should therefore be treated with caution.

Other than that, the displays of Figure 6.4a confirm the results from FEDA. Solomon Islands, which had the highest export contribution to GDP growth and instability, shows the biggest impulse responses, followed by PNG and Fiji whose export contributions to GDP were about similar. This also confirms what happened in Granger causality tests where SI's causality was highly significant in VAR models in levels, followed by both PNG and Fiji where causality was detected at lower levels of significance.

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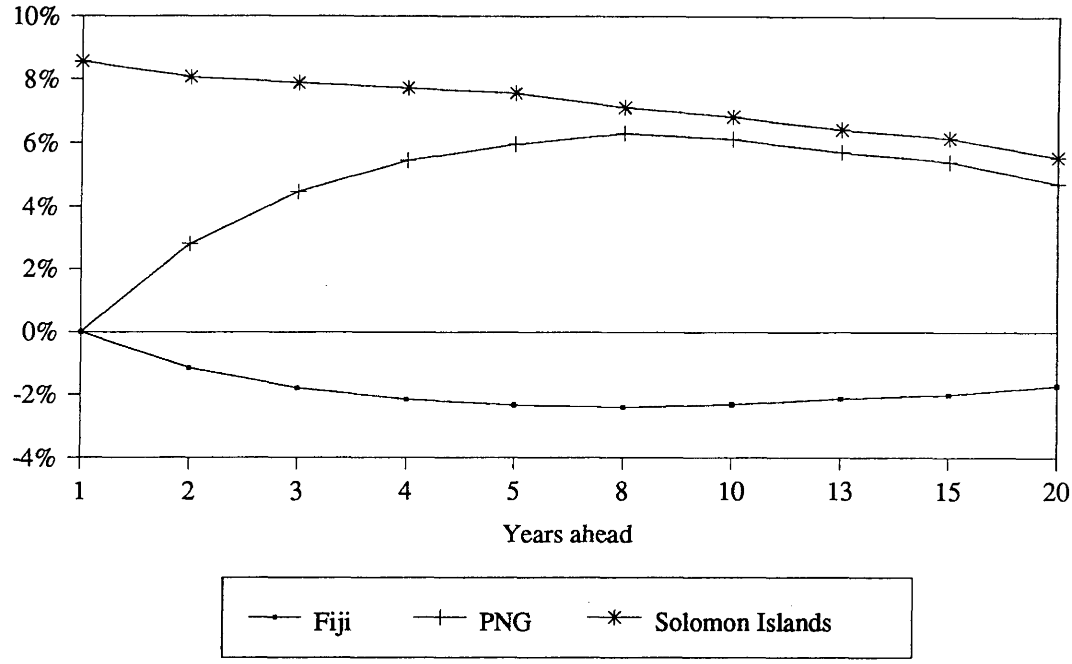
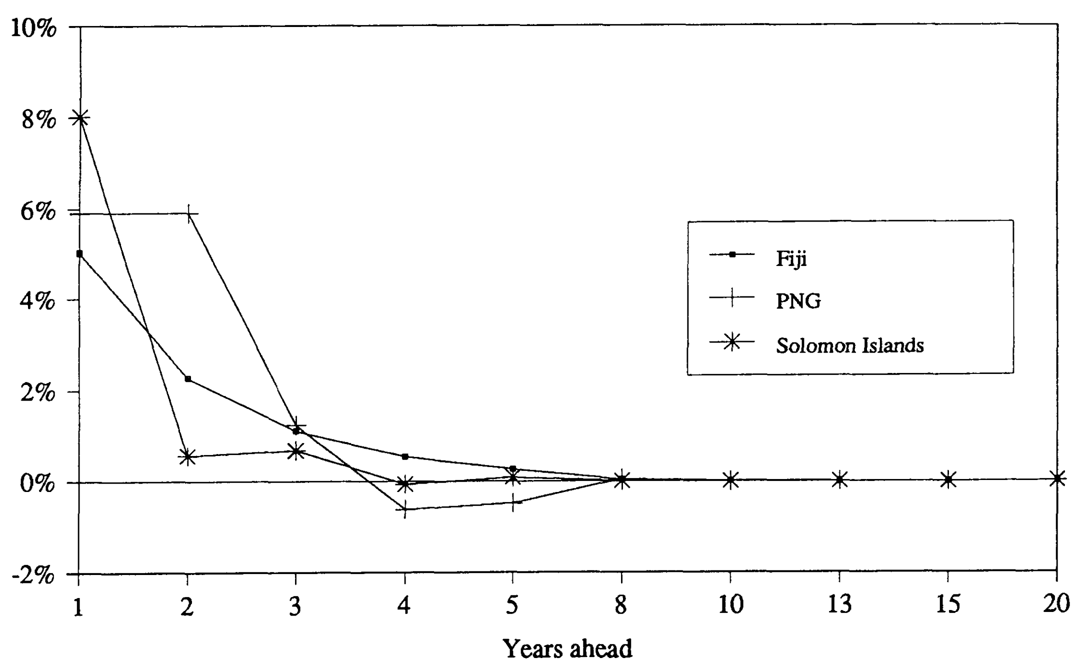
21 The unexpected shock could also be negative.

