UNIVERSITY OF SOUTHAMPTON

FACULTY OF LAW, ARTS & SOCIAL SCIENCES

School of Social Sciences

Economics Division

Essays on the Macroeconomic Impact of Insurance Market Integration

by

Reza Ofoghi

Thesis for the degree of Doctor of Philosophy

January 2008

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF LAW, ARTS & SOCIAL SCIENCES
School of Social Sciences, Economics Division

Doctor of Philosophy

Essays on the Macroeconomic Impact of Insurance Market Integration

by Reza Ofoghi

In chapter 1 we provide a general introduction to the topic.

In chapter 2, we study the effects of world and trading-block insurance market liberalization. For this purpose, we use a computable general equilibrium (CGE) model that includes 8 regions and 5 sectors. Except for the insurance and financial sectors, all other sectors are considered as perfectly competitive. To capture an imperfectly competitive structure, we assume that insurance firms with a non-competitive structure charge customers a price higher than their marginal cost. Then we estimate the Global Trade Analysis Project (GTAP) model both under a perfectly competitive structure and an imperfectly competitive one. Comparing the results of moving toward liberalization (i.e. moving from an imperfectly competitive structure to a perfectly competitive one), we conclude that the action that ensures a benefit for all parties consists in taking progressive steps toward liberalization based on GATS commitments.

In chapter 3, we investigate the relationship between insurance market development and economic growth within the UK. Some previous studies have shown that there is no long-run relationship between insurance development and economic growth for some OECD countries, including the UK. Those studies considered insurance markets as a whole. As it is possible to observe no cointegration at the aggregate level and cointegration at the disaggregated one and vice versa, we reassessed the conclusions using disaggregate data for insurance markets. We find a long-run relationship between insurance market development and economic growth. On the basis of a causality test, we conclude that the structure of the UK's insurance industry tends to display a demand-following pattern rather than a supply-leading one (i.e. growth promotes insurance market development, but not *vice versa*).

In chapter 4, we use disaggregate data for both the insurance industry and GDP, to be able to uncover any long-run relationship between insurance market development and sectoral growth in the UK. We find results consistent with those of chapter 3. Since it is generally accepted that unit root and cointegration tests suffer from a lack of power in distinguishing the unit root null from stationary alternatives, we use panel unit root and cointegration tests, which have higher power when compared both to univariate and multivariate counterparts. The panel unit root test results show that the variables are best characterized as being integrated of order one while the panel cointegration test results puts forward a long-run relationship between sectoral GDP and insurance market development, regardless of the importance of the sector in the UK economy[1].

[1] Still, given the limitations of the estimation techniques adopted, as recently highlighted by Caporale and Cerrato (2006), the robustness of our results remains to be ascertained. But this is beyond the scope of this work and is left for the future.

List of Contents

List of Tables

List of Figures

List of Appendices

ACKNOWLEDGEMENTS

First, I would like to thank and express my deep and sincere gratitude to my supervisor, Dr Maurice Kugler. His wide knowledge and logical way of thinking have been a great help to me. His understanding, encouragement and personal guidance have provided a good basis for the present thesis. It was a great pleasure for me to conduct this thesis under his supervision.

The financial support of the Ministry of Science, Research and Technology of the I. R. of Iran is gratefully acknowledged. In addition, I want to thank the Allameh Tabatabaii University and ECO College of Insurance for all their support. I wish furthermore to thank Dr Ahmad Tamimdari and the former Deans of ECO College of Insurance, Dr Mohammad Gholi Yousefi and Dr Hamid Zargham, and the present Dean, Dr Ali Emami Meybodi. Also, I wish to express my warm and sincere thanks to the Scientific Representative of the I. R. of Iran in the UK and Ireland for their support during my education, especially to Dr Naser Shams, Dr Alireza Salehi, Dr Behtash, Mrs Tadaion, Mrs Imami and Mr Kafaei.

I warmly thank all the academic staff of the Economics Department of the University of Southampton, especially Dr Patricia Rice for her financial support, which enabled me to present my paper at the 37th Conference of Money, Macro and Finance, as well as Dr Héctor Calvo Pardo, Mr Raymond O'Brien, Dr Xavier Mateos-Planas, Dr Jian Tong, Dr Jan Podivinsky, and my friends, Mr Greg Taylor and Mr Corrado Giulietti for their valuable advice, comments, and help. Also, I would like to thank the administrative staff of the School of Social Sciences, notably Ms Gill Crumplin, Mrs Chris Thorn, Mrs Fatima Fauzel, and Ms Claire Caffery, for all their kind help during my study.

I wish to express my warm and sincere thanks to Professor Guglielmo Maria Caporale from Brunel University for his comments, Professor Roberto Roson from the University of Ca' Foscari, Venezia, for his guidance on his model, Joaquim Oliveira Martins from OECD's Economic Department for his help, and Koji Nomura from Keio University, Japan, who kindly provided me with data on capital stock for the financial sector of Japan. I am also grateful to Professor Ken Pearson and Dr Michael Jerie from Monash University, Australia, for their useful guidance on GEMPACK software.

Finally, I want to thank my parents and I would like to give my special thanks to my wife Leena, whose patience enabled me to complete this thesis. Without her encouragement and understanding, it would have been impossible for me to finish this work.

To my dearest wife

Leena

Chapter 1

Introduction

This thesis is composed by three chapters analysing the relationship between insurance markets development and different measures of economic performance. Two main issues are empirically analysed: the effects of world and trading-block insurance market liberalization (Chapter 2) and the effects of insurance market development on economic growth within the UK (Chapters 3 and 4).

Negotiations on trade in services date back to the Uruguay Round in the 1990s. Not surprisingly, the analysis of the impact of trade liberalization on services is sparse. Most empirical studies on the effects of the liberalization of trade in services consider services as a whole, or at most, they separate the financial and the telecommunication sectors. Benjamin and Diao (2000) found that the western APEC members received the greatest welfare gains from service trade liberalization, while the developing economies gained more only if tariffs were eliminated. Robinson *et al.* (2002) came to the same conclusion when considering different regions, sectors and a different framework. But recently, Verikios and Zhang (2003) came to a different conclusion, when they considered the financial sector liberalization alone. They claimed that the biggest winners were South-East Asian and Latin American economies, with the USA and Canada being the only countries expected to be slightly worse off. Generally, regions with the highest barriers, such as developing countries, are expected to benefit the most.

Only recently, worldwide disaggregate data for the insurance sector has become available. Substantial gains from opening insurance markets are expected for economies that have comparative advantage in insurance, given the huge gap between insurance worldwide premiums and insurance exports. However, opening insurance markets could also be a source of benefit for those comparatively disadvantaged, like developing countries. If insurance liberalization makes available insurance services at lower prices while they are used as an intermediate input, an overall reduction in the costs of production is to be expected.

In chapter 2, we empirically assess the effects of insurance market liberalization on the world economy. We use a CGE model that includes 8 regions and 5 sectors. The regions include NAFTA, the EU (26 countries), Japan, Oceania, East Asia (Korea and China), as well as low-income (55), middle-income (93), and high-income (22) countries according to the World Bank classification. Sectors considered include food, manufacturing, the financial sector (excluding insurance), insurance, and other services (all services other than the financial and insurance sectors).

The focus of chapter 2 is to assess the effects of removing non-tariff barriers in the insurance sector. Following Benjamin and Diao (2000), we assume that non-tariff barriers in the insurance industry give a monopolistic power to the insurance firms in each region. Our strategy is to estimate the model under two alternative market structures: the GTAP standard model, which considers a perfect competition structure for all sectors, and Roson's (2006) imperfect competition approach, which assumes that firms with a non-competitive structure charge customers a price higher than their marginal cost. In our model, except for the insurance and financial sectors, all other sectors are considered as perfectly competitive. We then compare the estimation results to determine if and by how much moving from an imperfectly competitive structure to a perfectly competitive one for insurance markets (towards full liberalization) would affect the trading economies.

Results show that full liberalization decreases the welfare of developing countries (East Asia, and both low- and middle-income countries) while improving their GDP (quantity) indices. On the other hand, developed countries may find in their interest to take bigger steps towards liberalization, as it improves their welfare. Suspending negotiations by the developing countries causes a substantial welfare and GDP loss in most regions. However, it has a strong positive effect on the developing countries' balance of trade (and a negative effect on the balance of trade of developed countries). The results of our estimations also indicate that the best action to ensure that all parties benefit is to move on the basis of GATS commitments (or simply multilateral negotiations). This scenario dampens the adverse effects of aggressive moves towards either full liberalization or suspending negotiations.

In chapters 3 and 4 we study the relationship between insurance market development and economic growth within the UK. Insurance and reinsurance markets were mentioned as an essential engine of economic growth at the first UNCTAD conference in 1964. Insurance may positively affect an economy through several channels, including better risk sharing and more efficient management, promoting financial intermediation and stability (Ward and Zurbruegg (2000)), mobilizing savings, facilitating trade and commerce, encouraging loss mitigation, fostering efficient capital allocation, and also substituting for and/or complementing government security programmes (Skipper, 2001).

Ward and Zurbruegg's (2000) study compares the performance of the insurance industry across OECD countries, in terms of its contribution to economic growth. Surprisingly, they found no long-run relationship between economic growth and insurance development for countries such as Austria, Switzerland, the United Kingdom (UK) and the United States. Here we re-examine their conclusion for the UK, who has the biggest insurance market in Europe and the third largest in the world. To which extent can we accept that such a huge industry bears no relationship with the economy? One possible answer might come from recognizing that if there is an aggregation problem, it is possible to observe no cointegration at the aggregate level and cointegration at the disaggregated one (and vice versa, see Granger (1990)). To remove this problem, in chapter 3 we disaggregate data for the insurance industry into 9 different insurance markets, including life insurance, annuities, individual pension and other pension yearly and single premiums, motor insurance, accident and health insurance, liability insurance, property insurance, insurance against pecuniary loss, reinsurance and marine, aviation and transport (MAT) insurance.

We first check the order of the variables using unit root tests, including those due to Dickey and Fuller (1979), Philips and Perron (1988), and Elliot, Rothenberg and Stock's (1996). Next, we test for co-integration. Only then we examine the direction of causality by evaluating two possible patterns (demand-following and supply-leading) on the basis of a causality test. Finally, we quantify the strength of causality following Granger and Lin's (1995) approach, which further helps us in the identification of the direction of causality whenever bilateral causal relationships exist.

We find a long-run relationship between insurance market development (using insurance market size as a proxy) and economic growth for all components. Causality tests uncover bilateral relationships between insurance and GDP growth in six out of the nine insurance markets considered. However, Granger and Lin's (1995) measure shows that the strength of causality from GDP growth on insurance market development is more powerful than in the opposite direction. There is only weak evidence of development in three insurance markets causing GDP growth (the strength of causality is almost negligible). Based on these results, we conclude that the structure of the UK's insurance industry tends to display a demand-following pattern rather than a supply-leading one.

An important feature of chapter 4 is the use of disaggregate data for both the insurance industry and GDP, to be able to uncover any long-run relationship between insurance development and sectoral growth in the UK (Agriculture, Hunting, Forestry and Fishing, Manufacturing, Services, Mining and Quarrying, Construction and Electricity, Gas and Water supply).

We use panel unit root and cointegration tests as it is generally accepted that unit root tests (used in chapter 3) suffer from a lack of power in distinguishing the unit root null from stationary alternatives. Caporale and Cerrato (2006) conclude that the Im-Pesaran-Shin (1997) and Maddala and Wu (1999) panel unit root tests are to be preferred because they allow for heterogeneity under the alternative of stationarity. We use the Fisher's (1932) test which is proposed by Maddala and Wu (1999), as it is simple and straightforward to use, whereas for the panel cointegration test, we use the one proposed by Pedroni (2004).

Our results are consistent with those in chapter 3. In addition, the panel unit root tests show that the variables are best characterized as being integrated of order one while the panel cointegration test puts forward a long-run relationship between sectoral GDP and insurance market development, regardless of the importance of the sector in the UK economy. However, we should interpret these results with caution: Caporale and Cerrato's (2006) recent study warns about the strong assumptions underlying the distributional assumptions of the tests used. In particular, the asymptotic distribution of the aforementioned tests is derived under the assumption that the error terms are not cross-correlated. When this is not the case, the results of the tests are not valid.

Chapter 2

2.1 Introduction

There is much more debate on the impact of liberalization on trade in goods than on trade in services. The reason is that liberalization in trade for goods started more than five decades ago, while negotiations on trade in services returned to the Uruguay Round in the 1990s. As a result, there is much more research about trade in goods, while analysis of the impact of trade liberalization in services remains sparse.

Most studies on the effects of the liberalization of trade in services consider services as a whole. However, considering the great economic significance of financial and telecommunication sectors, some studies have focused on these sectors. The lack and scarcity of data have imposed limitations on exploring the economic impact of the trade liberalization of different service sectors. Thanks to improvements in the GTAP database, it is now possible to focus on some components of the services sector, such as the insurance and financial sectors.

Based on the world insurance SIGMA report in 2005, insurance premiums amounted to a total of US$3426 billion, which is 7.7% of worldwide economic value creation (GDP). Life insurance contributed 58%, or $1974 billion, and non-life 42%, or $1452 billion. Total premium volume grew by 2.5% in real terms. Life premiums increased by 3.9%, non-life premiums by 0.6%. The industrial countries continued to dominate the insurance market with an 88% share. Emerging markets increased their share by 1.1 percentage points (to 12%) because they grew faster than the world total and because their currencies hardened. Table 2.1 shows that world insurance premiums increased from US$2166 billion in 1998 to $3426 billion in 2005, which means that premiums grew with an average rate of 6.77 per cent per annum (in nominal terms).

Table 2.1 - Worlds insurance premium (billion US dollars): 1998-2005

year	1998	1999	2000	2001	2002	2003	2004	2005
Premium	2166	2337	2444	2415	2623	2958	3244	3426

Source: Sigma world insurance report, different years

The World Trade Organization's international trade statistics 2005 indicate that in 2003 the share of insurance in all services exports was about 2.8%, or $60 billion. Comparing the value of insurance premiums and insurance exports indicates about 2% of insurance produced was traded between nations. A possible explanation for this low level of insurance trade relative to the level of premiums is that national insurance markets are closed to foreign insurance companies, and one possible option to increase insurance trade is to expand bilateral or multilateral negotiations, which may increase the level of liberalization. Based on international trade theories and regarding the huge volume of world insurance premiums, economies can potentially benefit from opening their national markets.

Matto, Rathindran, and Subramanian (2006) discuss how an efficient and well-regulated financial sector provides an environment that helps to transform savings to investment in an efficient way. This transformation ensures that resources are deployed where they have the highest returns. In addition, benefits also arise from increased financial product variety and better risk-sharing in the economy. To ensure that economies get maximum benefits from the financial sector's contribution, they need to have an efficient financial sector. One possible way of obtaining a more efficient financial sector is liberalization. In addition to comparative advantage, Stiglitz and Charlton (2005) added four more sources which may cause economies to benefit from trade liberalization. Firstly, by opening foreign markets, it can expand the demand for domestic firms' goods and enable them to serve a larger market and realize gains from economies of scale. Secondly, it may make available a range of inputs at lower prices, lowering the costs of production. More competition is another channel by which trade liberalization may cause improvements in the efficiency of local production. Finally, trade liberalization may, through various channels, affect the rate of economic growth.

Our prediction is that the EU region will gain more than the NAFTA region from insurance liberalization, a fact consistent with Webster and Hardwick (2005). They found that most European countries have a comparative advantage in insurance services. Consequently, moving toward insurance liberalization must provide benefits for this region, other things held constant. However, the effects of insurance liberalization for developing and less developed countries are ambiguous. On the one hand, in middle-income and low-income countries, about 75 per cent of imported insurance is used as an intermediate input, so liberalization can provide cheaper insurance for production sectors. On the other hand, because these countries do not specialize in insurance, liberalization just in the insurance sector may cause a loss rather than a benefit. A first step to take then is to measure the benefits from liberalization. Therefore, we need to introduce an indicator for insurance liberalization. The question is how can we identify a set of barriers that should be reduced to facilitate trade in insurance services? Although in the case of goods the answer is straightforward since liberalization is accompanied by reductions in tariff and non-tariff barriers, in the case of service liberalization -in this chapter, insurance liberalization in particular- the answer is not as simple as for goods liberalization.

The answer to the above question can be found in the nature of the modes of supply for services. As we will discuss in detail later, the GATS agreement introduced four different modes of supply, including cross-border trade (mode 1), consumption abroad (mode 2), commercial presence (mode 3), and presence of natural persons (mode 4). In many cases, including banking and insurance services, commercial presence plays a vital role in order to provide services in another country, as it is difficult to sell in foreign markets without a local presence in those markets. Generally, it has been accepted that the limitations and regulations of national economies regarding the presence of foreign companies give monopoly power to local companies. Benjamin and Diao (2000) argue that imperfect competition is a useful framework for considering barriers to trade in services. These barriers include the costs of documentation for meeting foreign regulations, certification, government procurement requirements, obtaining foreign market information, and maintaining a distribution network. Such non-tariff barriers reduce market competition and are associated with some degree of imperfect competition, which increases opportunities for monopolistic pricing. Therefore, in the current study, insurance liberalization means to move from an insurance market with an imperfectly competitive structure towards a competitive one.

Benjamin and Diao (2000) argue that when monopolistic market powers and the need for spending on fixed costs are reduced by trade liberalization, economic welfare is bound to improve. However, we must keep in mind that we live in a world economy with numerous distortions such as import tariffs, export subsidies, and taxes. In general, removing one distortion, e. g. imperfectly competitive structure in national insurance markets, does not necessarily improve economic welfare (this discussion related to the theory of the second-best, and is true for all economies, regardless of whether they have a comparative advantage in the insurance industry or not).

Despite all theoretical arguments about the benefits of trade liberalization, there is no empirical study to assess the effects of insurance liberalization. Until now most studies have done on service liberalization have considered services as a whole or, at best, have only focused on financial services. In light of the growing volume of insurance premiums, and also of the international insurance trade -as a result of services agreements- one of the important empirical questions to be addressed regards the effects of the liberalization of insurance services on different economies around the world. In consequence, the main purpose of this study is to analyse and empirically dissect this important issue.

In this chapter, we use a CGE model that includes 8 regions and 5 sectors. The regions include NAFTA, the EU (26 countries), Japan, Oceania, East Asia (Korea and China), low-income (55), middle-income (93), and high-income (22) countries according to the World Bank classification. The rationale for classifying countries into the above 8 regions can be described as follows:

We considered two characteristics, share of worldwide premiums and regional agreements[1]. For example, we combined the data for the United States, Canada, and Mexico to cover the NAFTA region. In the same way, some of the biggest insurance markets are located in the EU region, e.g. the United Kingdom, which is the third largest insurance market in the world. By combining 26 countries that are members of the European Union, we constructed data for the EU. Japan has the second largest market in the world. For some regions, such as low-income, middle-income, and high-income, countries in each region have substantial differences with each other regarding their location in the world, culture, etc.; however, they have one characteristic in common: their level of development. We put Korea and China in one region because of their location and also their share in world-wide premiums, which in 2005 was almost equal to the share of the middle-income countries (with 93 countries) and larger than the share of the high-income and low-income countries.

Sectors include food, manufacturing, the financial sector (excluding insurance), insurance, and other services (all services other than the financial and insurance sectors). Following Benjamin and Diao (2000) we consider an imperfectly competitive structure for the financial and insurance sectors. This approach enables us to assess the effects of removing insurance barriers on the world economy. The other sectors are characterized by a perfectly competitive structure.

The remaining part of this study is structured as follows: in the next section, international agreements for the liberalization of trade in services will be reviewed. Then we provide a literature review. The following section considers data and structural information in the base year (2001). Then the model is discussed. This section contains two parts. In the first part, we will consider the GTAP model, which assumes a perfectly competitive structure for all sectors. Then technical aspects of the implementation of imperfect competition features in a CGE model (introduced by Roson, 2006) are

[1] For example, the United States has the largest insurance market in the world with a share of about 34 per cent of worldwide premiums written.

discussed. The seventh section introduces policy simulations. Then we provide results in the eighth section. Finally, we offer concluding remarks.

2.2 International agreements for the liberalization of trade in services

In this section, we review some of the most important international agreements for the liberalization in services around the world. These agreements are the Canada-US Free Trade Agreement, the North American Free Trade Agreement (NAFTA), the OECD's Code of Liberalization of Current Invisible Operations, and the General Agreement on Trade in Services (GATS).

2.2.1 - Canada-US Free Trade Agreement (FTA)

This agreement, finalized in October 1987, came into effect from 1st January 1988 between Canada and the United States, which were each other's largest trading partner at that time—their bilateral trading relationship being the largest in the world. Briefly, the main objectives of the agreement were to eliminate the barriers to trade in goods and services, facilitate the conditions of fair competition, liberalize conditions for investment, establish effective procedures for the joint administration of the agreement and resolution of disputes, and lay the foundation for further bilateral and multilateral cooperation to expand and enhance the benefits of the agreement. Part four of this agreement covered services, investment, and temporary entry. Article 1401 denoted that provision of a covered service includes: a) the production, distribution, sale, marketing and delivery of a covered service and the purchase or use thereof; b) access to, and use of, domestic distribution systems; c) the establishment of a commercial presence (other than an investment) for the purpose of distributing, marketing, delivering, or facilitating a covered service; and d) any investment for the provision of a covered service and any activity associated with the provision of a covered service. As we can see, this agreement covered a large range of activities to ensure further services liberalization. Article 1408 listed services covered in the agreement. Insurance-related activities in the above article were introduced as insurance services, segregated and other funds services (managed by insurance companies only), insurance agency services and brokering services. However, its *national treatment obligation with respect to* services applies to a limited number of sectors, but a wide range of measures, such as the right of establishment, access to a domestic distribution system, etc. This agreement was replaced by the North America Free Trade Agreement (NAFTA).

2.2.2 - North America Free Trade Agreement (NAFTA)

This agreement came into the force on 1st January 1994 between Canada, Mexico, and the United States. The objectives of this agreement are: a) eliminate barriers to trade in, and facilitate the cross-border movement of, goods and services; b) promote conditions of fair competition; c) increase substantially investment opportunities; d) provide adequate and effective protection and enforcement of intellectual property rights; e) create effective procedures for the implementation and application of the agreement, for its joint administration and for the resolution of disputes; and f) establish a framework for further trilateral, regional and multilateral cooperation to expand and enhance the benefits of the agreement. Like the FTA, and as mentioned in its objectives, this agreement covers trade in both goods and services. However, there are two significant differences that distinguish this agreement from the FTA. The first difference is in the MFN obligation that, in this agreement, applies to both parties and non-parties. The second difference is related to the range of national treatments and MFN, which applies to all services mentioned in the agreement. Part five covers investment, services, and related matters. Chapter 14 of the agreement is related to financial services. A financial service is defined as a service of a financial nature, including insurance, and a service incidental or auxiliary to a service of a financial nature. In contrast to the FTA, national treatment is accompanied by Most-Favoured-Nation treatment in NAFTA. Other roles for financial services are the right to establishment of financial institutions, and cross-border trade. Article 1403 about the establishment of financial institutions indicates that an investor of another party (nationality) should be permitted to establish a financial institution in the territory of a party in the juridical form chosen by such investor, and an investor of another party should be permitted to participate widely in a party's market. Article 1404 on cross-border trade prohibits parties from adopting any measure restricting any type of cross-border trade in financial services by cross-border financial service providers of another party that the party permits on the date of entry into force of the agreement and permits persons located in its territory, and its nationals wherever located, to purchase financial services from cross-border financial service providers of another party located in the territory of that other party or of another party.

2.2.3 - Code of Liberalization of Current Invisible Operations

This code consists of a preamble, four parts, which cover 22 articles, and four annexes. Based on Article 1 of this code, members (including 31 OECD countries) shall eliminate between one another restrictions on current invisible transactions and transfers (which are called "current invisible operations"). Article 9 refers to non-discrimination and denotes that "a member shall not discriminate as between other members in authorizing current invisible operations". This article is similar to the Most-Favoured-Nation article in the GATT agreement and has the same function. Annex A covers the list of current invisible operations, including business and industry, foreign trade, transport, insurance, banking and financial services, income from capital, travel and tourism, films, personal income and expenditure, public income and expenditure, and general (such as court expenses, fines, etc.). In addition, Annex A includes some sub-annexes for insurance, air transport, etc. For measures of liberalization (Article 2), "members shall grant any authorisation required for a current invisible operation specified in an item set out in annex A". The obligations of members are reported in Annex B of the code.

Part D of the annex defines insurance-related activities. These activities include social security and social insurance, insurance relating to goods in international trade, life assurance, all other insurance, transactions and transfers in connection with reinsurance and retrocession, and conditions for establishment and operation of branches and agencies of foreign insurers. There are also some annexes to Annex A. Part I of Annex I to Annex A states that insurance buyers in members of the agreement are free to buy insurance from a foreign insurer, whether it is established in the country of residence of the buyer or not. However, such contracts are subject to "the right of member states to regulate the activities of the insurer or of a third party in seeking insurance business". In addition, proposers in member states have the right to have transactions and transfers relating to life insurance with a foreign insurer not established in the country of residence of the proposer. Part III of the annex is about the conditions for establishment and operation of branches and agencies of foreign insurers and indicates that it should be ensured that there is "equivalent treatment for national insurers and insurers from other member states so that the latter shall not be liable to heavier burdens than those imposed on national insurers".

2.2.4 - General Agreement on Trade in Services (GATS)

Considering the importance of this agreement as the first multilateral agreement to cover trade in services, we provide some details of this agreement in this part. We use information provided by the WTO secretariat[2]. The creation of GATS was one of the major achievements of the Uruguay Round of trade negotiations held from 1986 to 1993. The GATS agreement defined its goal as trade expansion "under conditions of transparency and progressive liberalization and as a means of promoting the economic growth of all trading partners and the development of developing countries". Trade liberalization is not the final destination of the agreement, as the main goal is to promote growth and development.