**Figure 6.4a: GDP responses in VAR models in levels for selected SPINs**



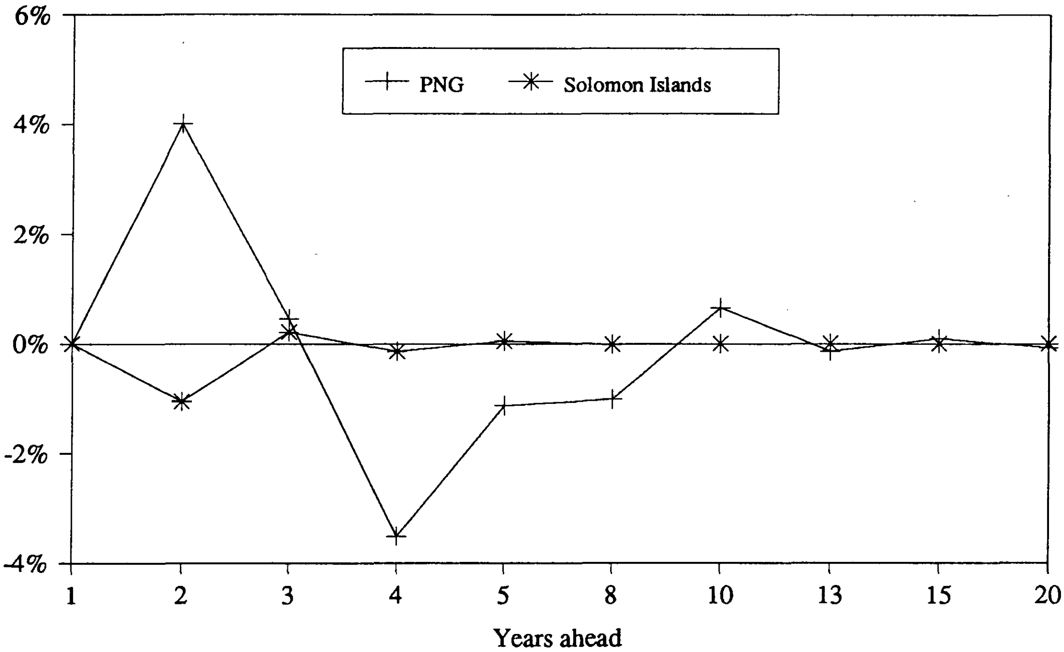

Note: GDP responses from 1 standard deviation export shock.
Source: Appendix 6.5.

**Figure 6.4b: GDP responses in VAR models in 1st differences for selected SPINs**




Note: GDP responses from 1 standard deviation export shock.
Source: Appendix 6.5.

**Figure 6.4c: GDP responses in ECM models for selected SPINs**




Note: GDP responses from 1 standard deviation export shock.
Source: Appendix 6.5.

### (b) IRA results for VAR models in first differences

IRA results for the VAR models in first differences for the selected SPINs are displayed in Figure 6.4b. Generally, the GDP responses were fairly large during the initial three years. The responses started diminishing progressively to approach zero by year 10 but were already trivial (less than one per cent) by year four. For the first three years, PNG's GDP responses were greatest and most persistent in magnitudes. This was followed by SI and Fiji in that order. However, the persistence of Fiji's GDP responses is stronger than that of SI.

Again, IRA results seem to confirm results from the previous analyses of FEDA and causality testing. PNG, where highly significant causality was detected with substantially high export contributions to GDP, showed the greatest impulse responses. This was followed by SI whose export contributions to GDP were almost double those of Fiji.

### (c) IRA results for ECMs

Figure 6.4c represents the GDP responses for the two countries (PNG and SI) where cointegration was found and, according to the theory (Engle and Granger 1987), cointegrated variables should be estimated by ECM modelling. While responses in PNG evoked by one standard deviation in export shock are larger than those in SI, they also persisted for longer periods than in SI, beyond year 10. The impulse responses picture for SI is smaller than in PNG and it collapsed to near zero by about year three.

The short–lived persistence of SI's GDP responses casts further doubt on the credibility of the cointegration results obtained earlier. Otherwise, the IRA from ECMs appear to support the causality and FEDA results based on ECMs. For example, PNG, where causality was detected and export contributions to GDP were substantial, received impulse responses which were greater in magnitude and more persistent over time than those received in SI. Although export contributions to GDP were substantially greater in SI, no causality was found for the ECMs.

It is now evident from the IRA results that unexpected shocks in exports in the selected SPINs almost always triggered responses in GDP, mostly in the same direction, both immediately and with lags. Immediate responses have often been larger in magnitude and their persistence over time diminished to trivial amounts. This is especially true for the VAR models in first differences and the ECMs.

## 6.7 Summary and Conclusions

The overall objective of this study was to establish empirically whether there exist some causal relationships between export expansion (and instability) and economic growth (and instability) in selected SPINs. To achieve the objective, the study was rationalised into long–run relationships which were analysed by the use of cointegration techniques and short–run relationships which were analysed by Granger causality tests, FEDA and IRA, all based on VAR models and ECMs.

(a) Using model specification tests (unit roots and cointegration tests), the results of empirical analyses indicated that:

(i) The univariate exports and GDP data series were at least I(1), implying that they are non–stationary variables. The unit roots were tested by applying ADF, PP and PC tests that generally led to rejection of the stationarity hypothesis.

(ii) Using ADF, PP and POC procedures, cointegration tests were applied to the errors of the same data series. All the three residual–based tests led to rejection of the no cointegration hypothesis in two selected SPINs, PNG and SI. With caution[22], this indicates that exports and GDP in the two selected SPINs had some long–run relationships, and that their co–movements should therefore not be ignored over the long run.

(b) Tests of short–run relationships which were based on VAR models in levels and first differences and on ECMs revealed, unambiguously, that bidirectional Granger causality between exports and GDP existed in PNG. But the situation in Fiji and SI was less clear because only one case of causality, again running in the opposite direction (GDP to exports), was found in only models based on VAR in levels. It is, of course, possible that the economic structures or policy regimes in Fiji and SI mean that there are no short-run causal relationships between exports and growth. On the other hand, the Fiji and SI results could have arisen due to difficulties created by the use of smaller samples than is normally desirable. In this respect, it could be prudent to put more emphasis on the results from the application of FEDA and IRA whose procedures are based on decomposition and, in nature, less dependent on long data series.

(c) Following the FEDA and IRA approaches, it can be concluded that short–run dynamic relationships existed between exports and GDP although the impact of exports on GDP largely faded away after a few years (as suggested by the IRA results). Further, given that the impulse responses do not settle down for the VAR in level models, the conclusions for both IRA and FEDA from the VAR in differences seem to be the most reliable in this study.

The above statement is strengthened by the fact that the results based on ECMs, in comparison with those based on VAR in differences, seem not to be very different from each other. The suggestion is that the inclusion of the disequilibrium error terms, which account for the long–run relationships among variables, did not assist in the overall analyses. In any case, although the coefficients of the disequilibrium errors in both PNG and SI had the right negative signs, as expected, they were found not to be statistically significant, making the long–run relationships found in PNG and SI doubtful.

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22 Caution is required here because the data analysed were of short time series sample sizes. This sample size limitation might lead to result distortions from the low–powered cointegration tests used.

The lack of evidence of long–run relationships, especially in the case of Fiji, can be attributed to many possible explanations. Three such explanations are short data series, the unsustainability of short–run impacts by exports on GDP (meaning that it was not possible to maintain long–run relationships), or the methods used for detecting such relationships may not have been sufficiently powerful.

In conclusion, the notion that exports are actually bad for economic growth in Melanesia can be dismissed. On the contrary, evidence generated in this study suggests the existence of positive relationships between export growth and GDP growth, and export instability and GDP instability.