The GATS agreement like GATT covers cross-border supply, and also adds three additional forms of supply, including consumption abroad, commercial presence, and movement of natural persons. The definitions of these modes of supplies are as follows:

[2] WTO Secretariat Publication (2005), *A Handbook on the GATS Agreement* (Cambridge University Press).

- Cross-border trade: from territory of one member into the territory of any other member (mode 1).
- Consumption abroad: in the territory of one member to the services consumer of any other member (mode 2).
- Commercial presence: by a service supplier of one member, through commercial presence, in the territory of any other member (mode 3).
- Movement of natural persons: by a service supplier of one member, through the presence of natural persons of a member in the territory of any other member (mode 4).

The share of individual modes in world services are just less than 30 per cent for mode 1, close to 15 per cent for mode 2, over 50 per cent for mode 3, and between 1 to 2 per cent for mode 4.

Services are classified into twelve core services sectors. The classification covers: business services (including professional services and computer services), communication services, construction and related engineering services, distribution services, educational services, environmental services, financial services (including insurance and banking), health-related and social services, tourism and travel-related services, recreational, cultural and sporting services, transport services, and other services not included elsewhere. The above sectors are subdivided into a total of some 160 sub-sectors.

The GATS consists of the text of the agreement, including a preamble, 29 articles arranged in six parts, various annexes, and a schedule of commitments for each WTO member. There are two types of legal obligations under GATS: unconditional obligations and conditional obligations. The first covers general obligations that should be respected regardless of the existence of specific commitments. The latter applies only to the sectors listed in the member's schedule of commitments. It is worth noting that in several cases the same article contains both unconditional and conditional obligations.

For unconditional obligations, members must respect rules about Most-Favoured-Nation (MFN) treatment, transparency, domestic regulation, monopolies, business practices, and subsidies. With respect to MFN, "each member shall accord immediately and unconditionally to services and service suppliers of any other member treatment no less favourable than that it accords to like services and service suppliers of any other country". However, exemptions could have been sought at the time of acceptance of the agreement with a maximum duration of ten years. Members must meet transparency obligations by publishing all relevant measures of general application pertaining to or affecting the operation of GATS. Based on the domestic regulation obligation, "members are committed to operating domestic mechanisms where individual service suppliers may seek legal redress". Article VIII:1 requires of members that monopolies or exclusive service providers do not act in a manner inconsistent with the MFN obligation and commitments. Article IX states, "members recognize that certain business practices of service suppliers, other than those falling the monopoly related provisions, may restrain competition and thereby restrict trade in services". Finally, regarding the fact that subsidies may have distortive effects on trade in services, members should take negotiations in order to reach an agreement to avoid such trade-induced distortions. In addition, "any member considering that it is adversely affected by a subsidy of another member may request consultations with that member on such matters".

Conditional obligations apply to sectors where specific commitments are made. These obligations cover the granting of market access and national treatment. Limitations on market access and national treatment should be listed by members in their schedule of commitments. Any entries under market access or national treatment may vary within a spectrum whose opposing ends are full commitment without limitations and full discretion to apply any measure falling under the relevant article. The schedule consists of two parts, including horizontal commitments that apply to all services sectors, and sector-specific commitments. Market access covers six types of restrictions that must not be maintained in the absence of limitations. These restrictions are the number of service suppliers, the value of service transactions or assets, the number of operations or quantity of output, the number of natural persons supplying a service, the type of legal entity or joint venture, and the participation of foreign capital. National treatment obligations indicate that "each member shall accord to services and service suppliers of any other member, in respect of all measures affecting the supply of services, treatment no less favourable than that it accords to its own like services and service suppliers".

As mentioned earlier, several annexes are covered by the GATS agreement. Regarding the crucial role of financial services, it contains an "annex on financial services". The annex applies to measures affecting the supply of financial services. Based on this annex, "a member shall not be prevented from taking measures for prudential reasons, including for the protection of investors, depositors, policy holders or persons to whom a fiduciary duty is owed by a financial service supplier, or to ensure the integrity and stability of the financial service. Where such measures do not conform with the provisions of the agreement, they shall not be used as a means of avoiding the member's commitments or obligations under the agreement". This annex defines financial services as "a service of a financial nature offered by a financial service supplier of a member". Consequently, insurance and insurance-related services are classified as a financial activity under this annex. More specifically, insurance activities are defined as: direct insurance (including co-insurance), which covers both life and non-life insurance; reinsurance and retrocession; insurance intermediation, such as brokerage and agency; and services auxiliary to insurance, such as consultancy, actuarial, risk assessment and claim settlement services.

2.3 Literature review

Francois (1995) used an overlapping-generations model to examine the dynamic implications of trade in financial services. The model highlights the role of finance, through capital accumulation, in the growth process. He emphasised the dynamic relationship between financial intermediation and the evolution of the capital stock, which had positive implications for the paths of income and consumption and for the inter-generational distribution of income. These results provided formal support for the argument that liberalizing trade in financial services generates dynamic effects grounded in the basic sources of comparative advantage. However, it seems that we should consider that this positive effect is very much country specific. For example, Gabriele (2002) investigated the relationship between service exports, goods exports, and GDP growth, focusing particularly on the role of developing and transition countries during the last two decades of the 20th century. He claimed that the growth-enhancing impact of exports as a whole in developing countries appeared to have declined in the 1990s, although this decline appeared to be due more to the merchandise component of exports rather than to the service component. In addition, most export-oriented service activities in developing countries tended to be concentrated in the less advanced service sectors, which were poorly integrated with the rest of the domestic economy. For example, in some sub-sectors, such as financial and insurance services, developing countries are minor players in international financial markets (Gabriele, 2004). In addition, due to the lack of policy focus, a higher degree of external integration did not translate into an overall technological upgrading and an improvement in developing countries' relative position in worldwide trade flows. Consequently, the ultimate economic results were unsatisfactory. On the other hand, it seems that other macro variables should be considered when we assess the effect of financial liberalization. For example, Caporale and Williams (2001) investigated the impact of financial liberalization on monetary policy effectiveness by considering consumption behaviour and the saving ratio for the UK because monetary policy could affect the macroeconomy by influencing them. They found that specifications applied to the model captured the UK behaviour reasonably well, and picked up the main shifts in the saving ratio. In addition, changes in the extent of financial regulation cause the transmission of monetary policy to alter in important ways which have implications for the way in which monetary policy should be implemented.

It seems that using general equilibrium models can provide a deeper insight when it comes to the effects of service liberalization on economies around the world. Benjamin and Diao (2000) studied service sector trade liberalization in the Asia-Pacific Economic Co-operation (APEC) forum. They used a global, multi-country, multi-sector applied general equilibrium model with imperfectly competitive service sectors. Regions were either an individual country or an aggregated region, including the United States, Canada, Japan, China, Mexico/Chile, Australia/New Zealand, Korea, Singapore, Hong Kong, Taiwan, Other South East Asia, the European Union, and the rest of the World. Eleven sectors were considered, including agriculture, energy, textiles and paper, petroleum chemical products, metals, transport industries, other manufacturing, non-traded services, transportation, other government services, and other private services. Non-tariff barriers (NTBs) in service trade are difficult to measure quantitatively as they are commonly represented by government regulations and other institutional elements. Consequently, the authors assumed that these barriers reduce market competition and increase the opportunities for monopolistic pricing. As a result, a reduction in the service sector's non-tariff barriers was modelled by eliminating the possibility for oligopolistic firms to price-discriminate between client countries within APEC, and lowering the fixed costs of firms undertaking service-exporting business. They concluded that the western APEC members received the greatest welfare gains from service trade liberalization, while the developing economies gained more only if tariffs were eliminated.

Robinson *et al.* (2002) evaluated the impact of service sector trade liberalization on the world economy for ten regions, including the US, the EU (15 members), Japan, other OECD countries, Asian newly industrialized countries, China, ASEAN, South Asia, Latin America, and the rest of the world. Eleven sectors were studied, among which utilities, construction, trade and transport, private services, public services and housing within the services sector. The other five sectors were agriculture, processed food, natural-resource-based products, non-durable consumer goods and intermediate and durable manufactures. Their CGE trade model focused on the services sectors. Although their measure of liberalization—based upon *ad valorem import protection reductions for service sectors*— was completely different from Benjamin and Diao's (2000) measure, they reached the same conclusion: Developed countries gain relatively more from increasing the export of services than do developing countries.

Verikios and Zhang (2003) came to a different conclusion when they assessed a global general equilibrium model to quantify the impact on global and regional economies of liberalizing trade in financial services. They used data on FDI, both inward and outward, and on barriers to establishment and operation of domestic firms and foreign affiliates. They concluded the biggest winners were South-East Asian and Latin American economies, with the USA and Canada being the only countries projected to be slightly worse off. In general, regions with the highest barriers, such as developing countries, were found to benefit the most.

The difference in the results of Verikios and Zhang vis-à-vis Benjamin and Diao (2000) and Robinson *et al.* (2002) might be attributed to the fact that Verikios and Zhang (2003) considered the financial sector instead of the service sector as a whole, and used data on FDI. However, it should be mentioned each of the above methods have their own weaknesses. For example, Benjamin and Diao's (2000) estimation suffers from a lack of data on fixed costs in the services sector, whilst Verikios and Zhang (2003) use estimations for FDI since this was not available for the financial sector in different regions.

Konan and Maskus (2006) used a CGE model of a small open economy (Tunisia) with multiple products, services and trading partners. In the model, restraints on service sector trade involved both cross-border supply (tariff-equivalent price wedges) and on foreign ownership (monopoly-rent distortions and efficiency costs). Results showed that goods-trade liberalization yields a modest gain in aggregate welfare. Welfare and GDP are both estimated to increase more than 7% in the case of service sector liberalization, which is more than three times the magnitude of the estimated gains from goods-trade liberalization alone. Further, perhaps 75% of service liberalization gains can be attributed to the liberalization of foreign investment barriers that impede mode 3 deliveries of services.

Matto *et al.* (2006) ran cross-country regressions for a sample of 60 countries for the period 1990–1999. It was assumed that an average annual growth rate of per capita GNP was dependent on openness to trade in services. The authors claimed that their paper provided some econometric evidence — relatively strong for the financial sector and less strong, but nevertheless statistically significant, for the telecommunications sector— that openness in the service sector influences long-run growth performance. In addition, the magnitudes of the coefficients on the liberalization indices were much higher for the regressions run over only developing countries. They suggested that that service liberalization could bring greater growth benefits to developing countries, a result that is consistent with Verikios and Zhang (2003). Using Cross-country regressions, Matto *et al.* (2006) do not consider differences among countries. Their sample contains a wide range of economies at different stages of development but a cross-sectional analysis does not allow different countries to exhibit different patterns of causality.

2.4 Data

The data used in this research comes from the latest GTAP database (version 6) which contains data for the world economy. The base year for the GTAP-6 database is 2001. The dataset includes 87 regions/countries covering almost all economies around the world. In addition, the dataset contains 57 sectors and five primary resources. The GTAP database is a SAM matrix of the regions and sectors (list of the regions and sectors can be found in detail in Appendix 2.1). We use GTAP's aggregation program (GTAPAgg Package) to aggregate data to eight aggregate regions and five aggregate sectors. The results reported in this research were obtained using the GEMPACK economic modelling software (Harrison and Pearson (1996)). For imperfect competition, the model is calibrated by assuming that both baseline profits and capital debt service are included in the SAM capital inflow. To compute calibration parameters we used different sources. Most of the data comes from the OECD STAN database for industrial analysis. In addition we use Jacob *et al.* (1997) and Pyo (1988) estimates for the capital stock. Some data are from the Bureau of Economic Analysis of the US Department of Commerce and from the Australian Bureau of Statistics. For the capital stock of Japan, we used Nomura's (2004) estimates. We should mention that we use the above statistics to compute Average Profit Margin (APM) for each region. Because of data availability, in each region we use statistics for countries which have a dominant share in insurance activities in that region. For example, we used the US statistics to compute APM for the NAFTA region. For the EU we use statistics for four major insurance markets in Europe, including the UK, France, Italy and Spain. Because the data is not available for developing countries, unfortunately we were not able to compute the index for the low- and middle-income countries. However, we consider the parameters based on the assumption that developed countries are more liberalized than developing countries. As a result, we assigned larger parameters for these two regions. To examine the robustness of the results, we test different parameters for the two regions. Results indicate that there were no substantial changes when we changed the parameters.

2.5 Structural information in the base year data (2001)

In Table 2.2, we consider some information about regions' share in world premiums and insurance exports. The table shows that NAFTA and the EU have the largest insurance markets, with world market shares of 39.8% and 30.74% respectively, followed by Japan, middle-income, East Asia and high-income regions. On the other hand, low-income countries' share of world insurance market is about 0.5 per cent. When we look at the share of regions in insurance exports, NAFTA is replaced by the EU, the latter having about 55% of exports. It is interesting that Japan, with a share of 18.5% of world premiums, has a share of just 0.6% of world insurance exports, which is the smallest share among all regions. In addition, middle-income countries have a relatively large share among the rest of the regions.

Table 2.2 - Region's share in world's premiums and insurance export

	NAFTA	EU	JAPAN	EASTASIA	OCENIA	LOW INCOME	MIDDLE INCOME	HIGH INCOEM	Total
Premium[3]	39.8	30.74	18.51	3.16	1.48	0.55	3.17	2.31	100
Export	22.3	54.3	0.6	1.3	1.8	1.7	11.3	6.7	100

In Table 2.3, we report some macro level economic indicators for each region. The data indicate that NAFTA, the EU, and Japan are the largest economies with respect to GDP, accounting for about 77 per cent of world GDP. Oceania, high-income and low-income countries are the smallest, as they constitute 1.3, 2.4, and 3 per cent of world GDP respectively. However, it is worth noting that low-income countries contain many more countries than the other two regions. Again, the NAFTA and EU regions are leading, with about 60 per cent of international trade. The smallest regions in international trade are Oceania and low-income countries.

Table 2.3 - Size of the economy by regions

	NAFTA	EU	JAPAN	EASTASIA	OCENIA	LOW INCOME	MIDDLE INCOME	HIGH INCOEM	Total
GDP	11415	8527	4177	1586	422	928	3485	738	31278
Export	1322	2776	453	562	96	164	1121	416	6910
imports	1354	2848	467	589	103	173	1180	429	7143
GDP as % of world	36.5	27.3	13.4	5.1	1.3	3	11.1	2.4	100
Export as % of world	19.1	40.2	6.6	8.1	1.4	2.4	13.7	10.4	100
Import as % of world	19	39.9	6.5	8.2	1.4	2.4	16.5	6	100

Table 2.4 presents the sectoral composition of regions' output. As expected, developed and high-income countries have relatively larger services sectors. Service sectors account for between 60% and 70% of these regions' output. The insurance sector has a relatively higher share of output in developed and high-income regions than do the other regions. On the other hand, developing and emerging economies have relatively large manufacturing and food sectors.

[3] Premiums data are provided by the world insurance report 2005 by Swissre, Sigma.

Table 2.4 - Sectoral composition of output

	NAFTA	EU	JAPAN	EASTASIA	OCENIA	LOW INCOME	MIDDLE INCOME	HIGH INCOEM
Food	5.7	6.9	5.3	12.8	9.7	22.4	15.7	4.2
Manufacturing	25.9	30.9	29.8	51.9	23.2	31.7	35.7	33.5
Financial	5.6	3.3	2.8	2	3.1	2.9	2.1	3.5
Insurance	2	1.3	1	0.4	1.7	0.6	1.1	1.1
Other Services	60.7	57.5	61.1	33	62.3	42.4	45.4	57.7
Total	100	100	100	100	100	100	100	100

Services play an indispensable role as intermediate input in all production activities (Robinson *et al.*, 2002) and the cost of various services constitutes a significant portion of total production costs in all sectors across regions. It is more than 26 per cent of agricultural production costs in the United States, about 25 per cent of manufacturing production costs in Japan, and 20 per cent costs of intermediate and durables in the EU. The costs of service inputs in advanced countries are higher than in developing countries. However, intermediate services inputs also constitute 15–20 per cent of production costs for manufacturing products even in developing countries. In addition, they mentioned that private services (include banking, insurance, business and various professional services), trade and transport are the most important sectors, constituting more than two-thirds of total service costs.

Although Robinson *et al.* (2002) mentioned the private service sector as one of the most important intermediate inputs, they considered the *financial* and business sectors as a whole. As a result, their study did not capture the role of the components of the services sector. In Table 2.5, we report insurance costs as an intermediate input in different production sectors across regions. Looking at the cost of insurance in economic sectors reveals some interesting points. First, the cost of insurance as an intermediate input in the insurance sector is the highest among other sectors without any exception. One explanation may lie in the fact that insurance companies also buy insurance (from re-insurers) to protect themselves against potential loss. Another point is that the cost of insurance in the insurance sector in developed countries is relatively higher than in developing countries. On the other hand, if we consider the manufacturing sector, the situation is the opposite. It seems that the share of insurance as an intermediate input in the insurance sector is positively correlated (negatively for the manufacturing sector) with the level of economic development. One possible explanation is that countries use more insurance in sectors in which they have comparative advantages. We leave this theory here for further future research..

Table 2.5 - Insurance inputs as a percentage of total production cost by sector across regions

	NAFTA	EU	JAPAN	EASTASIA	OCENIA	LOW INCOME	MIDDLE INCOME	HIGH INCOEM
Food	0.3	0.3	0.2	0.1	0.7	0.2	0.4	0.3
Manufacturing	0.2	0.3	0.2	0.2	0.4	0.5	0.5	0.2
Financial	0.3	3.7	0.1	0.4	7.5	1.4	2.4	0.8
Insurance	27.5	5.8	0.6	5	13.4	3.8	3.8	14.6
Other Services	0.3	0.6	0.3	0.4	0.6	0.6	0.5	0.4

As mentioned by Robinson *et al.* (2002), the input-output link (above table) is one of the important channels that transmit gains from insurance trade liberalization to the rest of the economy. However, to have a better view, we should look at the percentage of insurance imports used as an intermediate input. We provide this information in Table 2.6. The share is very high for some regions like Oceania and East Asia, which account for 97% and 91.4% respectively. It means that the shares of consumption from insurance import in these regions are almost nil. Japan has the lowest share of insurance imports used as intermediate input.

Table 2.6 - Percent of insurance imports used as intermediate inputs and consumption

	NAFTA	EU	JAPAN	EASTASIA	OCENIA	LOW INCOME	MIDDLE INCOME	HIGH INCOEM
Input	49.4	82.7	26.5	91.4	97	77.4	72	78
consumption	50.6	17.3	73.5	8.6	3	22.6	28	22
Total	100	100	100	100	100	100	100	100

Tables 2.7 and 2.8 report measures of trade dependence across regions. These measures are defined as the ratios of export to GDP and import to GDP. High-income, East Asia, EU and middle-income countries have the highest trade dependence. However, when it comes to trade in insurance, the situation is different. High-income and EU countries have the highest dependency ratio for insurance. On the other hand, East Asia and Japan have the lowest, and regions like NAFTA, middle-income and Oceania are in the middle.

Table 2.7 - Sectoral export dependence by region

	NAFTA	EU	JAPAN	EASTASIA	OCENIA	LOW INCOME	MIDDLE INCOME	HIGH INCOEM
Food	0.7	2.1	0.08	1.1	6.1	2.6	3.3	1.3
Manufacturing	8.5	23	9.8	31.7	12.2	12	24.1	38
Financial	0.1	0.4	0.04	0.07	0.14	0.05	0.08	0.36
Insurance	0.1	0.3	0.01	0.03	0.18	0.08	0.14	0.38
Other Services	2.1	6	0.9	2.4	4	2.9	4.5	16
Total	11.6	32.5	10.8	35.4	22.8	17.7	32.1	56.4

Table 2.8 - Sectoral import dependence by region

	NAFTA	EU	JAPAN	EASTASIA	OCENIA	LOW INCOME	MIDDLE INCOME	HIGH INCOEM
Food	0.8	2.3	0.09	1.2	6.6	2.8	3.6	1.4
Manufacturing	8.7	24.5	10.1	33.3	13.3	12.7	25.6	39.8
Financial	0.1	0.37	0.04	0.07	0.13	0.06	0.08	0.35
Insurance	0.08	0.27	0.01	0.03	0.18	0.08	0.13	0.38
Other Services	2.1	6	0.9	2.4	4.1	2.9	4.5	16.1
Total	11.8	33.4	11.1	37.1	24.4	18.7	33.9	58.1

2.6 Model

As mentioned earlier, in our research the world economy consists of 8 regions with 5 sectors. Except for the insurance and financial sectors, all other sectors are perfectly competitive. The focus of this study is to assess the effects of removing non-tariff barriers in the insurance sector on regional economies. Comparing barriers to trade in goods and services, it seems that measuring barriers to trade in services is much more complicated than measuring barriers to trade in goods. A large share of trade in goods can be classified as mode 1 supply (cross-border). However, the production and consumption of services must occur in the same location. This fact reveals that the commercial presence of foreign insurance companies in host countries plays an essential role in the trade in insurance services. Following Benjamin and Diao (2000), we assume that non-tariff barriers in the insurance industry give a monopolistic power to the insurance industry in each region. To capture an imperfect competitive sector, we use Roson's (2006) approach, which assumes that firms with a non-competitive structure charge customers a price higher than their marginal cost.

Our strategy is to estimate a model under two structures: the GTAP standard model, which considers a perfectly competitive structure for all sectors, and Roson's approach. We assume an imperfectly competitive structure for the insurance and financial sector markets. Then we compare the results under the two above-mentioned models. Comparing the results tells us whether moving from an imperfectly competitive structure to a perfectly competitive structure (moving towards liberalization) would affect regional economies. In the first part of this section, we describe the GTAP standard model. Full details of the GTAP model can be found in *Global Trade Analysis, Modelling and Application* (Hertel, 1997). Subsequently, Roson's method will be discussed.

2.6.1 - GTAP Standard Model (perfect competition)

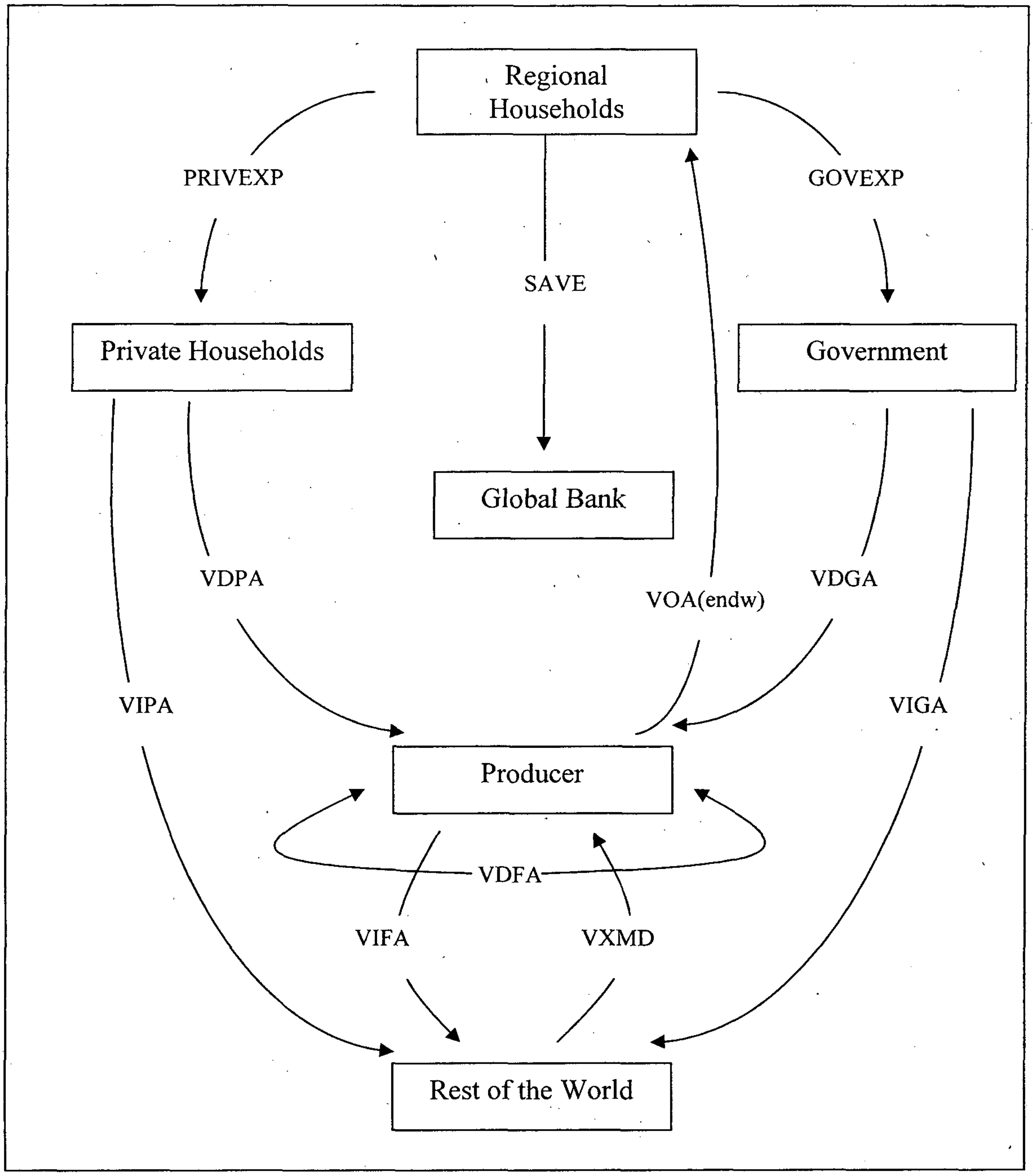
Here we provide GTAP's multi-region open economy model. There are two types of household in the GTAP model. Regional household covers both private households and the government. GTAP uses a Cobb-Douglas utility function to allocate expenditures of regional households to private expenditure, government expenditure and saving. Using a Cobb-Douglas utility function assigns a constant budget share to each type of household's expenditure. This means that an increase in household income does not change the share of each type of expenditure.

The above approach to household expenditure has advantages and disadvantages. On the one hand, using a regional utility function enables us to reach an unambiguous conclusion about the effects of the policy on regional welfare. For example, without the regional utility function, it is not possible to come to a conclusion in welfare terms when the policy causes lower relative prices for saving and government expenditures, and higher prices for a private household's commodity bundle. On the other hand, there is no relationship between government expenditures and revenues (taxes). In the model, an increase (decrease) in taxes is not associated with an increase (decrease) in expenditure. The reason lies in the incomplete data coverage for regional tax instruments.

In the absence of taxes, the only source of income in the GTAP model is endowment commodities (for a glossary of GTAP terms, please refer to Appendix 2.2). Households sell their endowments to firms and use this income to purchase goods and services. Firms combine endowment commodities with intermediate goods (VDFA) to produce goods and services. These goods and services are bought by households, including private households (VDPA), and government households (VDGA). In addition, firms buy some goods and services from abroad (import: VIFA) and sell to foreigners (export: VXMD). Another channel for international trade is households expenditures in imported goods and services. In the model the global bank is considered as an intermediary between global savings and regional investments.

In brief, households use their income, which they obtain from selling endowment commodities (which are perfectly mobile) and sluggish factors, to purchase goods and services that are produced by firms. The sources of household purchases are private household purchases, including expenditure on domestically produced goods and composite imports, and government purchases, including expenditure on domestically produced goods and composite imports. Households dispose their income according to a Cobb-Douglas per capita utility function over private household expenditures, government expenditures and saving. For private demand, the GTAP model uses a Constant Difference of Elasticities (CDE) functional form, because of the non-homothetic nature of people's preferences in the economy. For allocating government spending across composite goods, the model uses a Cobb-Douglas function. Figure 2.1 shows how households, firms, and the rest of the world are related to each other.

Figure 2.1 - Structure of GTAP model



Source: Global trade analysis: modelling and application

We now consider the level equations used by the GTAP model. Linear equations will be provided later. In the first seven equations, we consider payments received by firms in regions. Equation 2.1 indicates that if we add producer tax to the value of output at firms' prices, we get value of output at market prices:

$$VOA(i,r) + PTAX(i,r) = VOM(i,r) \tag{2.1}$$

Looking at equation 2.2, we see that value of output at market prices contains the value of domestic sales at market prices, plus the value of goods i exported by region r to region s (at region r's market prices), plus possible sales to the international transport sector:

$$VOM(i,r) = VDM(i,r) + VXMD(i,r,s) + VST(i,r) \tag{2.2}$$

Equation 2.3 divides the value of domestic sales into three parts, including value of domestic purchases by private households, government, and firms.

$$VDM(i,r) = VDPM(i,r) + VDGM(i,r) + \sum_{j \in PROC\_COMM} VDFM(i,j,r) \tag{2.3}$$

Equations 2.4 to 2.7 show the relationship between exports from one region to imports into another region. Equation 2.4 indicates that if we add export taxes to the value of exports at market prices, we can get the value of exports at world prices. Actually, the export tax converts exports at market prices to exports at FOB values. We need two more steps to reach the value of imports of a region. The first step is to add value of transportation at world prices (equation 2.5), and in the second step import tax must be added to the value of imports at world prices, which gives us the value of imports at market prices (equation 2.6). Equation 2.7 shows how composite imports are distributed among domestic private households, government, and firms.

$$VXMD(i,r,s) + XTAXD(i,r,s) = VXWD(i,r,s) \tag{2.4}$$

$$VXWD(i,r,s) + VTWR(i,r,s) = VIWS(i,r,s) \tag{2.5}$$

$$VIWS(i,r,s) + MTAX(i,r,s) = VIMS(i,r,s) \tag{2.6}$$

$$VIM(i,s) = VIPM(i,s) + VIGM(i,s) + \sum_{j \in PROD} VIFM(i,j,s) \tag{2.7}$$

In the next series of equations, we investigate the sources of households' and firms' purchases and also households' factor incomes. Equations 2.8-2.10, 2.11-2.13 and 2.14-2.17 show private household purchases, government purchases, and firms' purchases, including intermediate inputs and primary factor services (household factor income), respectively. The value of private households' purchases at agent prices consists of domestic purchases and composite imports. By deducting domestic commodity tax from domestic purchases at agent prices and import commodity tax from composite imports, we can get relevant values at market prices:

$$VPA(i,s) = VDPA(i,s) + VIPA(i,s) \tag{2.8}$$

$$VDPA(i,s) - DPTAX(i,s) = VDPM(i,s) \tag{2.9}$$

$$VIPA(i,s) - IPTAX(i,s) = VIPM(i,s) \tag{2.10}$$

The next three equations (equations 2.11-2.13) are completely analogous. The only difference is that acronym 'P' is replaced by 'G' in order to represent purchases by the government.

$$VGA(i,s) = VDGA(i,s) + VIGA(i,s) \tag{2.11}$$

$$VDGA(i,s) - DGTAX(i,s) = VDGM(i,s) \tag{2.12}$$

$$VIGA(i,s) - IGTAX(i,s) = VIGM(i,s) \tag{2.13}$$

Equations 2.14 to 2.17 denote the sources of firms' purchases. These include firms' purchases of intermediate inputs and purchases of primary factors. Firms' intermediate purchases can be broken into two parts: domestic and imported purchases. If we deduct intermediate input taxes, we reach firms' purchases at market prices. Equation 2.17 shows firms' purchases of primary factors (non-tradable factors, or as called by GTAP, endowment commodities, which are land, labour, and capital). Again, by deducting tax on endowment commodities, we move from firms' purchases at agent prices to market prices.

$$VFA(i,j,s) = VDFA(i,j,s) + VIFA(i,j,s) \tag{2.14}$$

$$VDFA(i,j,s) - DFTAX(i,j,s) = VDFM(i,j,s) \tag{2.15}$$

$$VIFA(i,j,s) - IFTAX(i,j,s) = VIFM(i,j,s) \tag{2.16}$$

$$VFA(i,j,s) - ETAX(i,j,s) = VFM(i,j,s) \tag{2.17}$$

Equation 2.18 imposes zero pure economic profit on the model, which imposes that revenues must equal expenditures. Equations 2.19 and 2.20 show households' factor service income from mobile endowments and sluggish endowments respectively:

$$VOA(j,s) = \sum_{i \in TRAD} VFA(i,j,s) + \sum_{i \in ENDW} VFA(i,j,s) \tag{2.18}$$

$$\sum_{i \in PROD} VFM(i,s) = VOM(i,s) - HTAX(i,s) = VOA(i,s) \tag{2.19}$$

$$VOM(i,s) - HTAX(i,s) = VOA(i,s) \tag{2.20}$$

As mentioned earlier, all the above equations are level equations. However, the equations in the GTAP model are designed on the basis of percentage changes in prices and quantities. In the rest of this section, we provide a linear representation of the non-linear GTAP model. As a matter of fact, instead of the above equations, the equations below are actually used in the GTAP model's computation. The linear combination of appropriately weighted price and quantity changes is used for linearization. To clarify how the equations below are obtained, here we provide an example:

The equation below gives the clearing condition for a tradable market:

$$\begin{aligned} & QO(i,r) * qo(i,r) = \\ & QDS(i,r) * qds(i,r) + QST(i,r) * qst(i,r) + \sum_{s \in REG} QXS(i,r,s) * qxs(i,r,s) \end{aligned}$$

Multiplying both sides by PM(i,r) yields equation 2.21. In some GTAP equations, a tradslack term is added to eliminate, selectively, market clearing for individual products. For example, if we fix the price in the equation, tradslack accounts for the excess of supply over demand in the new equilibrium.

$$\begin{aligned} & VOM(i,r) * qo(i,r) = \\ & VDM(i,r) * qds(i,r) + VST(i,r) * qst(i,r) + \sum_{s \in REG} VXMD(i,r,s) * qxs(i,r,s) \\ & + VOM(i,r) * tradslack(i,r) \end{aligned} \tag{2.21}$$

Equations 2.22 and 2.23 impose equilibrium conditions in the domestic market for tradable commodities (either imported or domestically produced).

A tradslack term does not appear in equations 2.22 and 2.23, as these equations refer to the same commodity treated in equation 2.21.

$$VIM(i,s)*qim(i,r) = \\ VIPM(i,r)*qpm(i,r) + VIGM(i,r)*qgm(i,r) + \sum_{j\in PROD} VIFM(i,j,r)*qfm(i,j,r) \tag{2.22}$$

$$VDM(i,r)*qds(i,r) = \\ VDPM(i,r)*qpd(i,r) + VDGM(i,r)*qgd(i,r) + \sum_{j\in PROC} VDFM(i,j,r)*qfd(i,j,r) \tag{2.23}$$

The model distinguishes between primary factors that are perfectly mobile between sectors and those that are sluggish in their adjustment. Consequently, equations 2.24 and 2.25 enforce market-clearing conditions for the non-tradable endowment commodity and for mobile factors and sluggish factors, respectively. The reason for distinguishing mobile and sluggish endowments is that rental rates across users are different for the former, while there is one market price for mobile primary factors. Again, a tradslack variable is added to equation 2.24 to capture the effects of exogenous price determination in the model (if applicable).

$$VOM(i,r)*qo(i,r) = \sum_{i\in PROD} VFM(i,,j,r)*qfe(i,j,r) + VOM(i,r)*endwslack(i,r) \tag{2.24}$$

$$qoes(i,j,r) = qfe(i,j,r) \tag{2.25}$$

Equation 2.26 imposes a zero pure profit condition on the model. This equation relates input prices to output prices. Input prices are separated from firms' prices for composite intermediate inputs and endowment commodities. The presence of a profitslack variable allows the model to fix output and eliminate the zero profit conditions for any sector. In a similar way, equation 2.27 is the zero profit condition for the international transport sector.

$$VOA(j,r)*ps(j,r) = \sum_{i\in TRAD} VFA(i,j,r)*pf(i,j,r) + \sum_{i\in ENDW} VFA(i,j,s)*pfe(i,j,r) \\ + VOA(j,r)*profitslak(j,r) \tag{2.26}$$

$$VT*pt = \sum_{i\in TRDE\_COMM} \sum_{r\in REG} VST(i,r)*pm(i,r) \tag{2.27}$$

Equation 2.28 ensures that expenditures in the model are exhausted by deducting saving from income in each region. In this equation, deducting savings and government expenditures from disposable income yields private expenditures for each region:

$$PRIVEXP(r) * yp(r) = \\ INCOME(r) * y(r) - SAVE(r) * [psave + qsave(r)] - \sum_{i \in TRAD} VGA(i,r) * [pg(i,r) + qg(i,r) \quad (2.28)$$

The next equation generates available income in each region. The equation takes account of changes in the value of regional endowments, as well as changes in net fiscal revenues owing to *ad valorem* taxes/subsidies. Even if tax rates do not change, revenues will change due to changes in market prices and quantities:

$$\begin{aligned} & INCOME(r) * y(r) = \\ & \sum_{i \in ENDW} VOA(i,r) * [ps(i,r) + qo(i,r)] - VDEP(r) * [pcgds(r) + kb(r)] \\ & + \sum_{i \in NSAV} VOM(i,r) * [pm(i,r) + qo(i,r)] - VOA(i,r) * [ps(i,r) + qo(i,r)] \\ & + \sum_{i \in ENDWM} \sum_{j \in PROD} VFA(i,j,r) * [pfe(i,j,r) + qfe(i,j,r)] - VFM(i,j,r) * [pm(i,r) + qfe(i,j,r)] \\ & + \sum_{i \in ENDWS} \sum_{j \in PROD} VFA(i,j,r)[pfe(i,j,r) + qfe(i,j,r)] - VFM(i,j,r) * [pmes(i,r) + qfe(i,j,r)] \\ & + \sum_{i \in PROD} \sum_{j \in TRAD} VIFA(i,j,r)[pfm(i,j,r) + qfm(i,j,r)] - VIFM(i,j,r) * [pim(i,r) + qfm(i,j,r)] \\ & + \sum_{i \in PROD} \sum_{j \in TRAD} VDFA(i,j,r)[pfd(i,j,r) + qfd(i,j,r)] - VDFM(i,j,r) * [pm(i,r) + qfd(i,j,r)] \\ & + \sum_{i \in TRAD} VIPA(i,r) * [ppm(i,r) + qpm(i,r)] - VIPM(i,r) * [pim(i,r) + qpm(i,r)] \\ & + \sum_{i \in TRAD} VDPA(i,r) * [ppd(i,r) + qpd(i,r)] - VDPM(i,r) * [pm(i,r) + qpd(i,r)] \\ & + \sum_{i \in TRAD} VIGA(i,r) * [pgm(i,r) + qgm(i,r)] - VIGM(i,r) * [pim(i,r) + qgm(i,r)] \\ & + \sum_{i \in TRAD} VDGA(i,r) * [pgd(i,r) + qgd(i,r)] - VDGM(i,r) * [pm(i,r) + qgd(i,r)] \\ & + \sum_{i \in TRAD} \sum_{j \in REG} VXWD(i,r,s)[pfob(i,r,s) + qxs(i,r,s)] - VXMD(i,r,s) * [pm(i,r) + qxs(i,r,s)] \\ & + \sum_{i \in TRAD} \sum_{j \in REG} VIMS(i,s,r)[pms(i,s,r) + qxs(i,s,r)] - VIWS(i,s,r) * [pcif(i,s,r) + qxs(i,s,r)] \\ & + INCOME(r) * incomeslack(r) \end{aligned} \quad (2.29)$$

Equations 2.30 to 2.34 refer to global savings and investment. Because of the nature of the model, which is a 'comparative static's model, current investment does not augment the productive stock of capital available to firms. The capital is constrained by the beginning-of-period capital stock, which is exogenous. As a result, equation 2.30, when investment and savings are specified exogenously, will facilitate accumulation of the targeted end-of-period capital stock. When investment is endogenous, it adjusts in order to accommodate the global demand or saving.

$$ke(r) = INVKERATIO(r) * qcgds(r) + [1.0 - INVKERATIO(r)] * kb(r) \qquad (2.30)$$

Equation 2.31 aggregates regional gross investment into global net investment. Equation 2.33 aggregates regional savings, and equations 2.32 and 2.34 permit us to either force the two to be equal or verify Walras' Law.

$$globalcgds(r) = \sum_{i \in REG} [REGINV(r) / GLOBINV(r)] * qcgds(r) - [VDEP(r) / GLOBINV(r)] * kb(r) \qquad (2.31)$$

$$walras\_\sup = globalcgds \qquad (2.32)$$

$$GLOBINV * walras\_dem = \sum_{r \in REG} SAVE(r) * qsave(r) \qquad (2.33)$$

$$walras\_\sup = walras\_dem + walraslack \qquad (2.34)$$

Price linkage equations are provided through equations 2.35 to 2.47. Equation 2.35 shows the role of income/output taxes that drive a wedge between the value of output at market prices and agent prices (VOM(i,r) and VOA(i,r)). The power of *ad valorem tax* in this case is simply given by TO(i,r)=VOA(i,r)/VOM(i,r). A TO(i,r) smaller than one means that firms/ households are actually receiving a subsidy on the commodity supplied, while a TO(i,r) larger than one implies a tax on the commodity. TO(i,r)=dTO(i,r)/TO(i,r) shows the percentage change of the power of the tax.

$$ps(i,r) = to(i,r) + pm(i,r) \qquad (2.35)$$

Equations 2.36 and 2.37 show price changes of endowment commodities which are demanded by firms at the market price, changes in the endowment commodity, plus the power of tax on the endowment commodity.

$$pfe(i,j,r) = tf(i,j,r) + pm(i,r) \tag{2.36}$$

$$pfe(i,j,r) = tf(i,j,r) + pmes(i,j,r) \tag{2.37}$$

Equations 2.38 to 2.40 show the linkage between domestic market prices and agents purchasing domestically produced, tradable commodities.

$$ppd(i,r) = tpd(i,r) + pm(i,r) \tag{2.38}$$

$$pgd(i,r) = tgd(i,r) + pm(i,r) \tag{2.39}$$

$$pfd(i,j,r) = tfd(i,j,r) + pm(i,r) \tag{2.40}$$

In the same way, equations 2.41 to 2.43 describe the linkage between the domestic market price of imports of good i, by source r, and diverse agents in regions s.

$$ppm(i,r) = tpm(i,r) + pim(i,r) \tag{2.41}$$

$$pgm(i,r) = tgm(i,r) + pim(i,r) \tag{2.42}$$

$$pfm(i,j,r) = tfm(i,j,r) + pim(i,r) \tag{2.43}$$

Equation 2.44 shows the percentage change in the domestic market price for tradable commodity i in region s, based on the change in the border price of that product, pcif, as well as two sources of interventions. Equation 2.45 indicates that the ratio of the domestic market price for i to the price of the import composite is fixed (model's assumption).

$$pms(i,r,s) = tm(i,s) + tms(i,r,s) + pcif(i,r,s) \tag{2.44}$$

$$pr(i,s) = pm(i,s) - pim(i,s) \tag{2.45}$$

Equation 2.46 links CIF and FOB prices. It is assumed that revenues cover costs on all individual routes, for all commodities.

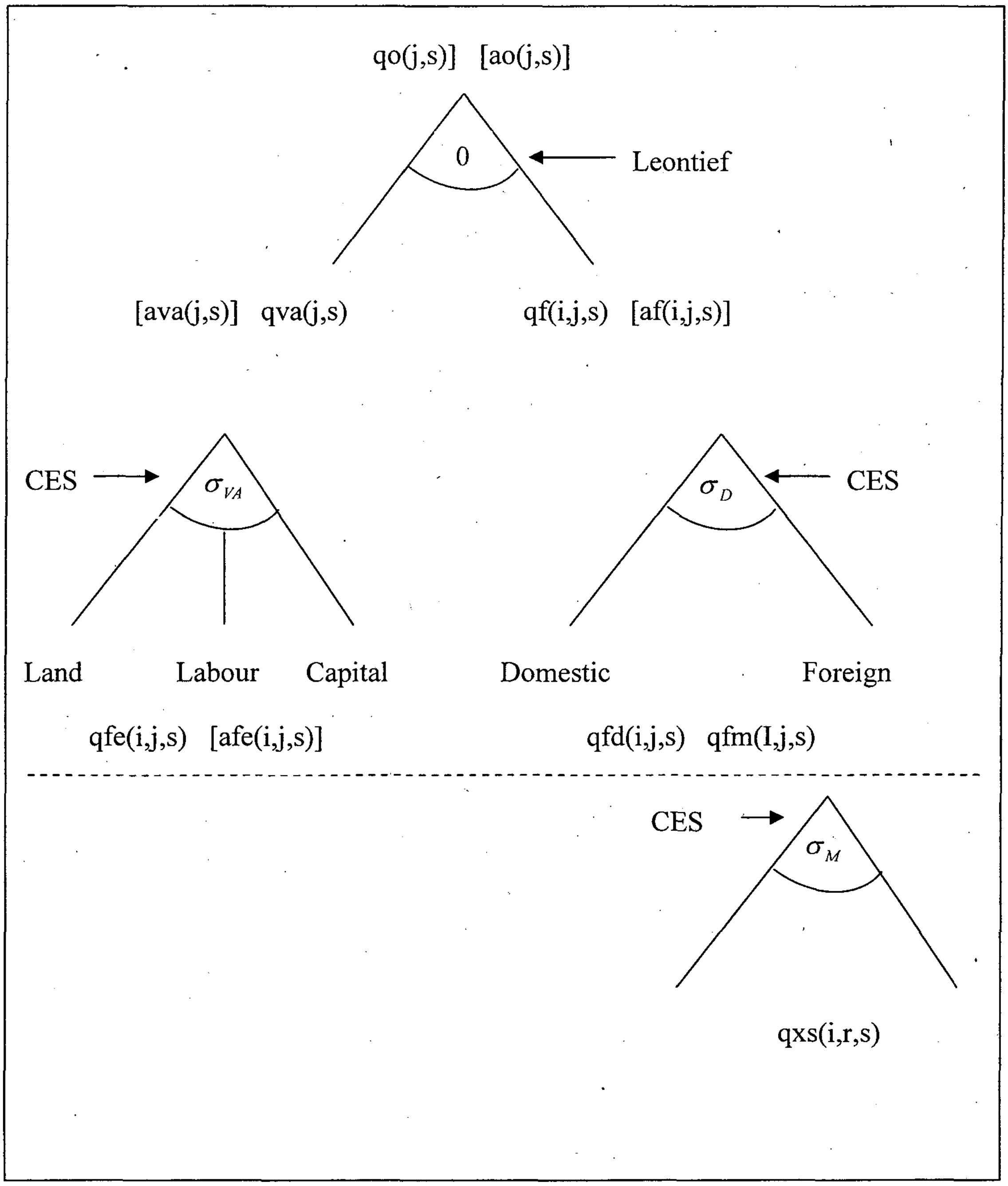
$$pcif(i,r,s) = FOBSHR(i,r,s) * pfob(i,r,s) + TRNSHR(i,r,s) * pt \tag{2.46}$$

Equation 2.47 completes the circle of price linkages in equations 2.35 to 2.46. In other words, it connects the FOB price of goods to domestic market price.

$$pfob(i,r,s) = pm(i,r) - tx(i,r) - txs(i,r,s) \tag{2.47}$$

All of the above equations explain the accounting relationships in the model. This part captures behavioural equations for both firms and households. We start with firms. On the next page we provide the production structure used by the GTAP model.

Figure 2.2 - Production structure



Source: Global trade analysis: modelling and application

Figure 2.2 shows the structure of firms (in all industries) in the model. At the top of the technology tree (Figure 2.2), is the output of the firms. At the bottom of the tree, we can see the inputs demanded by the firm. As usual, the firm combines primary factors, including land, labour and capital, and intermediate inputs to produce its output. Qfe, qfd, and qfm represent percentage changes in quantities of primary factors, domestic intermediate inputs, and imported intermediate inputs respectively. Imported intermediate inputs are sourced from particular exporters (qxs).

The GTAP model's assumptions about how firms combine inputs to produce output are as follows. The first assumption is about separability in choosing the optimal mix of primary factors and intermediate factors. In other words, firms choose their optimal level of primary factors independently of the prices of intermediate inputs. By assuming separability and constant return to scale, only the relative prices of land, labour and capital matter when firms choose the optimal level of primary factors. It is worth noting that separability is symmetric in the model. This means that the mix of intermediate inputs is also independent of the price of primary factors. As a matter of fact, by using the Leontief production function, the model assumes that there is a non-substitution relationship between primary factors and intermediate factors.

In the next step, we review substitution possibilities within primary factors on the one hand and intermediate inputs on the other hand. For primary factors, it is assumed that the elasticity of substitution between all primary factors is equal, which is not a strong assumption, but is forced by data availability constraints. For the case of intermediate inputs, it is assumed that imported intermediate inputs are separable from domestically produced intermediate inputs. Firms first decide on the sourcing of their imports, and then, based on the resulting import price, they determine the optimal mix of imported and domestic goods (Armington approach). The next series of equations provides firms' behavioural equations, portrayed in Figure 2.2.

Before going through these equations, it might be helpful to explain the type of CEF function in the GTAP model. The model adopts a CES functional form, invented by Arrow *et al.* (1961). Equations 2.48 to 2.56 cover four nests (branches) in the technology tree. Each nest has two types of equations. The first type is for substitution among inputs within nest, and the second type is for the composite price equation that determines the unit cost for the composite good produced by that nest.

Equations 2.48 and 2.49 represent the composite import nest. Equation 2.48 explains the percentage change in the composite price of imports, while equation 2.49 determines the sourcing of imports. MSHRS in equation 2.48 represents the share imports of a good from a specific region in the composite imports of a region.

$$pim(i,s) = \sum_{i \in REG} MSHRS(i,k,s) * pms(i,k,s) \tag{2.48}$$

$$qxs(i,r,s) = qim(i,s) - \sigma_m(i) * [pms(i,r,s) - pim(i,s)] \tag{2.49}$$

Equations 2.50 to 2.52 describe the composite intermediate inputs nest. FMSHR represents the share of imports in a firm's composite tradable commodity. The model considers different demand equations for imported and domestic goods (equations 2.51 and 2.52 respectively).

$$pf(i,j,r) = FMSHR(i,j,r) * pfm(i,j,r) + [1 - FMSHR(i,j,r)] * pfd(i,j,r) \tag{2.50}$$

$$qfm(i,j,s) = qf(i,j,s) - \sigma_D(i) * [pfm(i,j,s) - pf(i,j,s)] \tag{2.51}$$

$$qfd(i,j,s) = qf(i,j,s) - \sigma_D(i) * [pfd(i,j,s) - pf(i,j,s)] \tag{2.52}$$

Equations 2.53 and 2.54 describe the value-added nest. Equation 2.53 explains the changes in the price of value-added. SVA represents the share of primary factors in the total cost of value-added. Other factors that affect the price of value-added are the price of primary factors and the rate of primary factor-augmenting technical change. An afe(k,j,r) larger than zero indicates a decline in the effective price of primary factors.

$$pva(j,r) = \sum_{i \in ENDW} SVA(k,j,r) * [pfe(k,j,r) - afe(k,j,r)] \tag{2.53}$$

$$qfe(i,j,r) + afe(i,j,r) = qva(j,r) - \sigma_{VA}(j) + [pfe(i,j,r) - afe(i,j,r) - pva(j,r)] \tag{2.54}$$

Equations 2.55 and 2.56 represent the top-level nest. As mentioned before, the model assumes that there is no substitution between primary factors (value-added) and intermediate inputs. Consequently, the relative price component of these conditional demands drops out. The coefficients of technical change are denoted ava(j,r), af(i,j,r) and ao(j,r). These coefficients represent input-augmenting technical change in composite value-added, intermediates, and Hicks-neutral, respectively.

$$qva(j,r) + ava(j,r) = qo(j,r) - ao(j,r)] \tag{2.55}$$

$$qf(i,j,r) + af(i,j,r) = qo(j,r) - ao(j,r)] \tag{2.56}$$

The equation below imposes a zero profit condition. This equation reflects the effect of technical change on the composite output price.

$$\begin{aligned} & VOA(j,r) * [ps(j,r) + ao(j,r)] = \\ & \sum_{i \in TRAD\_COMM} VFA(i,j,r) * [pf(i,j,r) - af(i,j,r)] + \sum_{i \in ENDW\_COMM} VFA(i,j,s) * [pfe(i,j,r) - afe(i,j,r) - ava(j,r) \\ & + VOA(j,r) * profitslack(j,r) \end{aligned} \tag{2. 26'}$$

At this point, we have finished considering behavioural equations for firms. Now we consider equations for household behaviour. Equation 2.57 indicates that a household spends total regional income according to a Cobb-Douglas per capita utility function over the three forms of final demand: private household expenditures, government expenditures, and saving. Because of the nature of the Cobb-Douglas function, each form of demand represents a constant share of total income.

$$\begin{aligned} INCOME(r) * u(r) = {} & PRIVEXP(r) * up(r) + GOVEXP(r) * [ug(r) - pop(r)] \\ & + SAVE(r) * [(qsave(r) - pop(r)] \end{aligned} \tag{2.57}$$

Equation 2.58 indicates that changes in saving are driven by changes in regional income and the price of saving.

$$qsave(r) = y(r) - psave + saveslack(r) \quad (2.58)$$

In the same way, equation 2.59 shows that government activities are a function of regional income and prices.

$$ug(r) = y(r) - pgov(r) + govslack(r) \quad (2.59)$$

In equation 2.59, percentage changes in real government spending have been determined, and we now use equations 2.60 and 2.61 to allocate this spending across composite goods. Equation 2.60 establishes the aggregate price index for all government purchases, and equation 2.61 uses the price index to evaluate government demand for composite tradable goods.

$$pgov(r) = \sum_{i \in TRAD\_COMM} (VGA(i,r) / GOVEXP(r)) * pg(i,r) \quad (2.60)$$

$$qg(i,r) = ug(r) - [pg(i,r) - pgov(r)] \quad (2.61)$$

After establishing the price in equation 2.62, composite demand is allocated between imports and domestically produced goods as in equations 2.63 and 2.64. It is worth noting that due to the lack of use-specific Armington substitution parameters, σ_D is assumed to be equal across all users. This means that the only thing that distinguishes firms' and households' import demands is different import shares.

$$pg(i,s) = GMSHR(i,s) * pgm(i,s) + [1 - GMSHR(i,s)] * pgd(i,s) \quad (2.62)$$

$$qgm(i,s) = qg(i,s) + \sigma_D(i) * [pg(i,s) - pgm(i,s)] \quad (2.63)$$

$$qgd(i,s) = qg(i,s) + \sigma_D(i) * [pg(i,s) - pgd(i,s)] \quad (2.64)$$

The GTAP model uses a constant difference of elasticities (CDE) functional form for private household demand. In addition, the model assumes non-homothetic households, which means we must take into account the rate of population growth in computing the utility of private households. After some rearrangements, and using Shephard's lemma, the relationship between minimum expenditures, utility, and prices appears in equation 2.65:

$$yp(r) = \sum_{i \in TRAD} [CONSHR(i,r) * pp(i,r) + \sum_{i \in TRAD} [CONSHR(i,r) * INCPAR(i,r)] * up(r) \\ + pop(r) \tag{2.65}$$

Equation 2.66 determines per capita private household demands for tradable composite commodities:

$$qp(r) = \sum_{i \in TRAD} EP(i,k,r) * pp(k,r) + EY(i,r) * [yp(r) - pop(r)] + pop(r) \tag{2.66}$$

Similar to the firms' and government's cases, price is established in equation 2.67, and composite demand is allocated between imports and domestically produced goods as in equations 2.68 and 2.69:

$$pp(r) = PMSHR(i,s) * ppm(i,s) + [1 - PMSHR(i,s)] * ppd(i,s) \tag{2.67}$$

$$qpd(i,s) = qp(i,s) + \sigma_D(i) * [pp(i,s) - ppm(i,s)] \tag{2.68}$$

$$qpm(i,s) = qp(i,s) + \sigma_D(i) * [pg(i,s) - ppm(i,s)] \tag{2.69}$$

Equations 2.70 and 2.71 describe the responsiveness of imperfectly mobile factors of production to the change in rental rates. The elasticity of transformation in equation 2.71 is negative. As a result, an increase in the elasticity in absolute value means that as the degree of sluggishness diminishes, there is a tendency for rental rates across alternative uses to move together.

$$pm(i,r) = \sum_{i \in PROD\_COMM} REVSR(i,k,r) * pmes(i,k,r) \tag{2.70}$$

$$qoes(i,j,r) = qo(i,r) - endwslack(i,r) + \sigma_T(i) * [pm(i,r) - pmes(i,j,r)] \tag{2.71}$$

At this point, we have finished with accounting and behavioural equations. We consider next the macroeconomic closure of the GTAP model. The first important variable that needs to be discussed is investment, as well as the factors that determine aggregate investment. The GTAP model is concerned with simulating the effects of trade policy and resource-related shocks on the medium-term patterns of global production and trade rather than macroeconomic policies and monetary phenomena. For the investment case, GTAP uses the following accounting identity:

$$S - I \equiv X + R - M$$

Meaning that saving (S) minus investment (I) must be equal to the current account surplus, where R denotes international transfer receipts. By assuming that global investment equals saving in the initial equilibrium, we also assume that the current account balance is initially in equilibrium. In addition, if the right-hand side of the above identity is fixed in each region, each region's share in the global poll of net saving is fixed. In this way, equality of global saving and investment in the new equilibrium is also assured. The GTAP's equations for investment and global transportation in the GTAP standard model can be found in Appendix 2.3.

2.6.2 - GTAP's imperfect competition setup

Up to now we have discussed the equations that are used by the GTAP model, and now we are in the position to look briefly at GTAP's imperfect competition model, as modified by Roson (2006).

Price setting in oligopolistic models is based on mark-up rules:

$$p = \left(1 - \frac{1}{\varepsilon}\right)^{-1} mc \qquad (2.72)$$

Where p is the price, mc is the marginal cost and ε is the perceived price elasticity of demand. Most of the data for CGE models comes from a Social Accounting Matrix (SAM). The SAM can be used to estimate production volumes, demand for intermediate factors and value-added components, prices and tax levels. However, the SAM does not provide information as required by the imperfect competition closure (such as profit margins). For this reason, five additional pieces of information are needed in order to calibrate a CGE model with imperfect competition, including initial unitary profits (mark-up), industry elasticities, number of firms or production level per firm, conjectural variations, and a measure of economic scale. However, in Roson's model, not all the above parameters are needed.

Roson (2006) used the approach that was introduced by Gortz and Hansen (1999). They assumed that the producer optimizes profits on the only basis of variable costs, so that the model is calibrated assuming zero profits. On the other hand, the deviation of total revenue from variable costs constitutes a kind of rent. This rent covers fixed costs in the benchmark scenario. In a counterfactual equilibrium, there may be a positive or a negative difference between rent and fixed costs, depending on changes in mark-up revenue and fixed costs. Roson (2006) uses a mark-up approach to calibrate the imperfect competition model to allow for the possible existence of market power in some industries. In this approach, net profit is competed away by assigning it to a fictitious consumer who then demands a fictitious endowment commodity with the composition of fixed costs. The supply of this commodity is endogenously adjusted by the model, so as to satisfy mark-up equation 2.72, where marginal costs are computed as the cost of all factors (primary and intermediate) used in the production process, except the fictitious profit resource. Because of changes in net rents in the model simulations, the demand for fixed costs changes as well.

To calibrate the model, it must be assumed that both baseline profits and capital debt service are included in the SAM capital income flow. Next, we need to use a set of coefficients to calibrate the model. These coefficients tell the model how the initial capital endowment has to be split into two components: profits and actual capital. To introduce the set of coefficients, we use Average Profit Margin (APM):

$$APM = P / [(W.L + R.K) / Q] \qquad (2.73)$$

2.7 Description of the policy simulations

In our model we consider 8 regions, including NAFTA, the EU (25 countries), Japan, Oceania (Australia and New Zealand), East Asia (China and South Korea), low-income countries, middle-income countries, and high-income countries (the last three regions are classified based on World Bank classifications), and five sectors, including food, manufacturing, financial, insurance, and other services. In the model, the sectors that have a perfectly competitive structure are food, manufacturing and other services. The equations for the above sectors follow the standard GTAP model. Insurance and financial services have an imperfectly competitive structure (Roson's (2006) modification of the GTAP model).

We consider four experiments:

1-Removing import tariffs in food and manufacturing sectors in all regions under IMPERFECT COMPETITION structure for insurance and financial sectors and PERFECT COMPETITION structure for the rest.

2-Removing import tariffs in food and manufacturing sectors in all regions under PERFECT COMPETITION structure for all sectors (except financial sector).

Results obtained by CGE models with imperfect competition are typically compared with results generated under a standard closure, with perfectly competitive markets. It must be stressed that removing import tariffs in our experiments is not intended as a portrait of regions' tariff liberalization. By comparing the results of the two models, we are able to evaluate the effects of moving from imperfect competition markets to perfectly competitive ones. The main idea is that in contrast to most non-tariff barriers (NTBs) of commodity trade, many NTBs in services trade are difficult to measure quantitatively as they are commonly represented by government regulations and other institutional elements. Such NTBs reduce market competition. Accordingly, the differences in results from experiments 1 and 2 could be attributed to a move toward liberalization.

3-Removing import tariffs in food and manufacturing sectors in all regions under IMPERFECT COMPETITION, while benchmark coefficients (APM) are adjusted for SPECIFIC COMMITMENTS for the insurance sector under the GATS.

We use Hoekman's (1996) suggestion to compute two indicators: first, the number of commitments made relative to the maximum possible, and second, the average coverage of the schedule defined as the arithmetic weighted mean of the scale factors allocated (0 for unbound, 0.5 for bound restrictions, and 1 for no restrictions). The ratio of the second to the first indicator gives us the share of no restriction commitments to total possible commitments. The higher the number, the more liberal the country in a specific sector. We provide these numbers in the table below:

Table 2.9 - GATS commitments in different regions

Region	Liberalization indicator for insurance industry(percentage)
NAFTA	62.5
EU	37.5
JAPAN	25
Oceania	50
EAST ASIA	37.5
LOW-INCOME countries	29
MIDDLE-INCOME countries	30
HIGH-INCOME countries	35.7

We use these numbers to reduce initial data on market power (APM) in the insurance industry in an imperfect competition model. In this case, we interpret these indicators as moving toward liberalization. Hence, these commitments increase competition in insurance industries and decrease market power. We assume (for simplification) that there is a one-to-one inverse relationship between the indicator and APM. For example, if the liberalization indicator for insurance for all regions were 100%, the imperfect competition model would be reduced to a perfect competition model. This experiment helps us to see the effects of commitments made by members on their economy.

4-On 27 July 2006, it was announced by the WTO Director General that the Doha Development Agenda negotiations were to be suspended because the gaps between key players remained too wide. He said, "The feeling of frustration, regret and impatience was unanimously expressed by developing countries this afternoon." When previous negotiations failed in 2003, the US and Europe asserted that it was the developing countries who were the ultimate losers.

In this experiment we will try to evaluate whether developing countries are losers through the suspension of insurance negotiations or not. This means that we keep middle income, low income and East Asia's commitments on the insurance industry unchanged and liberalize other regions' commitments by, for example, 50%.

2.8 Results

First, we look at the effects of insurance liberalization on welfare as a major objective of trade liberalization. Before looking at the tables, again we must emphasise that the results from each experiment do not signify the pure effect of insurance liberalization. The reason for this is that we are forced to mix different structures (imperfect competition and perfect competition) with tariff removal. This tariff removal is not intended to portray tariff liberalization, and regions have not committed to remove tariffs completely. Rather, the experiments are intended to provide a comparator and to allow the simulation of insurance liberalization. For example, when we look at Table 2.10, a negative number for the NAFTA region does not mean that insurance liberalization reduces welfare in the region. In turn, we compare numbers in different experiments to see whether they have an expanding effect on welfare.

Table 2.10 shows the impact of insurance liberalization on different regions' welfare. As mentioned before, Webster and Hardwich (2005) claimed that most European countries have a comparative advantage in insurance services. Japan and the USA also have comparative advantages in insurance industry, although less than European countries. Considering their findings, we should not be surprised to see these regions better off when they move towards full liberalization (from EXP1 to EXP2). Insurance liberalization increases worldwide welfare. However, when we look at the regions, it brings welfare gains for four out of eight regions, including the EU, Japan, East Asia, and high-income countries (the difference between welfare indicators in EXP1 and EXP2 is positive). On the other hand, insurance liberalization has a negative effect on the welfare of NAFTA, Oceania, low-income and middle-income regions. It seems that this negative effect is much bigger for low- and middle-income countries than for NAFTA and Oceania.

Next, we look at what happens if regions move towards insurance liberalization based on their GATS commitments. For this reason we compare the results of EXP1 and EXP3, which reveal the welfare gains or losses before and after taking commitments. Overall, it seems that variation in welfare is smaller than in the situation where regions move towards full liberalization (EXP2). The NAFTA and EU regions gain in welfare terms (however, this is small). Japan's welfare remains almost unchanged. East Asia, Oceania, and middle-income countries face a loss in welfare terms. However, these losses for Oceania and middle-income countries are smaller than when they move towards full liberalization. The interesting point is the result for low-income and high-income countries. By making GATS commitments, low-income countries gain while high-income countries lose in welfare terms.

Finally, we consider EXP4 in which low-income, middle-income and East Asian countries do not move towards more liberalization, while the rest do. When we look at the results, we see that the only winners in this experiment are the NAFTA and Oceania regions. Worldwide welfare is negatively affected and most regions are losers as a result of implementing the developing countries' action.

Table 2.10 - Impact of insurance liberalization on social welfare across regions (as a percentage of GDP in base year)

Welfare	EXP1	EXP2	EXP3	EXP4
NAFTA	-0.0731	-0.0874	-0.0729	-0.0022
EU	0.0320	0.05431	0.0325	0.0265
JAPAN	0.2057	0.3499	0.2056	0.1326
EASTESIA	1.8381	2.1833	1.8362	-0.2253
OCEANIA	0.4477	0.4296	0.4342	0.6675
LOWINCOM	0.05898	-0.3522	0.05984	-0.1587
MIDINCOME	0.1445	-0.0211	0.1441	-0.1880
HIGHINCOM	0.7875	0.8358	0.7823	0.4015
World	0.1452	0.1531	0.1450	0.0055

Table 2.11 shows the percentage change in the GDP quantity index as a result of having different policies in different regions. Comparing EXP1 and EXP2 reveals that the NAFTA and EU regions' GDP increases (but by very little) because of insurance liberalization. The only region for which GDP increases significantly is Japan. However, middle-income countries experience increases in GDP as well. Other regions face a decline in GDP. Interestingly, making GATS commitments (EXP3) does not change a region's GDP quantity indicator (we can see very small changes for some regions, which can be ignored). The most important results can be found when we look at EXP4. This scenario leaves NAFTA's and the EU's indicators unchanged, while all other regions face a decline in their GDP quantity indicators. The declines are substantial for developing countries.

Table 2.11 - Percentage change in the GDP quantity index

GDP quantity	EXP1	EXP2	EXP3	EXP4
NAFTA	0	0.006	0	0
EU	0	0.006	0.001	0
JAPAN	0.105	0.13	0.105	0.091
EASTESIA	1.567	1.536	1.565	-0.049
OCENIA	0.097	0.083	0.092	0.061
LOWINCOM	0.841	0.829	0.84	-0.038
MIDINCOME	0.221	0.232	0.221	-0.032
HIGHINCOM	0.066	0.05	0.065	0.052

Next, we consider the effects of insurance liberalization on the trade surplus or deficit of regions. The information is summarized in Table 2.12. Full insurance liberalization expands the trade deficit only in low-income countries and the NAFTA region. On the other hand, full insurance liberalization helps other regions to improve their trade balances. GTAP commitments have less effect on a region's trade balance. Because of these commitments, NAFTA's trade balance still worsens but at a lower rate than in the previous experiment. The EU and Japan expand their deficits, while East Asia, Oceania, middle-income and high-income countries improve their trade balance. However, this gain is smaller than when they move towards full liberalization. Low-income countries are still in trade deficit, but with a lower deficit than when they fully liberalize. Again, we can see interesting results in EXP4. All regions, except East Asia, low-income and middle-income countries expand their trade deficits as a result of this scenario. The latter regions could gain a huge amount of trade surplus as a result of insurance trade limits.

Table 2.12 - Trade balance (US million dollars)

Trade balance	EXP1	EXP2	EXP3	EXP4
NAFTA	30981.8	26353.4	30917.2	2231.1
EU	18788.1	19034.8	18733.2	-2183.4
JAPAN	9331.9	9398.5	9314.8	-2053.9
EASTESIA	-18053	-16180.2	-18040.4	221.4
OCENIA	-1662.2	-1422.8	-1610.9	-2442.3
LOWINCOM	-8447.9	-8616.5	-8453.2	1289.4
MIDINCOME	-29411.4	-27530.4	-29372.1	5078.1
HIGHINCOM	-1527.1	-1036.5	-1489.3	-2140.4

Finally, we investigate how different scenarios can affect the insurance industry's net exports. The information is given in Table 2.13. Only the EU can expand its insurance net exports because of full liberalization. The net exports of middle-income countries remain unchanged and all other regions experience a deficit in net exports as a result of trade openness in the insurance sector. However, if regions move based on their GATS commitments, the condition is a little bit different. The EU still expand its net exports, but at a lower rate. NAFTA, low-income and middle-income countries gain. However, the rate of growth in net exports is smaller for middle-income countries. The big winners in EXP4 are again the developing countries. In addition, high-income countries improve their net insurance exports in this scenario. Except for East Asia, low-income, middle-income and high-income countries, all other regions' net insurance exports worsen.

Table 2.13 - Insurance sector net export trade balance (US million dollars)

Insurance net export	EXP1	EXP2	EXP3	EXP4
NAFTA	435.1	406.2	442.7	55.1
EU	22.1	170.6	41.4	-62.2
JAPAN	-28.9	-50.7	-28.6	-19.4
EASTESIA	-156.1	-178.4	-161.5	30.9
OCENIA	-53.9	-64.4	-58.04	-97.1
LOWINCOM	21.4	21.4	23	26.6
MIDINCOME	-80.3	-117.7	-86.7	170.5
HIGHINCOM	-159.3	-187.1	-172.2	-104.4

2.9 Summary and conclusion

There has been much more debate on the impact of trade liberalization in goods than in services. The reason for this is that trade liberalization in goods started more than five decades ago, while negotiations on trade in services returned to the Uruguay Round in the 1990s. We believe that in comparison to worldwide written premiums of about US$3426 billion, which is 7.7% of worldwide GDP, the level of trade in insurance is very low. A possible solution to increase insurance trade is to expand bilateral or multilateral negotiations, which will fuel liberalization. Regions can potentially gain from insurance trade (based on trade theories). However, we live in a world economy with several distortions, like import tariffs, export subsidies, taxes etc. There, removing one distortion, such as reducing the imperfectly competitive structure of national insurance markets, does not necessarily improve economic welfare. Therefore, the purpose of this study has been to evaluate, for the first time, how insurance liberalization in different regions would affect both regional and world macroeconomic variables, such as welfare, GDP quantity index and the balance of trade.

Methodologically, we use a CGE model including 8 regions and 5 sectors. The regions include NAFTA, the EU (26 countries), Japan, Oceania, East Asia (Korea and China), low-income (55), middle-income (93), and high-income (22) countries. Sectors include food, manufacturing, the financial sector (excluding insurance), the insurance sector, and other services (all services other than the financial sector). Following Benjamin and Diao (2000), we consider an imperfectly competitive structure for both the financial and insurance sectors. This approach enables us to assess how removing insurance barriers affects regional economies when a perfectly competitive structure is assumed in the other sectors.

First, we looked at the effects of insurance liberalization on regional welfare. Overall, insurance liberalization increases worldwide welfare. However, if we disaggregate by regions, we can then see that it brings welfare gains for just four out of eight, including the EU, Japan, East Asia, and high-income countries. The negative effects are much bigger for low- and middle-income countries than for NAFTA and Oceania. When regions move towards insurance liberalization based on their GATS commitments, the variation in welfare gains and losses across regions is smaller. In this situation, NAFTA, the EU, and low-income countries gain, while Japan remains almost unchanged. East Asia, Oceania, middle-income, and high-income countries face a loss in welfare terms. The EXP4 winners are only the NAFTA and Oceania regions. Worldwide welfare is negatively affected and most regions are losers because of adopting the developing countries' strategy.

Then we investigate the percentage change in the GDP quantity index. Moving towards full liberalization increases the GDP of Japan and middle-income countries significantly, while the change is almost nil for NAFTA and the EU, and other regions face a decline in GDP. Adopting GATS commitments has just a very small effect on all regions' GDP quantity indicators (all regions face a decline, except for NAFTA and the EU with no changes). Interestingly, declines are substantial for developing countries.

The full liberalization of insurance expands the trade deficits of NAFTA and low-income countries. GTAP commitments have fewer effects on a region's trade balance. Because of these commitments, NAFTA's trade balance still worsens but at a lower rate than in the previous experiment. The EU and Japan expand their deficits, while East Asia, Oceania, middle-income and high-income countries improve their trade balance. However, the gain is smaller than when they move towards full liberalization. Low-income countries are still in trade deficit, but it is lower than in the full liberalization scenario. Again, we can see interesting results in EXP4. All regions except developing countries expand their trade deficits as a result of this scenario. The latter regions could substantially increase their trade surpluses imposing insurance trade limits.

Finally, we see how different scenarios can affect the insurance industry's net exports. Only the EU can expand insurance net exports in a full liberalization scenario, while the net exports of middle-income countries remain unchanged and all other regions experience a deficit. However, if regions move based on their GATS commitments, the results are slightly different. The EU still expands its net exports, but at a lower rate. NAFTA, low-income and middle-income countries gain. However, the growth rate in net exports is smaller for middle-income countries. The big winners in suspending negotiations are again the developing countries. In addition, high-income countries improve their net insurance exports in this scenario.

For concluding remarks, we consider how different scenarios could affect macroeconomic variables. What happens if developing countries[4] adopt a full liberalization scenario (experiment 2)? These countries realize that this policy would decrease their welfare (in the majority of cases), although for middle-income countries it can improve the GDP quantity index. It has a positive effect on their balance of trade (except for low-income countries) and a negative effect on their net insurance exports. We may conclude that it is not in the interest of developing countries to move towards full liberalization of

[4] It is unlikely to be a good description for East Asia, low-income and middle-income countries. Still we call them developing countries on simplicity grounds.

trade in insurance if they consider welfare as a key goal. Although full liberalization has a positive effect on the balance of trade, aggressive commitments towards its implementation (via the GATS agreement) will make it difficult to suspend them in the future. On the basis of Article XII of GATS, members are allowed to adopt or maintain restrictions on trade in services on which it has undertaken specific commitments in the event of serious balance of payments and external financial difficulties. However, given that moving towards full liberalization does not have a negative effect on their balance of trade, these countries cannot use this article to suspend their commitments. Consequently, we might conclude that this policy is not in the interest of these regions.

In contrast with developing countries, developed countries (such as the EU and Japan) having comparative advantages in insurance services and with more liberalized markets (except for Japan which is highly regulated), may find it in their economies' interest to take bigger steps towards liberalization. What happens if during negotiations they force developing countries to accompany them? Developing countries may think it is not fair play and suspend negotiations. This move causes a substantial welfare and GDP loss in most regions. Surprisingly, it has a strong positive effect on the developing countries' balance of trade, and they may find it a useful move if their main goal is to improve the balance of payments. However, and as mentioned above, it decreases their welfare and GDP and is not a good policy in the long-run (it might be good in the short run). On the other hand, the balance of trade of developed countries would worsen. So, what is the best move?

It seems that the best action to ensure that all parties benefit is to move based on GATS commitments or simply negotiations. Negotiations can adjust the adverse effects of aggressive moves towards full liberalization or suspension. Developing countries are still losing welfare and GDP, albeit with a smaller amount. On the other hand, their improvements in their balance of trade are smaller as well. This is true for developed countries too. Negotiations adjust their gains and losses. It is in the interest of all parties to make progressive moves toward liberalization, which is the main goal of

GATS. Overall, we should keep in mind that, in this study, we have just considered a small fraction of trade in services, and that parties are not bound just to take action in the insurance industry. Gaining or losing as a result of insurance liberalization could be adjusted by appropriate movements in other service sectors, or even in trade in goods.

Chapter 3

3.1 Introduction

The importance of insurance in economic activities has been recognized for many years. The impact of insurance was already mentioned in the first conference of UNCTAD in 1964, when it was acknowledged that "a sound national insurance and reinsurance market is an essential characteristic of economic growth"[5].

It seems that insurance not only facilitates economic transactions through risk transfer and indemnification but also promotes financial intermediation (Ward and Zurbruegg, 2000). More specifically, insurance can affect economies in other ways, i.e. by promoting financial stability, mobilizing savings, facilitating trade and commerce, enabling risk to be managed more efficiently, encouraging loss mitigation and fostering an efficient allocation of capital, and by substituting for and/or complementing to government security programmes (Skipper, 2001).

In view of the importance of insurance in the economic literature, one would expect to find a large literature on the relationship between insurance market development[6] and economic growth., To the best of the author's knowledge, only a few studies focus on this relationship, considering either property liability insurance premiums (for example Beenstock *et al.* (1988) and Outreville (1990)) or total insurance premiums (Ward and Zurbruegg, 2000) as indicators of insurance activity.

By considering property liability premiums, Beenstock *et al.* (1988) and Outreville (1990) ignored other parts of the insurance industry (such as long-term insurance). On the other hand, Ward and Zurbruegg (2000) used

---

[5] Proceedings of the United Nations Conference on Trade and Development, First Act and Report, p.55, Vol. I, Annex A.IV.23.

[6] Measured as insurance market size, which is the most accepted measure for insurance activities and is defined as gross direct premiums written (Skipper, 1998)

aggregate variables of total insurance premiums. The availability of data for a longer period was advanced as a reason for using total premiums. However, Ward and Zurbruegg (2000) acknowledged Brown and Kim's (1993) suggestion that total premiums fail to account for different market forces in various countries, make comparisons difficult, and ignore regulatory effects on pricing.

Ward and Zurbruegg (2000) provide a framework to compare insurance industry performance across some OECD countries. However, studies on the aggregation problem have shown that it may be responsible for unreliable results. An example is cross-sectional aggregation, which occurs when a number of micro variables are aggregated to obtain a macro variable (Maddala and Kim, 1998). Granger (1990) showed that it is possible to have cointegration at the aggregate level and no cointegration at the disaggregate one, and vice versa. If this is the case, one may expect that Ward and Zurbruegg's (2000) findings about no long-run relationship between economic growth and insurance market size[7] to arise because of the use of aggregated data.

In 2003, the UK's total gross premiums amounted to US$335 million. If we consider the UK's insurance industry as a country, its fictitious income would have been ranked as seventeenth amongst 183 countries, based on the 2003 World Bank's ranking. Its population (insurance company employees) was about three hundred and fifty thousand. This country's huge outstanding investment was 893 billion pounds. This constitutes the interesting framework that inspired the present study: the objective is to evaluate the long-run relationship between insurance markets and economic growth in the United Kingdom. An important feature that distinguishes our research from Ward and Zurbruegg's (2000) study is the measure of market size. We quantify market size using net written premiums for the UK insurance market[8]. Disaggregated data for long-term insurance include life insurance, annuities,

[7] In countries such as Austria, Switzerland, the United Kingdom and the United States.
[8] The reason for using net instead of gross written premiums is that the former is available for longer periods.

individual pension and other pensions, yearly and single premiums (for simplicity we consider these as life insurance), and for general business insurance the data include motor, accident and health, liability, property, pecuniary loss, reinsurance and marine, aviation and transport (MAT). In addition, causality relationships are tested. Finally, Granger and Lin's (1995) approach is used to find the strength of causality. This measure helps us to determine the power of causality when there is evidence in favour of a bilateral causal relationship.

Section 3.2 briefly summarises the literature review. In Section 3.3, we describe the variables used in the estimation, and then review some facts about the UK insurance market. In Section 3.5, we provide the theoretical background. Section 3.6 deals with the estimation framework. We test variables for the presence of a unit root. Next, the nature of the long-run relationship between growth in GDP and insurance market size is estimated. We test whether development in insurance market size causes GDP or if the causality goes in the opposite direction. Finally, we offer concluding remarks.

3.2 Literature review

This part covers two areas of the literature. Firstly, we consider studies on the relationship between financial development and economic growth, putting particular emphasis on the role of the banking sector and the stock market. We classify this part in three categories, including theoretical, cross-country, and time-series studies. Most of this studies shed light on the relationship between the intermediation performance of the financial sector, namely the banking system, and economic growth. Then, we focus on the relationship between a specific part of the financial sector, the insurance market, and economic growth.

First, we consider some theoretical studies. Bencivenga and Smith (1991) used a three-period-lived overlapping-generations model where all agents (including banks) have access to liquid investment that is not directly productive, and illiquid investment that yields productive capital. They concluded that the development of financial intermediation would increase real growth rates, confirming Greenwood and Jovanovic's (1990) results on the inextricable link between economic growth and financial development. In addition, Greenwood and Jovanovic's (1990) mentioned that in the early stages of development in which exchange is largely unorganized, growth is slow, but as income levels rise, the financial structure becomes more extensive, and economic growth is more rapid. An advantage of Greenwood and Jovanovic (1990) relative to Bencivenga and Smith (1991) is that the former consider both possible causal directions. In their model, Greenwood and Jovanovic (1990) indicate that intermediaries improve resource allocation and foster growth, while a higher rate of growth makes intermediaries affordable to more individuals.

In contrast to aforementioned studies, that only emphasize the role of financial intermediation in improving the efficiency of investment, De Gregorio and Guidotti (1995) also focus on the effects of investment as an additional potential channel of transmission from financial development into growth. They consider the role of financial intermediaries in allocating capital (approximated by the ratio between bank credit to the private sector and GDP) to its best possible use. To test their model, they use a sample of 98 countries covering the 1960–85 periods. In addition, De Gregorio's (1992) panel data set was used for 12 Latin American countries for 1950–85. They found a positive effect of financial development on long-run growth of real per capita GDP, which was particularly strong in middle-income and low-income countries (negative in Latin American countries). The findings also showed that the effect of financial intermediation on growth is due mainly to its impact on the efficiency of investment, rather than to its volume.

Berthelemy and Varoudakis (1996) studied an endogenous growth model. The financial sector collects information about investment opportunities and directs saving towards more productive investments, thereby increasing the productivity of physical capital in a monopolistic competition framework. The interaction between the real and financial sectors generates multiple steady-state equilibria. One of these steady states is characterised by positive endogenous growth and a normal development of financial intermediation activities. They used the econometric model based on a B-convergence equation to examine whether this result of multiple steady states linked to the initial level of financial development was supported by cross-country data on economic growth for 95 countries. They found that educational development is a pre-condition for growth, while financial underdevelopment may become a particularly severe obstacle to growth in countries where that pre-condition is satisfied.

In this part, we provide some cross-country studies. Goldsmith (1966) claimed that developed countries exhibit a higher Financial Interrelations Ratio (FIR), defined as the ratio of the financial claims outstanding to national wealth, than less developed countries. Following Goldsmith's (1966) work, many studies have looked for a relationship between financial development and economic growth. His study suffers from some problems. He only considered 35 countries and his measure for financial development may not be an accurate proxy for the functioning of the financial system, as the pure size of the financial system may not be closely related to the financial services such as risk management and information processing (King and Levine (1993)). In addition, his model does not consider control variables that might influence growth, and also provides no information about the direction of causality.

King and Levine (1993) carried out a detailed empirical investigation by using data on over 80 countries from 1960 to 1989 by using different indicators for financial development, such as financial depth, importance of deposit banks relative to the central bank in allocating domestic credit, credit issued to non-financial private firms (divided by both total credit and by GDP). This study has two advantages over Goldsmith (1966). Firstly, by using the aforementioned indicators, it improves upon the measure of financial development. Secondly, their sample contains more countries. Their results indicate that all financial indicators are strongly correlated with growth, with the rate of physical capital accumulation, and with improvements in the efficiency of physical capital allocation. Their main finding is that the predetermined components of financial development indicators predict growth indicators. However, their study only focuses on only one segment of the financial system, namely banks. Another problem is that the study does not formally deal with the issue of causality. In all the estimations they consider, measures of GDP growth are a function of financial growth.

As mentioned above, King and Levine (1993) focus on the banking sector. However, in some countries financial development occurs to a large extent outside banking. To overcome this problem, Levine and Zervos (1998) inquire into whether measures of stock market liquidity, size, volatility and integration with world capital markets as well as bank development, are robustly correlated with current and future rates of economic growth, capital accumulation, productivity improvements, and saving rates, using data on 47 countries from 1976 through 1993. The results show that both stock market liquidity and bank development predict growth, capital accumulation, and productivity improvement. They found that stock market size, volatility, and international integration are not strongly linked with growth. However, Manning (2002) re-run Levine and Zervos (1998) regressions, examining the robustness of their results. He finds that scatter plots of residuals suggest that some of their results may depend on a few observations.

Levine *et al.* (2000) investigated whether the exogenous component of financial intermediaries' development influences economic growth and whether cross-country differences in legal and accounting systems explain differences in the level of financial development. The advantage of this study is to use both instrumental variable procedures and dynamic panel techniques for 74 countries, with data averaged over 5-year intervals of the period 1960–95. The results indicate that the exogenous components of financial intermediaries' development are positively associated with economic growth. In addition, cross-country differences in legal and accounting systems help account for differences in financial development. Beck *et al.* (2000) used a very similar data set and econometric procedures to Levine *et al.* (2000) to examine the relation between financial intermediaries' development and economic growth, total factor productivity, physical accumulation and private saving rates. They found that financial intermediaries exert a large, positive impact on total factor productivity growth, which feeds through to overall GDP growth; they also found that the long-run links between financial intermediaries' development and both physical capital growth and private savings rates are tenuous. Both previous studies suffer from limited longitudinal scope of panels and the use of averaging time periods.

Deidda and Fattouh (2002) used King and Levine's (1993) dataset to test the non-monotonic relationship between financial depth and growth by assuming an OLG economy. They claimed that financial depth was a reliable predictor for subsequent growth only in high-income countries.

McCaig and Stengos (2005) examined whether the exogenous component of financial intermediaries' development influenced economic growth, using a dataset consisting of 71 countries with data averaged over the period from 1960 to 1995. GMM regressions of economic growth on indicators of financial intermediaries' development using instruments such as religious composition, absolute latitude, etc., show a strong positive effect on growth whenever financial intermediation is measured by liquid liabilities and private credit as ratios to GDP.

A common problem among all above studies is that their dataset ends in 1995, before the Asian financial crisis; a period of economic downturn preceded by deepening financial markets. In addition, Manning (2002) claims that cross-country studies suffer from high correlation between financial, institutional, legal and regional factors, which makes if difficult to identify the effect of finance on growth. In addition, Trew (2006) claims that the time-series historical analysis based on financial depth have demonstrated clear and consistent results that supplement what was learned from the cross-sectional research. Consequently, here we consider time-series analysis for the relationship.

Demetriades and Hussein (1996) indicated that empirical work on the issue of causality between financial development and economic growth remained extremely sparse until that time. They advance the scarcity of sufficiently long time series of national accounts data in developing countries as a potential explanation. They therefore tried to determine whether financial development caused economic growth for 16 countries. To test cointegration and causality, they used Engle-Granger (1987) and Johansen (1988) cointegration techniques along with an error correction model (ECM). Their results show little evidence on finance being a leading sector in the process of economic development. However, there was evidence in favour of bi-directionality and some reverse causation.

Arestis and Demetriades (1997) criticized the use of cross-country analysis, such as King and Levine's (1993) study, which ignores the heterogeneity of slope coefficients across countries. They concluded that there were important differences between countries. Not only is it possible that long-run causality may vary across countries, but it is also likely that long-run relationships themselves exhibit substantial variation.

Neusser and Kugler (1998) investigated manufacturing growth and financial development for fourteen OECD countries. An important feature of their study is their definition of financial depth, which was defined by GDP including commercial and investment banks, pension funds and life and casualty insurance companies. For many OECD countries, they found a cointegrating relationship between the financial sector GDP and total factor productivity in the manufacturing sector.

Shan *et al.* (2001) and Shan and Morris (2002) used the Granger test for non-causality developed by Toda and Yamamoto (1995) to investigate the relationship between financial development and economic growth for nine OECD countries and China, and nineteen OECD countries and China, separately. Little support for the hypothesis that finance causes growth was found. In another study, Shan (2005) used quarterly time-series data from 10 OECD countries and China and reported that, at best, there is weak evidence supporting the hypothesis that financial development leads economic growth. In addition, an insignificant effect of financial development on economic growth was reported by Dawson (2003) for 13 Central and East European Countries.

Caporale *et al.* (2004) attempted to answer whether stock market development causes economic growth. They argued that any inference about financial liberalization causing savings or investment to grow, or about financial intermediation determining economic growth, derived from bivariate causality tests could be invalid as a result of omitting important variables. They used tests for causality in a Vector Autoregressive (VAR) framework for seven countries (Argentina, Chile, Greece, Korea, Malaysia, Philippines and Portugal). The market capitalisation ratio and the value traded ratio were used as indicators for stock market development. They concluded that a well-developed stock market can foster economic growth in the long run and that well-functioning stock markets can promote economic development by fuelling the financial engine of growth. Caporale *et al.* (2005) used the same econometric methodology to investigate the same questions for Chile, Korea, Malaysia and the Philippines. The results were consistent with their previous paper.

Beenstock *et al.* (1988) attempted to derive a demand function for property-liability insurance as a function of income and interest rates. Based on the results, higher interest rates tend to raise premiums. In addition, property liability insurance was found to be a superior good. Outreville (1990) evaluated the relationship between written property liability insurance premiums and economic and financial development with a cross-section of 55 developing countries. A positive relationship between the logarithm of property liability premiums per capita and GDP per capita was found. Truett and Truett (1990) compared the demand for life insurance in Mexico and the United States. Their findings implied that age, education, and income affect the demand for life insurance and that the income elasticity of demand for life insurance is much higher in Mexico than in the United States.

Browne and Kim (1993) considered some factors that may affect the demand for life insurance in different countries. The important factors found include: the dependency ratio, national income, government spending on social security, inflation, the price of insurance, and predominance of Islam religion. Brown *et al.* (2000) focused on two lines of insurance: motor vehicle and general liability. Results suggested that income had a far greater effect on motor vehicle insurance consumption than on general liability insurance consumption.

The potential relationship between growth in the insurance industry and GDP growth was examined by Ward and Zurbruegg (2000) for OECD countries. Their results indicate that there was no cointegrating relationship for Austria, Switzerland, the UK and the US. For Australia, Canada, France, Italy and Japan, the null hypothesis of no cointegration relationship was rejected. A VAR causality test showed that real premiums Granger-cause real GDP for Canada, Italy and Japan, while real GDP Granger causes real premiums only in the case of Italy.

3.3 Description of the data

It is worth considering definitions of different types of insurance. Here we use the definitions provided by the Association of British Insurers website[9]. Long-term insurance includes life insurances and pension plans that can last for many years. General insurance covers insurance of (non-life) risks where the policy offers coverage for a limited period, usually one year. Motor policies cover the legal liabilities arising from the use of a motor vehicle. Private car, motorcycle, commercial vehicles and fleets are included within this category. Comprehensive policies also cover damage to the vehicle. Accident and health covers – including two main types of business – personal accident and medical expenses. Personal accident policies pay a lump sum or weekly benefits in the event of accidental death or a specified injury. Medical expenses insurance pays the costs of treatment for acute conditions. Liability

[9] The website address is http://www.abi.org.uk.

insurance covers legal responsibility for causing loss to third parts through provoked physical injuries or damage to properties. Property policies cover specified property that may be damaged or destroyed by events or perils such as fire, storm or theft. Pecuniary loss relates to financial losses that may have occurred, e.g. consequential loss and mortgage indemnity policies. Reinsurance is the cover insurance that companies can purchase to protect themselves against extended losses or unexpected combined losses. Marine, aviation and transport (MAT) covers damage to both the hull and cargo of ships or aeroplanes, along with liability for property damage, injury and death to passengers and others. Indemnities are also provided for the goods that may be lost or damaged whilst in transit.

All variables in our dataset are imputed in real terms and transformed into natural logarithms. The data for insurance premiums come from publications of the Association of British Insurers (ABI). These data are available on an annual basis and cover the period 1971 to 2003 for general insurance (for reinsurance and MAT the data cover 1971 to 1997). For long-term insurance premiums, the data extend to 2003 and start back in 1966. Data for GDP come from the Economic and Social Data Service (ESDS) and the World Bank.

3.4 The UK insurance industry facts

Here we describe some information on the UK insurance industry published by the Association of British Insurers. In 2003, the UK insurance industry was the largest in Europe and the third largest in the world, accounting for 8.4% of total worldwide premium income. The UK life and general insurance markets are the largest in Europe. The penetration rate (premiums as a percentage of GDP) is the highest in Europe and second in the world. About 348,000 people were working directly and indirectly in 772 insurance companies in the UK, comprising a third of all financial services jobs. Almost 568 of these companies are active in general insurance, 159 are authorized for long-term insurance and 45 legally entitled to do both. The largest ten motor and long-term insurers handle, respectively, 82% and 72% of the business. Total net premiums on general insurance amounted to £30 billion, while total premiums for long-term insurance reached £90 billion. This accounts for 17% of investment in the stock market. General insurance investment amounted to £106.5 billion, while long-term investments were £1032.5 billion. The payout per working day was almost £222 million in pension and life insurance, and £74 million in general insurance. Figures show that the percentage of households that bought some kind of insurance varied from 1% for income protection to 78% for home contents. Percentages for motor, life insurance, mortgage protection, personal pension and medical insurance were 71%, 50%, 20%, 15% and 10%, respectively. Personal protection with £2379 and home contents with £149 were respectively the highest and lowest average annual expenditure. For motor and life insurance these amounts were £605 and £828. Each day in 2003, pensioners and long-term savers were paid £139 million by insurance companies, and this compares to £126 million state pensions paid by the UK government. UK insurance exports (premiums minus claims) amount to just below £6.4 billion. This roughly corresponds to a third of total UK food, beverage and tobacco exports, and almost half of the value of UK oil exports.

3.5 Theoretical background

As outlined later, a possible channel from financial development to economic growth is the supply-leading pattern. This means that financial development causes economic growth.

In this section, we present theoretical support for the existence of this potential pattern. The discussion is based on the model proposed by Obstfeld (1994). In his model, a reduction in uncertainty, which we interpret as a more developed insurance industry (as more risk-transferring opportunities exist), can spur economic growth.

In the model, a closed economy is populated by identical infinitely-lived individuals who face the choice between consuming or investing a single good. The economic decision interval has length *h*. At time *t* a representative household maximizes the inter-temporal objective $U(t)$ defined by the recursion

$$f([1-R]U(t)) = \left(\frac{1-R}{1-\frac{1}{\varepsilon}}\right) C(t)^{1-(\frac{1}{\varepsilon})} h + e^{-\delta h} f([1-R]E_t U(t+h)) \tag{3.1}$$

where the function $f(x)$ is given by

$$f(x) = \left(\frac{1-R}{1-\frac{1}{\varepsilon}}\right) x^{(1-\frac{1}{\varepsilon})/(1-R)} \tag{3.2}$$

In (3.1), E_t denotes the expectation conditional on time-t information, $C(t)$ is consumption at time t, and $\delta > 0$ is the subjective rate of time preference. The parameter $R > 0$ in (3.1) and (3.2) measures the household's relative risk aversion, and the parameter $\varepsilon > 0$ is its inter-temporal elasticity of substitution.

Individuals save by accumulating capital and by making risk-free loans that pay real interest at the instantaneous rate $i(t)$. One unit of consumption can be transformed into one unit of capital (or vice versa) at zero cost. Capital comes in two verities: riskless capital offering a sure instantaneous yield of r (a constant) and risky capital offering a random instantaneous yield with constant expected value $\alpha > r$. Therefore individuals face a portfolio decision – how to allocate their wealth among the two types of capital and loans – as well as a saving decision.

The analysis is simplified by observing that, when $i_t > r$, individuals wish to hold no safe capital and cannot go short in that asset. The opposite case ($i_t < r$) is inconsistent with equilibrium because it implies a sure arbitrage profit from borrowing for investment in safe capital. Finally, if $i_t = r$, the division of an individual's safe asset between safe capital and loan is indeterminate.

Given such behaviour of the interest rate, the individual's problem reduces to a choice over two assets: risky capital and a composite safe asset offering sure instantaneous real return *i*(*t*).

Let $V^B(t)$ denote the cumulative time-t value of a unit of output invested in a safe asset at time 0 and $V^K(t)$ the cumulative time-t value of a unit of output invested in risky capital at time 0. Clearly $V^B(0) = V^K(0) = 1$. With payouts reinvested and continuously compounded, $V^B(t)$ obeys the ordinary differential equation:

$$dV^B(t) = iV^B(t)dt \tag{3.3}$$

The stochastic law of motion for $V^K(t)$ is described by the geometric diffusion process (3.4)

$$dV^K(t)/V^K(t) = \alpha dt + \sigma dz(t) \tag{3.4}$$

In (3.4), $dz(t)$ is a standard Wiener process, such that $z(t) = z(0) + \int_0^1 dz(s)$ and σ^2 is the instantaneous variance of return.

Per capita wealth $W(t)$ is the sum of per capita holdings of the composite safe asset, $B(t)$, and per capita holdings of risky capital, $K(t)$:

$$W(t) = B(t) + K(t) \tag{3.5}$$

Equations (3.3), (3.4), and (3.5) imply that

$$dW(t) = iB(t)dt + \alpha K(t)dt + \sigma K(t)dz(t) - C(t)dt \tag{3.6}$$

Let $\omega(t)$ denote the fraction of wealth invested in risky capital. An alternative way to write (3.6) is as:

$$dW(t) = \{ \ \omega(t)\alpha + [1-\omega(t)]i \ \} W(t)dt + \omega(t)\sigma W(t)dz(t) - C(t)dt \qquad (3.7)$$

Let $J(W_t)$ denote the maximum feasible level of lifetime utility when wealth at time t equals W_t. In continuous time the stochastic Bellman equation resulting from maximizing U_t in (3.1) is:

$$0 = \max_{\omega,C} \{ \left(\frac{1-R}{1-\frac{1}{\varepsilon}} \right) C(t)^{1-(\frac{1}{\varepsilon})} h - \sigma f([1-R]J(w)) + (1-R)f'([1-R]J(W))[J'(W)(\omega\alpha W + [1-\omega]iW - C) + 1/2J''(W)\omega^2\sigma^2W^2]) \}$$

(3.8)

given by equation (3.8), above. From (3.8), the first order conditions with respect to ω and C follow:

$$J'(W)(\alpha - i) + J''(W)\omega\sigma^2 W = 0 \qquad (3.9)$$

$$C^{-1/\varepsilon} - f'([1-R]J(W))J'(W) = 0 \qquad (3.10)$$

The form of equation (3.1) suggests a guess that maximized lifetime utility U is given by $J(W) = (\alpha W)^{1-R}/(1-R)$ for some constant $\alpha > 0$. Given the functional form for $J(W)$, (3.9) and (3.10) simplify. Equation (3.9) now implies that demand for the risky asset is a constant fraction of wealth:

$$\omega = (\alpha - i)/R\sigma^2 \qquad (3.11)$$

Equation (3.10) becomes $C = \alpha^{1-\varepsilon}W$, so that the consumption–wealth ratio is also a constant, denoted by μ. Substitution into (3.8) shows that

$$\mu = C/W = \varepsilon\{\delta - (1-1/\varepsilon)[i + (\alpha - i)^2/2R\sigma^2] \} \qquad (3.12)$$

and confirms that the value function is

$$J(W)=[\mu^{1/(1-\varepsilon)}W]^{1-R}/(1-R) \tag{3.13}$$

Equilibrium growth in this closed economy can now be described. Because the two capital goods can be interchanged in a one-to-one ratio, instantaneous asset-supply changes always accommodate the equilibrium asset demand given by (3.11). There are two types of equilibrium: one in which both types of capital are held and one in which only risky capital is.

The first type of equilibrium occurs when $(\alpha-r)/R\sigma^2 \le 1$. In this case the interest rate *i* is equal to *r*, and the share of the economy's wealth held in the form of risky capital is given by (3.11), i.e. $\omega=(\alpha-i)/R\sigma^2 \le 1$.

An alternative possibility, however, is when $(\alpha-r)/R\sigma^2 > 1$. Given this inequality, an interest rate of $i=r$ is impossible: it would imply that the closed economy, in the aggregate, prefers a shortage of risk-free assets. The second type of equilibrium occurs in the case of an incipient excess supply of risk-free assets at an interest rate equal to *r*. In this equilibrium, the interest rate *i* rises above *r* until the excess supply of risk-free assets is eliminated, that is, until $\omega=(\alpha-i)/R\sigma^2=1$. The implied equilibrium interest rate is $i=\alpha-R\sigma^2>r$.

The equilibrium interest rate helps to determine an equilibrium rate of economic growth. Equations (3.7) and (3.12) imply that wealth-accumulation equation

$$dW=[\omega\alpha+(1-\omega)i-\mu]Wdt+\omega\sigma Wdz \tag{3.14}$$

By (3.12) and (3.14), per capita consumption follows the stochastic process:

$$dC=[\omega\alpha+(1-\omega)i-\mu]Cdt+\omega\sigma Cdz \tag{3.15}$$

Define g as the instantaneous expected growth rate of consumption:

$$g \equiv \frac{1}{C(t)}\left[\frac{E_t dC(t)}{dt}\right]$$

Equation (3.15) shows that g is endogenously determined as the average expected return on wealth, $\omega\alpha + (1-\omega)i$, minus the ratio of consumption to wealth, μ. The combination of this result with (3.11) and (3.12) leads to a closed-form expression for expected consumption-growth rate:

$$g = \varepsilon(i-\delta) + (1+\varepsilon)(\alpha - i)^2 / 2R\sigma^2 \quad (3.16)$$

In an equilibrium in which no riskless capital is held, the growth rate g can be expressed as

$$g = \varepsilon(\alpha-\delta) + (1-\varepsilon)R\sigma^2 / 2 \quad (3.17)$$

which follows from substitution of $\alpha - R\sigma^2$ for i in (3.16).

To get some preliminary insight into the determination of growth, consider the effects of a fall in σ . If the economy holds some risk-free capital, so that i may be held constant at r in (3.16) for small reductions in σ, then the growth rate rises unambiguously.

When all the capital in the economy is already in risky form, however, there cannot be any equilibrium portfolio shift for a closed economy. In this case equation (3.17) applies; it shows that a fall in σ raises growth when $\varepsilon > 1$, but reduces it in the opposite case.

3.6 Estimation framework

The importance of a stationary process has been well recognized in the field of estimating an econometric model. To estimate an econometric model, it is important to know whether the Data Generating Process (DGP) of variables is based on a stationary process or not. The variance and covariance of a stochastic process are finite and independent of time if the process is stationary. In the presence of a non-stationary process, standard estimation techniques can not be used. In addition, this might cause a problem of spurious regression[10] (Verbeek, 2004). There is some evidence showing that most of the macroeconomic variables are non-stationary. For example, Nelson and Plosser (1982) investigated whether macroeconomic time series are better characterized as stationary fluctuations around a deterministic trend or as non-stationary processes that have no tendency to return to a deterministic path. Using long historical time series for the U.S., they could not reject the hypothesis that series were non-stationary stochastic processes with no tendency to return to a trend line. To avoid the problem that may arise because of the existence of non-stationary variables, one should identify the order of integration of variables.

In the first step, we examine the order of integration of the variables with the help of unit root tests. Although several methods have been proposed, there is no uniformly powerful test for unit roots. Nevertheless, it seems that three approaches have been more popular: The first was provided by Dickey and Fuller (1979) and later developed by Said and Dickey (1984). The second was presented by Philips and Perron (1988) (for simplicity PP test), and is sometimes known as the non-parametric method. The last approach is due to Elliot *et al.* (1996). They proposed a modified version of the Dickey-Fuller test, known as DF-GLS test. In the following paragraphs, we will consider the assumptions of each approach and their advantages and disadvantages.

Dickey and Fuller (1979) considered a first order autoregressive model with an independent and identically distributed error terms with mean zero and variance σ^2. In the model $y_t = \rho y_{t-1} + \varepsilon_t$, if $|\rho| < 1$, then y_t is stationary, otherwise it is non-stationary. By assuming non-stationary as the null hypothesis, they drove representations for the limiting distribution of $\hat{\rho}$ and

[10] In this case, two independent variables are spuriously related, causing unreliable inference.

$\hat{\tau}$. By using representations, tables of the percentage points for statistics were provided by Fuller (1976). After the distributions had been generalized to models with intercept and trend, the tables were provided in Dickey and Fuller (1981). Said and Dickey (1984) extend the Dickey and Fuller unit root test by using an autoregressive model from order ρ. They allowed some heterogeneity and serial correlations in errors. They showed that using least squares to estimate coefficients in their autoregression model produces statistics whose limit distribution and percentiles were previously tabulated for DF tests. In addition, they claimed that it is possible to approximate an ARIMA(p,1,d) by an autoregression whose order is a function of the number of observations.

Phillips and Perron (1988) proposed a non-parametric approach with respect to nuisance parameters and thereby allowed for a very wide class of time series models in which there is a unit root. Their model seems to have a significant advantage when there are moving average components in the time series. They replaced standard errors of the regression which measure scale effects in the conventional t ratios by the general standard error estimates which allowed for serial covariance as well as variance. By using this method, they allowed for some heterogeneity and serial correlations in errors. Each statistic also involved an additive correction term showing that the magnitude depends on the difference between the corresponding variance estimates. The limit distribution of the test statistics is the same as the one tabulated by Fuller (1976).

A family of tests whose asymptotic power function is tangent to the power envelope at one point and were never far below the envelope were proposed by Elliot *et al.* (1996). They showed that in a series with no deterministic component, some different tests (such as Dickey-Fuller and Phillips-Perron tests) are asymptotically equivalent to members of the family mentioned above. In the presence of an unknown mean or linear trend, however, these tests are dominated by members of the family of point-optimal invariant tests. Therefore, they propose a modified Dickey-Fuller test by considering a regression with locally de-trended variables for y_t. They claimed that, in the presence of an unknown mean or trend, the power of the test substantially improved.

Several studies showed that the Phillips-Perron (1988) non-parametric test has serious size distortion in finite samples when the data generating process has a predominance of negative autocorrelation in first difference. On the other hand, if moving-average components are important in the structure of the series, the Said and Dickey approach may have a substantially lower power (Maddala and Kim, 1998). Monte Carlo studies do not reveal a clear ranking of the power of the two tests (Verbeek, 2004).

In the second step, we test for cointegration. When the linear combination of variables that are integrated of order one is integrated of order zero, these variables are cointegrated. The most important application of cointegration in economics is that it shows there is a long-run relationship between cointegrated variables. The cointegration test proposed by Johansen (1988) is the most popular test. The author presented likelihood methods for the analysis of cointegration in VAR models without constant and trend. The objectives of his articles are manifold: to find the number of cointegrating relations in non-stationary data, to estimate these relations and to test economic hypotheses. He claimed that the advantage of his approach is that inference could be based entirely on eigenvalues' proprieties. The extended test, which includes trends, was provided by Johansen (1992) and Perron and Campbell (1993).

Nine cointegration tests were considered by Haug (1996), including single-equation-based tests and system-based tests, to compare their power and size distortions. Using Monte Carlo simulations, he concluded that Stock and Watson's test had fairly high and stable power across all the cases that were considered. On the other hand, Engle-Granger (1987) and Johansen's (1992) test had the least size distortions. In this article, we will use Johansen's (1992) cointegration test.

Cointegration analysis does not provide information about two possible patterns identified by Patrick (1966) in the causal relationship between financial development and economic growth. In the demand-following pattern, GDP growth causes an increase in the demand for financial services. In the supply-leading pattern, the expansion of financial services causes an increase in the demand for services and economic growth. In the demand-following pattern, an increase in demand causes an increase in the price of insurance. On the other hand, the supply-leading pattern causes an increase in supply following a decrease in the price of insurance. If we had data for the price index of insurance, we could determine whether an expansion in insurance activities causes prices to increase or to decrease, which could help us understanding which of the patterns above is applicable. Unfortunately, no satisfactory national measure for the price of insurance exists (Skipper, 1998), so we will try to evaluate patterns by using a causality test. We must keep in mind that while cointegration techniques tests long-run relationships, while Granger causality concerns testing short-run relationships. In addition, failing to include the error correction term when modelling cointegrated I(1) processes will result in models that are misspecified, where testing for causality could lead to erroneous conclusions. Then, we consider both the short run and the long run in an error correction model (Maddala and Kim, 1998). We will use the approaches of Demetriades and Hussein (1996) and Arestis and Demetriades (1997) for causality tests. In their method, traditional Granger's equations are re-parameterised to achieve an error correction model (ECM) as follows:

$$\Delta x_{1t} = \mu_1 + \gamma_{11}(L)\Delta x_{1,t-1} + \gamma_{12}(L)\Delta x_{2,t-1} + (\Pi_{11}(1) - 1)x_{1,t-1} + \Pi_{12}(1)x_{2,t-1} + \varepsilon_{1t} \quad (3.18)$$

$$\Delta x_{2t} = \mu_2 + \gamma_{21}(L)\Delta x_{1,t-1} + \gamma_{22}(L)\Delta x_{2,t-1} + \Pi_{21}(1)x_{1,t-1} + (\Pi_{22}(1) - 1)x_{2,t-1} + \varepsilon_{2t} \quad (3.19)$$

which can be written as:

$$\Delta X_t = \mu + \Gamma(L)\Delta X_{t-1} + P_0 X_{t-1} + \varepsilon_t \quad (3.20)$$

When variables are integrated of order one, but there exists a linear combination which is stationary, P_0 equals $\alpha\beta$ (the matrix of error correction terms and the cointegrating vectors, respectively).

$$\Delta X_t = \mu + \Gamma(L)\Delta X_{t-1} + \alpha(\beta X_{t-1}) + \varepsilon_t \tag{3.21}$$

Based on the above equation, there are two sources of causal relationships between variables, either through lagged dynamic terms (short run), or through the lagged cointegrating vector (long run). In each case, the null hypothesis of no causal relationship can be tested through exclusion tests.

We also calculate the strength of causality using the Granger and Lin (1995) approach. They proposed a measure for the strength of causality from the second to the first variable by considering the definition below:

$$M_{2\to 1} = \ln(1 + \frac{\alpha_1^2(1-\rho^2)}{(\alpha_1\rho - \alpha_2)^2}) \tag{3.22}$$

where α_1 and α_2 are coefficients of a lagged cointegrating vector model and ρ is the correlation coefficient between the two innovations of the error correction model. $M_{2\to 1}$ measures the long-run predictive content of the second series with respect to the first (Neusser and Kugler, 1998).

Following Ward and Zurbruegg (2000), we use a number of explanatory variables for possible inclusion in the models. Because of the different nature of long-term and general insurance, different explanatory variables are included in the models. For example, for life insurance (both yearly and single premiums) we consider variables, including population, dependency ratio, number of third-level education students, life expectancy, real interest rate, government expenditure on social security, inflation rate and saving rate. Empirical evidence that supports the inclusion of these variables in the model is in Browne and Kim (1993). We know less about factors that affect the demand for general insurance. We then consider only population and education as exogenous variables in the general-insurance-related models. We use the Hausman (1978) specification test to determine whether the variables mentioned are exogenous. In addition, a set of dummy variables (including three oil shocks) are included in the models, depending on whether these dummies are significant in the models.

3.7 Empirical results

We investigate the hypothesis of non-stationary data using the three tests described in the previous section: the number of lags are determined using Ng and Perron's (1995) suggestions, Ng and Perron's (2001) MIC criterion, and Newey and West (1994) for augmented Dickey-Fuller (1994), DF-GLS and Phillips and Perron (1988) unit root test, respectively. Ng and Perron (1995) analysed the choice of the lag for the augmented Dickey-Fuller test in *a general autoregressive moving average model*. They concluded that some information-based rules such as Akaike information and Schwartz criteria do not focus on lower-bound condition on t and tend to select truncation lags that are too small for some values of the parameter. They suggested that Hall's (1994) general to specific modelling strategy is preferable to other methods. He proposes to start with a general model with a maximum number of k lags and tests whether the coefficients of the last lags are significant, then repeats the procedure until a rejection occurs or the sequential testing leads to the boundary zero.

We take up Ng and Perron's (2001) suggestion for the optimal lag lengths in the DF-GLS test by considering a class of modified information criteria (MIC) with a penalty factor that depends on the sample. They argued that when there are errors with a moving-average root close to -1, a high order augmented autoregression is necessary for unit root tests to have good size, but information criteria such as AIC and BIC tend to select a small truncation lag. Their method takes into account the fact that the bias in the sum of the autoregressive coefficients is highly dependent on k and adapts to the type of deterministic components. Based on Monte Carlo experiments, they found that MIC yields huge size improvements over the DF-GLS test.

In the computation of the Phillips-Perron (1988) test, we used the Newey and West (1994) method for determining the truncation lag. Newey and West (1994) method has some advantages to the other methods (e.g. Andrews-Monahan (1992)). Firstly, they showed how to select the bandwidth optimally when the form of autocorrelation was unknown. Secondly, by performing Monte Carlo studies, they concluded that their method was complementary to Andrews-Monahan. Finally, it is more convenient computationally, since it does not require fitting of an ARMA model.

The results for unit root tests are reported in Tables 3.1 and 3.2. The null hypothesis of unit root test on the level of variables cannot be rejected in almost all cases. The only exception is liability insurance. In this case, ADF and DF-GLS tests show that we can reject the null hypothesis of unit root at 5%, but another test (PP) leads to opposite conclusions. Evidence in Table 3.2, which shows tests for unit root test on the first difference of the variables, suggests that the variables are best characterized as being integrated of order one. This table shows that at least two out of three tests imply that we can reject the null hypothesis of the unit root test. The only exception is reinsurance premiums, which are stationary based on the PP test and non-stationary based on the ADF and DF-GLS tests.

Table 3.1- Unit root test on levels

Variable	Period	ADF	DF-GLS	PP
Real GDP	1966-2003	-3.17(1)	-2.13 (2)	-2.34
Life insurance-Yearly premia	1966-2003	-3.18(5)	-2.07 (1)	-1.57
Life insurance-Single premia	1966-2003	-3.04(2)	-1.75(1)	-2.67
Motor insurance	1971-2003	-2.3(5)	-1.73(2)	-2.3
Accident and health insurance	1971-2003	-1.06(0)	-0.76(1)	-1.02
Property insurance	1971-2003	-1.64 (1)	-0.84(2)	-1.29
Liability insurance	1971-2003	-3.73**(1)	-3.45**(1)	-2.47
Pecuniary loss insurance	1971-2003	-1.62(0)	-2.84(1)	-1.79
Reinsurance	1971-1997	-0.56 (3)	-0.467(1)	0.07
Marine-Aviation-Transport	1971-1997	-3.21 (0)	-1.41(2)	-3.17

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of the autoregressive polynomial is in parenthesis. Lag length selection as suggested by Ng and Perron (1995), Ng and Perron's MIC criterion (2001) and Newey and West (1994) for augmented Dickey-Fuller, ADF-GLS and Phillips and Perron unit root test, respectively.

All regressions include a constant and linear time trend.

Table 3.2- Unit root test on differences

Variable	Period	ADF	DF-GLS	PP
Real GDP	1966-2003	-4.66***(1)	-3.8***(1)	-4.11***
Life insurance-Yearly premia	1966-2003	-3.88***(0)	-1.24 (4)	-4.03***
Life insurance-Single premia	1966-2003	-6.77***(1)	-3.55***(1)	-6.79***
Motor insurance	1971-2003	-4.66***(1)	-0.94(6)	-3.29**
Accident and health insurance	1971-2003	-5.58***(0)	-1.46 (3)	-5.59***
Property insurance	1971-2003	-4.37***(1)	-0.73(6)	-3.49**
Liability insurance	1971-2003	-4.35***(5)	-1.16 (7)	-3.34**
Pecuniary loss insurance	1971-2003	-4.55***(0)	-2.28**(1)	-4.57***
Reinsurance	1971-1997	-1.07 (2)	-1.22(2)	-4.72***
Marine-Aviation-Transport	1971-1997	-5.59*** (1)	-2.58**(2)	-7.87***

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of the autoregressive polynomial is in parenthesis. Lag length selection as suggested by Ng and Perron (1995), Ng and Perron's MIC criterion (2001) and Newey and West (1994) for augmented Dickey-Fuller, ADF-GLS and Phillips and Perron unit root test, respectively.

The results in Table 3.3 indicate education as the only variable that is exogenous to the system (except for accident and health and pecuniary loss insurance). It is noticeable that we tested whether including education in the models did lead to a significant improvement in the model. It appeared it had a significant effect just for life insurance models. Therefore, we included only education in the life insurance models.

Table 3.3- Hausman exogeneity test

Variable	Population	Dependency ratio	Education	Life expectancy	Real Interest	Social securitysec	inflation	Saving rate
GDP	15.2***	-1.73*	0.32	-1.74*	-1.9*	-4.96***	-4.27***	-2.38**
Life insurance-Yearly	-1.58	-3.47***	-1.26	0.14	-2.25**	-2.21**	-0.91	-2.14**
GDP	3.81***	3.03***	0.526	-2.05**	-2.04**	3.83***	-3.39**	-1.82*
Life insurance -Single	0.206	-0.8	-0.87	0.95	2.05**	-0.58	-1.9*	-1.02
GDP	4.63***	-	0.78	-	-	-	-	-
Motor insurance	-1.94*	-	0.13	-	-	-	-	-
GDP	3.95***	-	-1.1	-	-	-	-	-
Accident and health	-5.33***	-	-2.46**	-	-	-	-	-
GDP	5.09***	-	-0.47	-	-	-	-	-
Property insurance	-5.68***	-	-0.61	-	-	-	-	-
GDP	4.34***	-	-0.76	-	-	-	-	-
Liability insurance	-1.05	-	-0.29	-	-	-	-	-
GDP	1.69	-	-2.24**	-	-	-	-	-
Pecuniary loss insurance	2*	-	2.75**	-	-	-	-	-

By considering that all of the variables are best characterized as being integrated of order one, we evaluate the long-run relationship between components of insurance premiums and GDP. We used Johansen's (1992) test to find whether there exists a cointegration vector. Although Johansen and Juselius (1990) argued that the maximum eigenvalue test may be better than a trace test, we used both of them. Table 3.4 reports the cointegration test for each insurance market and GDP. The results imply evidence for rejection of no long-run relationship and in favour of cointegration at the 1% level for all cases. One might conclude that using disaggregated data in our model caused different results from Ward and Zurbruegg (2000) results. In Table 3.5, we report the results for the cointegration test without trend (*although* we know it is relevant to have trend in all regressions) to see whether the results will be affected. Again, in all cases (except life insurance single premiums) we can reject the null hypothesis of no cointegration. In addition, we double-checked the results by using aggregate data. When we include the trend, the evidence is in favour of cointegration between total premiums written and GDP growth while excluding relevant trend from the regression indicates no long-run relationship. These evidences might be considered as another reason to explain why Ward and Zurbruegg (2000) found no cointegration relationship between insurance markets and economic growth for the UK economy.

Table 3.4 - Cointegration tests

Variable	Johansen λ_{Trace}	Johansen $\lambda_{\max}$
	$H_0 : r = 0$	$H_0 : r = 0$
Life insurance-Yearly premia	49.16***(4)	38.23***
Life insurance-Single premia	43.08***(5)	32.88***
Motor insurance	37.6***(2)	25.5***
Accident and health insurance	81.84**(2)	54.65***
Property insurance	28.49***(2)	23.99***
Liability insurance	21.4***(5)	20.38***
Pecuniary loss insurance	65.29***(5)	62.49***
Reinsurance	52.97***(2)	36.18***
MAT	27.27***(2)	20.55***

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.
The order of the autoregressive polynomial is in parenthesis. Lag length selection as suggested by Ng and Perron (1995).
Critical values are taken from Osterwald-Lenum (1992). All regressions include a constant and linear time Except liability and pecuniary loss insurance).

Table 3.5 - Cointegration tests

Variable	Johansen λ_{Trace}	Johansen $\lambda_{\max}$
	$H_0 : r = 0$	$H_0 : r = 0$
Life insurance-Yearly premia	18.55***(3)	14.65**
Life insurance-Single premia	12.68(3)	12.64
Motor insurance	16.64***(3)	14.56**
Accident and health insurance	68.52***(2)	51.04***
Property insurance	39.75***(1)	34.65***
Liability insurance	21.40**(5)	20.38***
Pecuniary loss insurance	65.29***(5)	62.49***
Reinsurance	36.95***(3)	24.19***
MAT	26.18***(1)	18.92***

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of the autoregressive polynomial is in parenthesis. Lag length selection as suggested by Ng and Perron (1995).

Critical values are taken from Osterwald-Lenum (1992).

In Table 3.6, we report one *F*-test and one *t*-test relating to the exclusion of relevant variables from the ECM for the null hypothesis of no causal relationship for both the short and the long run. The results show that there is evidence in favour of a bilateral long-run causal relationships for 6 out of 9 markets and one-way long-run causality from three insurance markets, including life insurance single premiums, motor and MAT insurance, to GDP growth. Five out of 9 insurance markets cause economic growth in the short run, while GDP has no short-run effect on insurance markets.

Although the results indicate a bi-directional causal relationship in most cases, Granger and Lin's (1995) measure shows that the strength of causality from GDP to insurance markets is more powerful. On the other hand, this measure is small for the cases in which insurance markets cause GDP.

In order to summarise the results, we report in Table 3.7 the results of the cointegration and the causality tests for each case considered.

Table 3.6 – Causality test

Variable	GDP does not cause Insurance Premium		Insurance premium does not cause GDP	
	Short-Run	Long-Run	Short-Run	Long-Run
	$\gamma_{12}(L)=0$	$\alpha_1=0$	$\gamma_{21}(L)=0$	$\alpha_2=0$
	$F(k,n)$	$t(n)$	$F(k,n)$	$t(n)$
Life insurance-Yearly premia	1.39	2.07** 1.57	2.5*	2.39** 0.19
Life insurance-Single premia	0.66	0.83 2.28	2.57*	3.21*** 0.01
Motor insurance	1.32	1.5 0.56	1.72	3.8*** 0.59
Accident and health insurance	1.08	2.95*** 2.09	3.09*	2.54** 0.03
Property insurance	0.44	2.11** 1.93	0.01	3.63*** 0.01
Liability insurance	1.41	3.1*** 1.20	0.93	1.75** 0.03
Pecuniary loss insurance	1.03	2.3** 1.67	5***	2.85** 0.02
Reinsurance	1.4	1.79* 1.3	5.24**	3.14*** 0.09
MAT	0.27	0.196 0.7	0.22	3.33*** 0.17

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of VAR and sample periods as indicated in table three. The values on the first lines are F and t statistic. The values on the second line for long-run columns are strength of causality (Granger and Lin, 1995).

Table 3.7 – Summary of results

Variable	Cointegration	GDP causes Insurance premium		Insurance premium causes GDP	
		Short run	Long run	Short run	Long run
Life insurance-Yearly premia	Yes	No	Yes	Yes	Yes
Life insurance-Single premia	Yes	No	No	Yes	Yes
Motor insurance	Yes	No	No	No	Yes
Accident and health insurance	Yes	No	Yes	Yes	Yes
Property insurance	yes	No	Yes	No	Yes
Liability insurance	Yes	No	Yes	No	Yes
Pecuniary loss insurance	Yes	No	Yes	Yes	Yes
Reinsurance	Yes	No	Yes	Yes	Yes
MAT	Yes	No	No	No	Yes

3.8 Summary and conclusion

The first conference of UNCTAD in 1964 acknowledged that the national insurance and reinsurance market was an essential characteristic of economic growth. In addition, in almost all textbooks that have been written about insurance, it is suggested that insurance has a positive effect on the economy through better risk sharing and indemnification opportunities, and by promoting financial intermediation. Nevertheless, only a few papers have empirically assessed these relationships.

The link between growth in the insurance industry and GDP growth was examined by Ward and Zurbruegg (2000) for the OECD economies. Surprisingly, their cointegration analysis showed there was no long-run relationship between growth in the insurance industry and GDP growth for some OECD countries, including the UK. To avoid the aggregation problem, which may cause unreliable results[11], we used disaggregated insurance data, such as long-term, motor, property, etc.

Compared to Ward and Zurbruegg's (2000) findings, our results are somewhat surprising, because we find a long-run relationship between development in insurance market size and GDP growth for all components, relying on Johansen's λ_{Trace} and $\lambda_{\max}$ cointegration tests. The results are in favour of a rejection of no long-run relationship and in favour of cointegration at 1% level for all cases, which implies a long-run relationship between insurance market development and economic growth rather than a cyclical effect. Therefore, it is possible that Ward and Zurbruegg's (2000) results are affected by an aggregation problem. Another possibility is that a relevant trend was excluded from the regression.

In addition, because cointegration analysis does not provide information about possible patterns (demand-following and supply-leading), we used causality tests. Although the results indicate bilateral relationships between

[11] Granger (1990) shows that it is possible to have cointegration at the aggregate level and not at the disaggregate level, and vice versa.

six out of nine insurance markets' development and GDP growth, Granger and Lin's (1995) measure show that the strength of causality from GDP to insurance markets is more powerful than in the opposite case. There is evidence that three insurance markets cause GDP growth. However, the strength of causality is almost negligible. It is noticeable that 5 out of 9 *insurance markets cause economic growth in the short run.*

Based on these results, we conclude that the structure of the UK's insurance industry tends to be demand-following rather than supply-leading, which means that insurance market development has a small long-run effect on the UK's economic growth, and mostly follows it[12].

[12] At best, there is weak support for the hypothesis that insurance development leads economic growth. However, insurance markets may have short-run effects on the economy.

Chapter 4

4.1 Introduction

The relationship between financial development and economic growth has received considerable attention. While almost all of these studies have focused on banking and stock market indicators, some studies, such as Ward and Zurbruegg's (2000), considered the relationship between the insurance market, which was categorized as non-money-issuing financial institutions by Goldsmith (1966), and economic growth. In addition, if there is any long-run relationship, it is also important to determine the direction of causality. If GDP growth causes insurance market development, there is no economic implication, as policies that ensure economic growth can expand the insurance industry. On the other hand, if insurance causes GDP growth, policies and regulations targeted at improving the operation and in-depth of the insurance market would also promote economic growth.

How financial development affects economic growth varies within a spectrum whose opposing ends range from a definite and certain positive effect on economic growth to little support for the view that finance is a leading sector in the process of economic development. We can mention Greenwood and Jovanovic's (1990), Bencivenga and Smith's (1991) and King and Levine's (1993) studies, which support the former opinion. Greenwood and Jovanovic's (1990) study implied that growth provided the wherewithal to develop the financial structure, whereas the financial structure in turn allowed for higher growth since investment could be undertaken more efficiently. The development of financial intermediation will increase real growth rates (Bencivenga & Smith, 1991). The predetermined component of financial development indicators significantly predicted the growth indicators for over 80 countries from 1960 through 1989 (King and Levine (1993)). Financial intermediaries exert a large, positive impact on total factor productivity growth, and that the long run links between financial intermediaries' development and both physical capital growth and private savings rates are tenuous (Beck *et al.*, 2000). On the other hand, some studies mentioned that this effect varied across countries and was strong in middle- and low-income countries (negative in Latin American countries) and relatively small in high-income countries (De Gregorio and Guidotti, 1995). Also, the evidence provided little support to the view that finance is a leading sector in the process of economic development, and the results were very much country specific. There cannot be wholesale acceptance of the view that finance leads growth, just as there cannot be wholesale acceptance of the view that finance follows growth (Demetrides and Hussein, 1996). Finally, Shan and Morris (2002) used a Granger non-causality test to investigate the relationship between financial development and economic growth for nineteen OECD countries and China. Little support was found for the hypothesis that finance leads growth.

In the previous chapter, we found a long-run relationship between development in insurance markets and economic growth for all components by using Johansen's λ_{Trace} and $\lambda_{\max}$ cointegration tests for the UK. Causality tests implied that there was at best weak support for the hypothesis that insurance development leads economic growth for the UK economy. In this chapter, we will try to address the nature of this relationship by further disaggregating the UK GDP into its sectoral components, to re-evaluate the long run relationship between insurance market development and economic growth. Insurance markets include long-term Insurance (life insurance and pension plans), and general insurance includes motor, accident and health cover, liability, property, pecuniary insurance, reinsurance and marine, aviation and transport (MAT). We consider all sectors in the UK economy, including Agriculture, Hunting, Forestry and Fishing, Manufacturing, Services, Mining and Quarrying, Construction and the Electricity, Gas and Water supply sectors. The first three sectors cover about 90% of the UK's GDP. In the case of the UK economy, agriculture and service sectors have the lowest and highest shares in GDP, respectively. Another feature of this study is to use a panel cointegration approach in addition to cointegration estimation.

In addition, the direction of causality will be tested. Section 4.2 reviews some facts about the UK's GDP components. In section 4.3, we consider some important Acts for insurance activities by the UK and European Community (EC). As we found weak evidence for the supply-leading pattern, in Section 4.4 we provide a model which captures both demand-following and supply-leading patterns. Then we describe the estimation framework. We test the variables to identify of the presence of a unit root. After that, the nature of the long run relationship between sectoral growth and insurance market size will be estimated by using a cointegration test. Then, we test whether insurance development causes sectoral growth, or vice versa, using the panel cointegration approach. Finally, the last section summarizes and concludes.

4.2 Trends in the UK's GDP

The United Kingdom's economy experienced a 2.4% annual average increase in real gross domestic product from 1966 until 2003. Although the annual growth rate of GDP was positive during the above period, evidence shows that the UK economy experienced negative growth rates in three periods including 1973–74, 1979–80 and 1990, in which oil shocks happened. It seems that Hamilton's (1983) proposition, which mentioned oil shocks as a contributing factor in at least some of the US recessions prior to 1972, is correct for the UK economy. Because it is not customary to express output data in money terms in output approaches (Curwen, 1994), we report a series of index numbers to compare the growth rate and position of each component.

In Table 4.1, we report the weight of each component in total output (GDP) out of 1000:

Table 4.1 - Weight in total output

	1970	1980	1990	2000
Agriculture, Forestry and Fishing	28.9	22	19	10.6
Mining and Quarrying	15.7	64	22	30.1
Manufacturing	324	266	237	181.3
Electricity, Gas and Water supply	32.4	31	22	19.2
Construction	64	63	72	54.2
Services	535	554	628	704.6

Each sub-category is assigned a proportion of the total weight according to the proportion of GDP. If we interpret the weight of each component as the degree of importance of that component in the economy, we can conclude that the service sector is the most important sector in the UK economy. This is not surprising, because the contribution of the service sector to GDP is more than that of the production sector in most developed countries. In 2000, after the service sector, the manufacturing sector had the biggest contribution in the formation of value-added in the UK economy. The ranks of construction, mining and quarrying, electricity, gas and water supply agriculture, forestry and fishing, and manufacturing were third, fourth, fifth, sixth, and second, respectively. Although the table shows that sectors have experienced fluctuations in their shares in total GDP, with the exception of the service sector and the mining and quarrying sector, all other sectors' shares have decreased since 1970.

4.3 Insurance regulations in the UK[13]

Governments have always had an interest in economic activities. The UK government's interest in the insurance industry has not been an exception. Protecting the public against insurance company failures, such as the failures that happened during the 1960s and 1970s, may be the most important reason for government legislation. We can summarise the government's

[13] For this section, we exploited the information provided by Merkin and Rodger (1997) and Holyoake (2002).

main provisions regarding the insurance industries in seven series of Acts that have been passed since the nineteenth century. The Life Assurance Companies Act 1870 obligated companies to make a deposit of £20,000 with the High Court before starting business. By the 1909 Act, fire, personal accident and bond investment were included in the supervision. From the 1909 Act until the 1940s, several new classes were introduced, causing the government to feel that a new series of regulations was needed. This new Act came into force in 1946 as the Assurance Companies Act 1946 by considering motor, aviation and transit insurance. In addition, the fact that liabilities exceeded assets for several insurance companies caused the deposit system that had been set up by the 1909 Act to be replaced by a new system which obliged companies to satisfy certain solvency requirements. These solvency requirements were measured in terms of solvency margins, which related to the amount by which assets were to exceed liabilities. The failure of some motor insurance companies during the 1960s caused the government to feel that a new series of regulations was needed. New rules came into force as the Companies Act 1967, which introduced new solvency margins as well as regulations for the authorization of insurers, management of companies, etc. A number of failures of insurance companies during the 1970s caused an increase in legislation and supervision of insurance companies. In addition, the UK's entry into the European Economic Community (EEC), which was intended to bring about some harmonization of European insurance legislation, was another reason for more regulations during the 1970s. Finally, we can say that the Insurance Companies Act 1982, which came into effect on 28 January 1983, contains a complete set of government regulations. It includes a wide range of orders for authorization, solvency, monitoring, intervention, the conduct of business and winding up. For authorization, it distinguishes between the UK, European and external companies, for which different requirements apply to each type. The solvency margin is determined by calculations based on premium basis or claims basis. The greater in each case is the base for determining the solvency margin. Solvency margins are monitored to guarantee whether standards are being maintained. The Financial Services Authority (FSA) can intervene when a company fails to observe the Act. Day-to-day aspects such as the prevention of misleading advertisements are considered in the conduct of business section. The FSA has the power to wind up the activity of insurance companies that fail to meet the terms of the Act.

In addition to internal legislation, the European Parliament has issued a number of directives in order to create a single insurance market for both life and non-life insurance for members of the European Community, from 1973 onwards. It seems that the main aim of these directives is to facilitate insurance companies' activities across the European Community (EC). For example, an insurance company that has its home state authorisation and wants to establish its activity in another EC country does not have to have the authorisation of the host country. This means that authorisation is only required for UK insurers and insurers which are located outside the European Environment Agency (EEA).

In addition to European Parliament legislation that attempts to provide a single market for insurance for the members of the EC, some Acts that have been passed by the UK to help to provide a more competitive market for insurance. For example, the Building Societies Act 1986 permits the setting up of insurance companies. Another example is the Competition Act 1998, which came into force on 1 March 2000. It introduces two main prohibitions:

1-Prohibition of anti-competitive agreements: the Act will prohibit agreements that have the object or the effect of preventing, restricting or distorting competition in the UK. Since anti-competitive behaviour between companies may occur without a clearly delineated agreement, the prohibition covers not only agreements but also decisions by associations of companies and concerted practices. There is an illustrative list of practices that would infringe the prohibition.

2-Prohibition of abuse of a dominant position in a market: the second prohibition introduced by the Act is the prohibition of abuse of a dominant position in the UK or in part of it, where this affects trade within the UK. Again there is an illustrative list of the kind of conducts which may constitute an abuse, such as limiting production, markets or technical development to the detriment of the consumer. Behaviour which infringes the prohibition will be unlawful and subject to penalties. The prohibition of abuse of a dominant market position will become the principal tool for dealing with anti-competitive conduct by monopolists. The monopoly provisions of the Fair Trading Act will, however, continue to have some value in the future, albeit in strictly limited circumstances.

4.4 Theoretical background

As the main contribution of this paper is empirical, we use econometric methods to analyse the relationship between insurance premiums and GDP for the UK. To establish our empirical strategy, we review some theoretical models that identify a relationship between economic development and risk diversification. In the previous chapter, we looked at Obstfeld's (1994) model, which provides a supply-leading pattern (insurance market development leads to GDP growth). However, our results in chapter 3 identify bilateral relationships between six out of nine insurance markets' development and GDP growth and just three supply-leading patterns. To overcome this problem, we will rely on Acemoglu and Zilibotti's (1997) theoretical model, where economic development provides better diversification opportunities, promoting further insurance market development. The more projects are open, the higher the proportion of savings that agents are willing to put into risky investments. In turn, when the capital stock of the economy is larger, there will be more savings, and more projects can be started. Therefore, development goes hand in hand with the expansion of markets, which provides better diversification opportunities (supply-leading and demand-following patterns co-exist). Nevertheless, this process is full of perils because with limited investments in imperfectly correlated projects, the economy is subject to considerable randomness and spends a long time fluctuating in the stage of low accumulated capital. Only economies that receive "lucky draws" will grow, whereas those are unfortunate enough to receive a series of "bad news" will stagnate. As lucky economies grow, the takeoff stage will be reached, and full diversification of idiosyncratic risks will be achieved.

The preferences of consumers over final goods are defined as:

$$E_t U(c_t, c_{t+1}) = \log(c_t) + \beta \int_0^1 \log(c_{t+1}^j) d_j \tag{4.1}$$

where j represents the two states of nature, which are assumed to be equally likely. Each agent discounts the future at the rate β and has a rate of relative risk aversion equal to one. Although the realization of the state of nature does not influence the productivity of the final-good sector, it affects consumption since it determines how much capital each agent takes into the final-good production stage and the equilibrium price of capital.

The output of the final-good sector is given by:

$$Y_t = AK_t^{\alpha} L_t^{1-\alpha} \tag{4.2}$$

The aggregate stock of capital depends on realization of the state of nature. If the state of nature is j, then $K_{t+1}^j = \int_{\Omega_t} (r\phi_{h,t} + RF_{h,t}^j) dh,$ where $F_{h,t}^j$ is the amount of saving invested by agent $h \in \Omega_t$ in sector j, $\phi_{h,t}$ is the amount invested in the safe asset, and Ω_t is the set of young agents at time t. Since both labour and capital trade in competitive markets, equilibrium factor prices in state j are given by:

$$W_{t+1}^j = (1-\alpha)A(K_{t+1}^j)^{\alpha} \equiv (1-\alpha)A\left[\int_{\Omega_t} (r\phi_{h,t} + rF_{h,t}^j) dh\right]^{\alpha} \tag{4.3}$$

and

$$\rho_{t+1}^j = \alpha A(K_{t+1}^j)^{\alpha-1} \equiv \alpha A\left[\int_{\Omega_t} (r\phi_{h,t} + rF_{h,t}^j) dh\right]^{\alpha-1} \tag{4.4}$$

The wage earning of a young agent conditional on realization of state j will then be $w_t^j = W_t^j / \alpha$.

Intermediate sector firms are run by agents who compete to get funds by issuing financial securities and selling them to other agents in the stock market. Each agent can run at most one project, although more than one agent can compete to run the same project.

Decisions are made in two stages. In the first stage, each agent $h \in \Omega_t$ takes the announcements of all other agents as given and announces his plan to run at most one project in the intermediate sector and sells an unlimited quantity of the associated basic arrow security. Securities are labelled by the indices of the project to which they are attached. The unit price of security j is denoted by $P_{j,h,t}$ and subscript h implies that the security is issued by agent h. In the second stage, all agents behave competitively, take as given the set of securities offered and the price of each security announced in the first period, and announce their saving s_t, their demand for the safe ϕ_t, and their demand for each security j, F_t^j. Therefore, optimal consumption, savings, and portfolio decisions can be characterized as the solutions to the following optimization program:

$$\max_{s_t, \phi_t, \{F_t^j\}_{0 \le j \le 1}} \log(c_t) + \beta \int_0^1 \log(c_{t+1}^j) d_j \tag{4.5}$$

subject to

$$\phi_t + \int_0^1 P_t^j(Z_t) F_t^j d_j = s_t \tag{4.6}$$

$$c_{t+1}^j = \rho_{t+1}^j (r\phi_t + RF_t^j) \tag{4.7}$$

$$F_t^j = 0 \;\forall\; j \notin J_t(Z_t) \tag{4.8}$$

and

$$c_t + s_t \le w_t + v_t \tag{4.9}$$

where $P_t^j(Z_t)$ is the minimum price at which security j is offered, ρ_{t+1}^j is the price of capital in state j, and v_t is the commission the agent obtains for running a project.

In the competitive equilibrium, all agents take prices as given and maximize their utility.

We start the characterization of equilibrium with two useful observations. First, because preferences are logarithmic, the following saving rule is obtained irrespective of the risk-return trade-off:

$$s_t^* \equiv s^*(w_t) = \frac{\beta}{1+\beta} w_t \qquad (4.10)$$

Given this result, an agent's optimization problem can be broken into two parts: the amount of saving is determined, and then an optimal portfolio is chosen. Second, free entry into the intermediate good sector implies that $v_{h,t} = 0$ for all *t, h*.

The problem of maximizing $\log \int_0^1 [\rho_{t+1}^j (r\phi_t + RF_t^j)] dj$ with respect to ϕ_t and $\{ F_t^j \}$ can be written as:

$$\max_{\phi_t, F_t} n_t [\log \int_0^1 [\rho_{t+1}^{(q_G)} (r\phi_t + RF_t) + (1-n_t) \log[\rho_{t+1}^{(q_B)} (r\phi_t)] \qquad (4.11)$$

subject to

$$\phi_t + nF_t = s_t^* \qquad (4.12)$$

where n_t and ρ_{t+1}^j are taken as parametric by the agent, and s_t^* is given by (4.10). The term $\rho_{t+1}^{(q_B)} = \alpha(r\phi_t)^{\alpha-1}$ is the marginal product of capital in the bad state, when the realized state is $j > n_t$ and no risky investment pays off;

$\rho_{t+1}^{(q_G)} = \alpha(RF_t + r\phi_t)^{\alpha-1}$ applies in the good state, that is, when the realized state is $j \le n_t$. Simple maximization gives:

$$\phi_t^* = \frac{(1-n_t)R}{R - rn_t} s_t^* \qquad (4.13)$$

and

$$F_t^{j*} = \begin{cases} F_t^* \equiv \dfrac{R-r}{R-rn_t} s_t^* & \forall \ j \le n_t \\ 0 & \forall \ j > n_t \end{cases} \qquad (4.14)$$

Demand for each asset grows as the measure of open projects increases because when more securities are available, the risk diversification opportunities improve and consumers become more willing to reduce their investments in the safe asset and increase their investment in risky projects.

Let us introduce an additional assumption, that is, $R \ge (2-\gamma)r$. The following proposition characterizes the static equilibrium conditional on K_t.

$$n_t^*(K_t) = \begin{cases} \dfrac{(R+r\gamma) - \left\{(R+r\gamma^2 - 4r\left[(R-r)(1-\gamma)\dfrac{\Gamma}{D}K_t^\alpha + \gamma R\right]\right\}^{1/2}}{2r} & if \ K_t \le \left(\dfrac{D}{\Gamma}\right)^{1/\alpha} \\ 1 & if \ K_t \succ \left(\dfrac{D}{\Gamma}\right)^{1/\alpha} \end{cases}$$

(4.15)

where $\Gamma \equiv A(1-\alpha)[\beta/(1+\beta)]$. There then exists a unique equilibrium such that, in the first stage, for all $h \in \Omega_t$, either $Z_{h,t}^* = \varnothing$ or $Z_{h,t}^* = (j,1)$, where $j \in [0, n_t^*]$; and for all $j \in [0, n_t^*]$, there exists $h \in \Omega_t$ such that $Z_{h,t}^* = (j,1)$. In the second stage,

$$s_t^* = \frac{\beta}{1+\beta}\frac{(1-\alpha)AK_t}{\alpha}$$

and ϕ_t^* and F_t^{j*} are given by (4.13) and (4.14). Factor returns are given by (4.3) and (4.4).

The above proposition characterizes the equilibrium allocation and prices for given K_t. From (4.3), (4.10), (4.13), and (4.14), this stochastic process is obtained as:

$$K_{t+1} = \begin{cases} \frac{r(1-n_t^*)}{R-rn_t^*} R\Gamma K_t^\alpha & prob.\, 1-n_t^* \\ R\Gamma K_t^\alpha & prob.\, n_t^* \end{cases} \tag{4.16}$$

where $n_t^* = n^*(K_t)$ is given by equation (4.15). The capital stock follows a Markov process in which the level of capital next period depends on whether the economy is lucky in the current period (which happens when the risky investments pay off, with probability n_t^*). As the economy develops, it can afford to open more sectors, and the probability of transferring a large capital stock to the next period, n_t^*, increases. Also from (4.16), the expected productivity of an economy depends on its level of development and diversification. To see this, define expected "total factor productivity" by:

$$\sigma^l(n^*(K_t)) = (1-n^*)\frac{r(1-n^*)}{R-rn^*}R + n^*R \tag{4.17}$$

To formalize the dynamics of development, we define the following concepts: (i) QSSB: the "quasi steady state" of an economy that always has unlucky draws. An economy would converge to this quasi steady state if it follows the optimal investment characterized above but the sectors invested never pay off because of bad luck. (ii) QSSG: the "quasi steady state" of an economy that always receives good news. The capital stocks of these two quasi steady states are:

$$K^{QSSB} = \left\{ \frac{r[1-n^*(K^{QSSB})]}{R - rn^*(K^{QSSB})} R\Gamma \right\}^{1/(1-\alpha)} \qquad (4.18)$$

$$K^{QSSG} = (R\Gamma)^{1/(1-\alpha)}$$

If uncertainty could be completely removed, that is $K^{QSSG} = 1$, then there would never be bad news, and the good quasi steady state would be a real steady state; a point, if reached, from which the economy would never depart. From equations (4.15) and (4.18), the condition for this steady state to exist is that the saving level corresponding to K^{QSSG} be sufficient to ensure a balanced portfolio of investments, of at least D, in all the intermediate sectors. Thus if

$$D \langle \Gamma^{1/(1-\alpha)} R^{\alpha/(1-\alpha)} \qquad (4.19)$$

a steady state will exist, which we denote by K^{SS}.

Next, note that at very low levels of capital, the Inada conditions of the production function guarantee positive growth even conditional on bad news. Then there is a range in which growth occurs conditional on only good draws. Although this level of capital is not a steady state, it is a point around which the economy will spend some time. When economies are below this level, they all grow toward it. When they are above this level, their output falls when they receive bad shocks, and the probability of bad news is very high when the economy has a level of capital stock just above K^{QSSB}. Yet, as good news are received, the capital stock will grow and the probability of a further lucky draw will increase. Note that even when it grows, the economy is still exposed to large undiversified risks and will typically experience some setbacks. Finally, provided that (4.19) is satisfied, the economy will eventually enter a region where all idiosyncratic risks will be removed (since all projects are open and an equal amount is invested in all projects), and there will be deterministic convergence to K^{SS}.

In Acemoglu and Zilibotti's (1997) model, causality operates in both directions. However, there are considerably fewer theoretical models on the demand-following pattern. Berthelemy and Varoudakis (1996) convincingly argue that there are good reasons to believe that causality also runs from per capita income to development of financial structures (demand-following pattern). They use an endogenous growth model in which learning by doing externalities in the real sector form the source of long-run growth. In their model, they assume that the financial sector (banks) directs savings towards more productive investments and technical efficiency of the financial sector is an increasing function of the collected volume of savings. Consequently, the real sector has a sort of positive external effect on the financial sector via the volume of savings. We believe their model can provide an explanation for the demand-following pattern because economic growth followed by an increase in savings promotes the development of the financial sector. In addition, Imbs and Wacziarg (2003) use sectoral data, including financial institutions and insurance, for different countries and show that economies grow through two stages of diversification. At first, sectoral diversification increases, but there exists a level of per capita income beyond which the sectoral distribution of economic activity starts concentrating again and theories for diversification or concentration seems to be at play at different points of the development process. Briefly, based on the above study, it seems that diversification follows economic growth, which can be interpreted as a demand-following pattern during the development process.

Unfortunately, there is no unique theoretical model to cover all possible patterns for the relationship between financial development and economic growth. Consequently, Obstfeld's (1994) model is used as a theoretical background for the supply-leading pattern, while Acemoglu and Zilibotti's (1997) and Berthelemy and Varoudakis' (1996) models explain both bilateral relationships and demand-following patterns, respectively.

4.5 Estimation framework

We follow the same empirical methodology as in Chapter 3. First, we check the order of cointegration of the variables by using unit root tests. Second, we test for cointegration as proposed by Johansen (1988). Then Demetriades and Hussein's (1996) and Arestis and Demetriades's (1997) approaches are used for causality testing. We also compute the strength of causality by using the Granger and Lin (1995) approach. In addition, we test for possible inclusion of the exogenous variables that were mentioned in the previous chapter. Also, a set of dummy variables are included in the models, including one for each of the three oil shocks. Finally, we use panel unit root and cointegration tests. To do this, we test the stationarity of the data. It is generally accepted that unit root tests, such as the tests that have been commonly used suffer from lack of power in distinguishing the unit root null from stationary alternatives (Maddala and Wu, 1999). One way of increasing the power of unit root tests based on a single time series is to use panel data unit root tests. Caporale and Cerrato (2006) critically reviewed some panel unit root tests:

Generally, panel unit root tests have higher power relative to single unit root tests. They may reduce the problem of multicollinearity, they are more informative about long-run behaviour than time series, and they may alleviate spurious regression problems. However, they are not a panacea and some issues should be considered when we use these tests. The first problem is that in many cases the asymptotic distribution is derived under the assumption that the error terms are not cross-correlated. However, this assumption is often violated, and therefore the tests are not valid.

Pesaran (2004) develops a simple general test of cross-sectional dependence of errors in linear panel data models. The test overcomes the problems that its alternative tests, including testing for spatial correlation pioneered by Moran (1948) and the Lagrange multiplier approach of Breusch and Pagan (1980), suffer from. While spatial correlation tests depend on the choice of spatial matrix, the Lagrange multiplier test is valid for *N* relatively small and *T* sufficiently large. Even scaled versions of the Lagrange multiplier test (applicable for large *N* and *T*) exhibit substantial size distortions for *N* large and *T* small. In addition, the test is applicable in a variety of contexts, including dynamic heterogeneous panels with (possibly) multiple breaks and unit roots, unbalanced panels, as well as for spatial panels. To solve the cross-sectional dependence problem, Maddala and Wu (1999) proposed to bootstrap distributions to draw statistical inference. Another solution is to use the GLS-based corrections proposed by Pedroni (1997).

Another problem is that in many of these tests homogeneity across sectional units is assumed. Im *et al.* (1997) and Pedroni (1999) remove this problem by allowing for heterogeneity across the sectional units. Finally, many of these tests do not allow for multiple cointegrating vectors, a question addressed by Larsson *et al.* (2001) in the context of panel cointegration methods.

Here, we consider five panel unit root tests and review their advantages and disadvantages by using Caporale and Cerrato (2006) study. A first test is proposed by Levine and Lin (1993) (for simplicity, LL test) which have been widely used in the literature. This test allows for fixed effects, unit-specific time trends, and common time effects. However, it restricts the speed of convergence to long-run equilibrium under the alternative of stationarity to be the same for all countries, and assumes that the errors are independent across the units. In addition, the test requires that the data are generated independently across individuals which can be relaxed by subtracting the cross-sectional average from observed data. In a modified version of this test (LL2), the assumption of no serial correlation can be relaxed.

A characteristic which distinguishes Im *et al.* (1997) from Levine and Lin (1993) is that the former allows the speed of convergence to long-run equilibrium under the alternative of stationarity to vary across countries. In addition, instead of pooling the data, one can perform separate unit root tests for the *N* cross-section units. Another important feature of the test is to adjust the statistic for the cross-section across units. Disadvantages include low power for a small time-series dimension in each group, and compared to the LL2 test, it is very sensitive to the order of the underlying ADF regressions. Karlsson and Lothgren (2000) showed that the power of the above tests depends on *N*, the number of series in the panel, *T*, the time series dimension in each individual series, and on the proportion of stationary series in the panel. For example, the probability of rejecting the null hypothesis increases with *T*. It means for large *T*, one may reject the null even if it is true and for small *T*, vice versa.

Bai and Ng (2004) use a decomposition method to construct panel unit root tests. The tests are applied to two unobserved components of the data, one with the characteristic that is strongly correlated with available series (common factors), and one with the characteristic that is largely unit specific (idiosyncratic errors). They show that common factors can be consistently estimated irrespective of the stationarity property of the idiosyncratic errors. In addition, common factors and idiosyncratic errors can be integrated of different orders. They use KPSS and modified Sargan and Bhargava (1983) tests on the estimated of above elements. Their tests are robust to cross-sectional dependence. However, The KPSS test rejects the stationarity null hypothesis too often. The modified Sargan and Bhargava (MSB) test has good size and power properties when it is used to test the components separately.

Taylor and Sarno (1998) criticized panel unit root tests arguing that they have a high probability of rejecting the null hypothesis of joint non-stationarity when just one series in the panel is mean reverting (for exchange rates). They suggest an alternative multivariate unit root test, where the null hypothesis is rejected only if all the series are generated by mean reverting process. The weakness of the test is that it is reliable only when applied to a panel with small cross-sectional dimension.

Maddala and Wu (1999) suggest the test developed by Fisher (1932). This test uses a decomposition method to construct a panel unit root test, and similarly to the Im *et al.* (1997) test, allows for heterogeneity of the root across units. However, the test is more powerful than the Im *et al.* (1997) test and tries to overcome some of the Im *et al.* (1997) test difficulties, such as the requirement of a balanced or complete panel, and allowing for a limited amount of cross-correlation across units through common time effects, which is unlikely to take this simple form. Again, like Im *et al.* (1997) test, it suffers from cross-sectional dependence. Maddala and Wu (1999) suggest using bootstrap methods to obtain its empirical distribution. Caporale and Cerrato (2006) conclude that the Maddala and Wu (1999) and Im *et al.*(1997) tests are to be preferred as they allow for heterogeneity under the alternative of stationarity and also, cross-sectional dependence is taken into account by using two alternative methods, i.e. demeaning procedure and non-parametric bootstrap.

Maddala and Wu (1999) review three panel data unit root tests in their study, including the LL test (Levin-Lin (1993)), the IPS test (Im *et al.* (1997)) and Fisher's test (1932), and give their comments as described below:

A. The LL tests test a very restrictive hypothesis that is rarely of practical interest.

B. The IPS test (is claimed to be a generalization of the LL tests. However, it is better viewed as a way of combining the evidence of several independent unit root tests.

C. The Im *et al.* (1997) study compares power of the LL and IPS tests and argues that the IPS test is more powerful than the LL test. However, strictly speaking, the power comparison is not valid. Although the null hypothesis is the same in the two tests, the alternative hypothesis is different. The LL tests are based on homogeneity of the autoregressive parameter (although there is heterogeneity in the error variance and the serial correlation structure of the errors). Thus the tests are based on pooled regressions. The IPS test, on the other hand, is based on heterogeneity of the autoregressive parameter. As argued earlier, the test amounts to a combination of different independent tests. There is no pooling of the data involved as in the LL tests.

D. The Fisher test and the IPS test are directly comparable. The aim of both tests is a combination of the significance of different independent tests. The Fisher test is non-parametric; whatever test statistic we use for testing for a unit root for each sample, we can get the p-values Π_i and then $-2\sum \log_e \Pi_i \approx \chi^2$ with *2N* d.f., where N is the number of separate samples. The IPS test, on the other hand, is parametric. The distribution of the t-bar statistic involves the mean and variance of the t-statistics used. IPS computes this for the ADF test statistic for different values of the number lags used and different sample sizes. However, these tables are valid only if the ADF test is used for the unit root tests. Also, if the length of the time series for the different samples is different, there is a problem using the tables prepared by IPS. The Fisher test does not have any such limitations. It can be used with any unit root test, and even if the ADF test is used, the choice of the lag length for each sample can be separately determined. Also, there is no restriction of the sample sizes for different samples (they can vary according to the availability of the data).

E. The Fisher test is an exact test. The IPS test is an asymptotic test. Note that this does not lead to a huge difference in finite sample results, since the adjustment terms in the IPS test are derived from simulations, while p-values in the Fisher test are also derived from simulations. However, the asymptotic validity of the tests depends on different conditions. For the IPS test the asymptotic results depend on N going to infinity while for the Fisher test they depend on T going to infinity.

F. The crucial element that distinguishes the two tests is that the Fisher test is based on combining the significance levels of the different tests, and the IPS test is based on combining the test significance. Which is better is the question.

G. Both the Fisher test and IPS test are based on combining independent tests. So if there is contemporaneous correlation, then there are correlations among the individual test statistics. Both tests will need modifications in this case.

Monte Carlo simulations were used in their study. They concluded that the Fisher test was simple and straightforward to use and was a better test than the LL and IPS tests. Some other conservative tests (applicable in the case of correlated tests) based on Bonferroni bounds have also been found to be inferior to the Fisher test. After considering the reasons mentioned above, we use Fisher's test in our study. For obtaining p-values we use results from ADF and PP tests.

After looking at some panel unit root tests, here we consider panel cointegration tests. There are two main approaches about panel cointegration tests: based on the null hypothesis of cointegration and based on the null of no cointegration. McCoskey and Kao (1998) test is based on the first approach. The test proposes a residual-based Lagrange Multiplier to deal with the nuisance parameters issue in a single equation model. The model allows for different slopes and intercepts, and the regressors are assumed to be endogenous, but not cointegrated. They used the dynamic OLS estimator (DOLS) and the fully modified OLS estimator (FMOLS). The asymptotic distribution is free of nuisance parameters (when the test uses DOLS to construct LM) and the test seems to be robust to heteroscedasticity. McCoskey and Kao (1998) used Monte Carlo methods and found the tests performed better, in terms of power, for a large T. Also, when N and T are very close, and there is a negative moving average, the LM-DOLS test had higher power compared to the LM-FM.

Pedroni's (1997,1999) test is based on the second approach and allows for considerable heterogeneity in the panel. He assumes a heterogeneous slope coefficient, fixed effects and individual specific deterministic trends and constructs seven different panel cointegration tests. Also, he assumes the idiosyncratic error terms to be independent across individual members of the panel, and proposes a GLS-based correction to allow for feedback across individual members of the panel. He performs Monte Carlo simulations to study the small sample (power and size) properties of the seven statistics. He finds that the size distortions for all proposed panel cointegration statistics are small, provided that there is not a negative moving average component in Data Generating Process (DGP). In terms of size distortions, the panel-rho statistics seem to exhibit the least distortions among the seven statistics. In terms of power, the group ADF does very well, followed by the panel ADF and panel-rho. The above tests are residual-based, and do not allow for the possibility of multiple cointegrating vectors. However, Larsson *et al.* (2001) address this issue, and propose a likelihood-based test of the cointegrating rank in heterogeneous panels.

Pedroni (1997,1999) assumes that there is no cross-sectional dependency between error terms. Bai and NG (2004) remove this problem by testing on unobserved idiosyncratic errors instead of testing observed data. In addition, Bai and Kao (2005) use a factor model to characterize cross-sectional dependence for panel cointegration tests. To model the cross-sectional dependence, they assume the error term follows a factor model (e.g., Bai and Ng (2004)). They propose a continuous-updated fully modified (CUP-FM) estimator that is constructed by estimating parameters and long-run covariance matrix and loading recursively. They also compare for the finite sample properties of the OLS, two-step fully modified (2S-FM), and CUP-FM estimators. They found that the first and second estimators had non-negligible bias in finite samples, and that the CUP-FM estimator improved over them.

For the panel cointegration test, we use Pedroni's (2004) approach. In earlier working paper versions of this paper, he examined the properties of spurious regressions and residual-based tests for the null hypothesis of no cointegration for both homogeneous and heterogeneous panels, and studied special conditions under which tests for the null hypothesis of no cointegration with homogeneous slope coefficients are asymptotically equivalent to raw panel unit root tests. In the last version he focused on the most general of these results, namely, the tests for the null hypothesis of no cointegration for panels with heterogeneous dynamics and heterogeneous slope coefficients. In particular, he considered both between-dimension and within-dimension residual-based test statistics. Each of these tests is able to accommodate individual specific short-run dynamics and individual specific fixed effects and deterministic trends, as well as individual specific slope coefficients. He derived limiting distributions for these under the null and showed that each follows a standard normal and is free of nuisance parameters.

In its most general form, the following type of regression is considered:

$$y_{it} = \alpha_i + \delta_i t + \beta_i X_{it} + e_{it} \tag{4.20}$$

for a time series panel of observables y_{it} and X_{it} for members $i = 1,\dots,N$ over time periods $t = 1,\dots,T$, where X_{it} is an m-dimensional column vector for each member i and β_i is an m-dimensional row vector for each member i. The variables y_{it} and X_{it} are assumed to be integrated of order one, denoted I(1), for each member i of the panel, and under the null of no cointegration the residual e_{it} will also be I(1). The parameters α_i and δ_i allow for the possibility of member-specific fixed effects and deterministic trends, respectively. The slope coefficients β_i are also permitted to vary by individual, so that in general the cointegrating vectors may be heterogeneous across members of the panel.

We use $Z_{\hat{\rho}_{NT^{-1}}}$ (panel-rho) and $Z_{\hat{t}_{NT}}$ (panel-*t*) statistics which are estimated as below:

$$Z_{\hat{\rho}_{NT^{-1}}} = (\sum_{i=1}^{N} A_{22i})^{-1} \sum_{i=1}^{N} (A_{21i} - T\hat{\lambda}_i) \tag{4.21}$$

$$t_{\hat{t}_{NT}} = (\tilde{\sigma}^2_{NT} \sum_{i=1}^{N} A_{22i})^{-1/2} \sum_{i=1}^{N} (A_{21i} - T\hat{\lambda}_i) \tag{4.22}$$

Where:

$$\tilde{e}_{it} = (\Delta\hat{e}_{it}, \hat{e}_{it-1})', \quad A_i = \sum_{i=1}^{T} \tilde{e}_{it}\tilde{e}'_{it}, \quad \hat{\mu}_{it} = \hat{e}_{it} - \hat{\rho}_i \hat{e}_{it-1}, \quad \hat{\lambda}_i = T^{-1}\sum_{s=1}^{K} w_{sk} \sum_{t=s+1}^{T} \hat{\mu}_{it}\hat{\mu}_{i,t-s}$$

$$w_{sk} = 1 - s/(1-K),\ \hat{s}_i^2 = T^{-1}\sum_{t=2}^{T} \hat{\mu}^2_{it},\ \hat{\sigma}_i^2 = \hat{s}_i^2 + 2\hat{\lambda}_i,\ \hat{\sigma}_{NT}^2 = N^{-1}\sum_{i=1}^{N}\hat{\sigma}_i^2$$

For regressions of the form given above, we will be interested in studying the properties of tests for the null hypothesis: "all of the individuals of the panel are not cointegrated." For the alternative hypothesis, it is worth noting that if the underlying DGP is assumed to require that all individuals of the panel be either uniformly cointegrated or uniformly not cointegrated, then the natural interpretation for the alternative hypothesis is simply: "all of the individuals are cointegrated." On the other hand, if the underlying DGP is assumed to permit individual members of the panel to differ in whether or not they are cointegrated, then the natural interpretation for the alternative hypothesis should be: "a significant portion of the individuals are cointegrated."

4.6 Empirical results

We investigated the hypothesis of non-stationary data by using three tests, mentioned in the previous section. For the level of variables, the number of lags is determined by using Ng and Perron's (1995) suggestion, Ng and Perron's MIC criterion (2001), and Newey and West (1994) for augmented Dickey-Fuller, DF-GLS and Phillips and Perron (1988) unit root tests, respectively.

The results for unit root tests are reported in Tables 4.2 and 4.3. The null hypothesis of a unit root on the levels of the variables cannot be rejected in almost all cases. The only exception is liability insurance. In this case, ADF and DF-GLS tests show that we can reject the null hypothesis of unit root at 5%, but another test (PP) implies that we cannot reject it. The evidence in Table 4.3, which shows tests for unit root test on the first difference of variables, suggests that variables are best characterized as being integrated of order one. This table shows that at least two out of three tests imply that we can reject the null hypothesis of a unit root. The only exception is reinsurance premiums, which is stationary based on PP test and non-stationary based on ADF and DF-GLS tests.

Table 4.2- Unit root test on levels

Variable	Period	ADF	DF-GLS	PP
Agricultural GDP	1966-2003	-1.93(0)	-1.29(1)	-1.97
Manufacturing GDP	1966-2003	-3.06(1)	-2.69(2)	-2.27
Service GDP	1966-2003	-2.15(1)	-2.38(1)	-1.78
Mining and Quarrying GDP	1966-2003	-2.96(4)	-1.54(1)	-1.48
Construction GDP	1966-2003	-4.16**(5)	-2.54(2)	-2.23
Electricity, Gas and Water supply GDP	1966-2003	-1.67(0)	-1.08(1)	-1.39
Life insurance-Yearly	1966-2003	-3.185(5)	-2.073(1)	-1.573
Life insurance-Single	1966-2003	-3.036(2)	-1.746(1)	-2.671
Motor insurance	1971-2003	-2.298(5)	-1.73 (2)	-2.3
Accident and health	1971-2003	-1.058(0)	-0.76(1)	-1.02
Property insurance	1971-2003	-1.639 (1)	-0.84(2)	-1.29
Liability insurance	1971-2003	-3.727**(1)	-3.45**(1)	-2.47
Pecuniary loss insurance	1971-2003	-1.623(0)	-2.84(1)	-1.79
Reinsurance	1971-1997	-0.5601(3)	-0.467(1)	0.069
Marine-Aviation-Transport	1971-1997	-3.213(0)	-1.409(2)	-3.173

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of the autoregressive polynomial is in parenthesis. Lag length selection as suggested by Ng and Perron (1995), Ng and Perron's MAIC criterion (2001) and Newey and West (1994) for augmented Dickey-Fuller, ADF-GLS and Phillips and Perron unit root test, respectively.All regressions include a constant and linear time trend.

Table 4.3- Unit root test on differences

Variable	Period	ADF Ng perron	DF-GLS MIC	PP
Agricultural GDP	1966-2003	-7.15***(0)	-2.31**(2)	-7.1***
Manufacturing GDP	1966-2003	-4.693***(0)	-3.7***(1)	-4.6***
Service GDP	1966-2003	-2.72*(5)	-2.17** (2)	-3.82***
Mining and Quarrying GDP	1966-2003	-4.25***(0)	-1.7*(3)	-4.31***
Construction GDP	1966-2003	-4.32***(1)	-1.65*(4)	-3.12**
Electricity, Gas and Water supply GDP	1966-2003	-5.28***(1)	-0.31(6)	-7.08***
Life insurance-Yearly	1966-2003	-3.881***(0)	-1.243(4)	-4.035***
Life insurance-Single	1966-2003	-6.77****(0)	-3.555***(1)	-6.786***
Motor insurance	1971-2003	-4.66***(1)	-0.939(6)	-3.294**
Accident and health	1971-2003	-5.58***(0)	-1.465(3)	-5.587***
Property insurance	1971-2003	-4.372***(1)	-0.73(6)	-3.4893**
Liability insurance	1971-2003	-4.351***(5)	-1.162(7)	-3.343**
Pecuniary loss insurance	1971-2003	-4.554***(0)	-2.279**(1)	-4.574***
Reinsurance	1971-1997	-1.073(2)	-1.219(2)	-4.718***
Marine-Aviation-Transport	1971-1997	-5.596*** (1)	-2.579**(2)	-7.875***

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of the autoregressive polynomial is in parenthesis. Lag length selection as suggested by Ng and Perron (1995), Ng and Perron's MIC criterion (2001) and Newey and West (1994) for augmented Dickey-Fuller, ADF-GLS and Phillips and Perron unit root test, respectively.

By considering that all of the variables are best characterized as being integrated of order one, we evaluated the long-run relationship between components of insurance premiums and GDP. For this reason, we used Johansen's (1988) procedure to find whether there exists a cointegration vector. Table 4.4 reports the cointegration test results for each insurance market and components of GDP.

Table 4.4 – Johansen's λ_{Trace} cointegration tests between economic sectors and insurance premiums

Variable	Agriculture	Manufacturing	Service	Mining-Quarrying	Construction	Electricity Gas Water
Life insurance-Yearly	18.51***(2)	32.34***(4)	31.02***(4)	31.63***(1)	9.88(3)	15.86(4)
Life insurance-Single	11.68(1)	13.7*(1)	42.41***(5)	29.83***(4)	16.96(4)	8.61(3)
Motor insurance	25.92***(2)	78.36***(2)	24.16***(4)	19.69**(2)	22.7***(3)	25.48***(2)
Accident and health	57.03***(1)	24.77***(5)	98.21***(4)	64.75***(1)	61.2***(2)	59.23***(1)
Property insurance	23.91***(1)	15.41**(2)	13.53*(2)	16.43(1)	19.94**(2)	18.06**(2)
Liability insurance	17.34**(2)	22.25***(2)	19.61**(2)	18.95**(2)	40.94***(5)	19.5**(2)
Pecuniary loss insurance	53.69***(1)	61.19***(4)	69.92***(4)	59.34***(1)	56.97***(5)	50.53***(1)
Reinsurance	30.26***(3)	60.44***(5)	28.27***(2)	27.15***(1)	60.61***(5)	37.22***(1)
Marine-Aviation-Transport	20.55***(4)	7.2(1)	20.17***(4)	25.88***(4)	38.95***(2)	25.56***(1)

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of the autoregressive polynomial is in parenthesis. Lag length selection as suggested by Ng and Perron (1995). Critical values are taken from Osterwald-Lenum (1992).

We summarise the results for each sector below:

Agriculture: Long-run relationship between yearly life insurance, motor, accident and health, property, pecuniary loss, MAT insurance, reinsurance and agriculture GDP has been confirmed at 1% significance level. This relationship is significant at the 5% level for liability insurance. There is no long-run relationship for single life insurance markets and GDP.

Manufacturing: Again, there is evidence in favour of rejection of no long-run relationship and in favour of cointegration for life insurance. For yearly premiums, this relationship is confirmed at the 1% level, but for single premiums the significance level is 10%. For motor, accident and health, liability, pecuniary loss insurance and reinsurance, the significance level is 1%, whereas it is 5% for property insurance. The null hypothesis of no long-run relationship for MAT insurance and GDP cannot be rejected.

Services: Results show a much more powerful long-run relationship between insurance markets and the services sector than for other economic sectors. The long-run relationship is significant at the 1% level for seven out of nine markets, including life insurance (both yearly and single premiums), motor, accident and health, pecuniary loss, MAT insurance and reinsurance. The significance level is 5% for liability insurance and 10% for property insurance and reinsurance. This sector is the only sector which has a long-run relationship with all components of the insurance market.

Mining and Quarrying: Based on the results, we can see evidence in favour of rejection of no long-run relationship and in favour of cointegration at the 1% level for life insurance (both yearly and single premiums), accident and health, pecuniary loss, MAT insurance and reinsurance. The significance level is 5% for motor and liability insurance. We cannot reject the null hypothesis of no long-run relationship for property insurance and GDP.

Construction: Unlike the other sectors mentioned above, we cannot reject the null hypothesis of no long-run relationship between this sector's GDP and both life insurance markets. A long-run relationship exists at the 1% level for motor, accident and health, liability, pecuniary loss, MAT insurance and reinsurance, and at 5% for property insurance.

Electricity, Gas and Water: Again, like the construction sector, the results indicate no long-run relationship between life insurance (both yearly and single premiums) and this sector's GDP. Long-run relationships between motor, accident and health, pecuniary loss, MAT, reinsurance and MAT insurance and electricity, gas and water GDP are significant at 1%. This relationship is significant at the 5% level for property and liability.

In Tables 4.5 to 4.10, we report one *F*-test and one *t*-test relating to the exclusion of relevant variables from ECM for the null hypothesis of no causal relationship for short-run and long-run respectively. We do not report test results for long-run relationships in the ECM model for components of insurance which have no long-run relationship with economic sectors based on cointegration tests. We summarise the results for each sector below:

Agriculture sector:

Short run: Agriculture GDP causes motor and MAT insurance, and accident and health insurance causes agriculture GDP.

Long run: There is one bilateral causal relationship between accident and health and agriculture GDP. In addition, this sector has a causal relationship with three insurance markets: liability, pecuniary loss and MAT insurance. However, two insurance markets have causal relationships with GDP, including motor insurance and reinsurance. Considering the fact that Granger and Lin's (1995) measure for the case of bilateral relationship is much larger when the relationship is from GDP to insurance market than the other way, and also that significance levels are 10% when two insurance markets cause GDP, we conclude that the relationship under scrutiny presents a demand-following pattern for this sector.

Table 4.5 – Causality test between Agricultural sector and insurance premiums

Variable	GDP does not cause Insurance premium		Insurance premium does not cause GDP	
	Short-Run	Long-Run	Short-Run	Long-Run
	$\gamma_{12}(L)=0$	$\alpha_1=0$	$\gamma_{21}(L)=0$	$\alpha_2=0$
	$F(k,n)$	$t(n)$	$F(k,n)$	$t(n)$
Life insurance-Yearly	1.1	0.26	1.2	1.39
		0.1		0.026
Life insurance-Single	0.7	-	1.35	-
Motor insurance	3.5**	1.62	0.5	1.87*
		0.13		0.47
Accident and health	0.18	2.91***	4*	3.28***
		1.63		0.005
Property insurance	0.3	1.38	0.15	3.41***
		0.11		0.57
Liability insurance	0.63	3.41***	0.57	1.56
		0.38		0.24
Pecuniary loss insurance	0.03	2.82***	1.38	1.32
		0.67		0.09
Reinsurance	0.93	0.32	0.53	1.96*
		0.45		0.51
Marine-Aviation-Transport	4.53**	2.23**	0.91	0.49
		1.29		0.001

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of VAR and sample periods as indicated in table three. The values on the first lines are F-statistic.

The values on the second line for long-run columns are strength of causality (Granger and Lin, 1995).

Manufacturing sector:

Short run: Pecuniary loss insurance and reinsurance have causal relationships with manufacturing GDP in the short run. The results imply a bilateral causal relationship between accident and health insurance and the manufacturing sector.

Long run: Results indicate five one-way long-run causal relationships, including from manufacturing GDP to life insurance (both yearly and single premiums), motor, liability and reinsurance, which all are significant at least at the 5% level. Three bilateral long-run causal relationships exist between manufacturing GDP and property accident and health and pecuniary loss insurance. In one case (accident and health insurance), Granger and Lin's (1995) measure is almost equal. For the rest, this measure is larger when manufacturing has a causal relationship with the insurance market. Again, it seems that also for this sector, a demand-following pattern is present.

Table 4.6 – Causality test between Manufacturing sector and insurance premiums

Variable	GDP does not cause insurance premium		Insurance premium does not cause GDP	
	Short-Run	Long-Run	Short-Run	Long-Run
	$\gamma_{12}(L)=0$	$\alpha_1=0$	$\gamma_{21}(L)=0$	$\alpha_2=0$
	$F(k,n)$	$t(n)$	$F(k,n)$	$t(n)$
Life insurance-Yearly	1.43	1.9*	0.68	0.03
		0.15		0.0003
Life insurance-Single	0.09	2.22**	0.82	0.06
		3.42		0.00005
Motor insurance	0.07	2.14**	2.17	1.7
		1.44		0.001
Accident and health	2.66*	2.19**	6.71***	3.65***
		1.62		1.61
Property insurance	0.89	2.12**	0.14	2.45**
		0.9		0.72
Liability insurance	1.5	2.56**	0.74	0.97
		2.37		0.006
Pecuniary loss insurance	0.84	3.01***	9.5***	2.46**
		0.32		0.0006
Reinsurance	0.94	3.6***	5.94**	0.38
		0.26		0.0004
Marine-Aviation-Transport	0.59	-	1	-

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of VAR and sample periods as indicated in table three. The values on the first lines are F-statistic.

Services sector:

Short run: This sector has a causal relationship with motor insurance, while pecuniary loss insurance has a causal relationship with the service sector. There is evidence in favour of bilateral causal relationships between life insurance (both yearly and single premiums), accident and health insurance and services GDP.

Long run: Results show six bilateral causal relationships in the long run. In four out of six bilateral relationships, Granger and Lin's (1995) measure of strength of causality is much larger when the services sector has a causal relationship with insurance markets. In addition, there is a two one-way causal long-run relationship from services GDP to property and liability insurance and one one-way causal relationship from yearly life insurance to services GDP. The evidence implies that the pattern in this sector is also more likely to be demand-following than supply-leading.

Table 4.7 – Causality test between Service sector and insurance premiums

Variable	GDP does not cause insurance premium		Insurance premium does not cause GDP	
	Short-Run	Long-Run	Short-Run	Long-Run
	$\gamma_{12}(L) = 0$	$\alpha_1 = 0$	$\gamma_{21}(L) = 0$	$\alpha_2 = 0$
	$F(k,n)$	$t(n)$	$F(k,n)$	$t(n)$
Life insurance-Yearly	2.27*	1.02	6.8***	5.25***
		0.54		0.25
Life insurance-Single	3.21**	3.46***	3.46**	3.28***
		1.45		0.01
Motor insurance	7.1***	3.43**	1.79	2.56**
		0.04		1.8
Accident and health	8.3***	6.71***	4.4**	3.15***
		0.9		0.008
Property insurance	0.28	2.33**	0.27	1.71
		0.7		0.12
Liability insurance	0.06	3.37***	0.1	0.79
		2.31		2.26
Pecuniary loss insurance	0.65	2.63**	4.8***	1.92*
		0.96		0.3
Reinsurance	0.32	1.92*	0.17	2.36**
		0.85		0.008
Marine-Aviation-Transport	2.14	2.33**	0.5	1.9*
		0.11		0.47

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of VAR and sample periods as indicated in table three. The values on the first lines are F-statistic.

Mining and Quarrying sector:

Short run: This sector has a causal relationship with life insurance single premiums and MAT insurance, while life insurance yearly premiums, property and reinsurance markets have causal relationships with this sector in the short run.

Long run: There are five one-way causal long-run relationships from mining and quarrying GDP to life insurance single premiums, motor, accident and health, liability insurance and reinsurance, and just one causal relationship from life insurance yearly premiums to this sector. In the case of bilateral relationships (two cases), Granger and Lin's (1995) measure is almost zero when insurance markets have causal relationships with this sector. By considering all the evidence, we conclude that the pattern in this sector is also a demand-following one.

Table 4.8 – Causality test between Mining and Quarrying sector and insurance premiums

Variable	GDP does not cause insurance premium		Insurance premium does not cause GDP	
	Short-Run	Long-Run	Short-Run	Long-Run
	$\gamma_{12}(L)=0$	$\alpha_1=0$	$\gamma_{21}(L)=0$	$\alpha_2=0$
	$F(k,n)$	$t(n)$	$F(k,n)$	$t(n)$
Life insurance-Yearly	0.24	0.94	3.26***	5.38***
		0.63		.02
Life insurance-Single	4.65***	4.96***	1.89	0.57
		0.7		0.08
Motor insurance	0.65	2.03*	0.15	0.78
		0.1		0.28
Accident and health	1.13	3.07***	0.88	0.94
		0.95		0.11
Property insurance	0.4	-	2.09**	-
Liability insurance	1.15	3.3***	0.74	0.72
		0.12		0.24
Pecuniary loss insurance	1.16	2.96**	0.67	1.87*
		0.17		0.09
Reinsurance	1.54	2.95**	2.16**	0.47
		1.38		0.05
Marine-Aviation-Transport	6.87***	3.88***	2.4	2.32**
		1.04		0.06

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of VAR and sample periods as indicated in table three. The values on the first lines are F-statistic.

Construction sector:

Short run: This sector has a causal relationship with life insurance yearly premiums and liability insurance, while motor insurance has a causal relationship with this sector in the short run.

Long run: There are four bilateral causal long-run relationships. In all cases Granger and Lin's (1995) measure is bigger for construction. In addition, the construction sector has a causal relationship with liability insurance, while reinsurance has a causal relationship with construction GDP (with Granger and Lin's (1995) measure almost equal to zero) in the long run. Again, it seems that the insurance market pattern in this sector is more likely to be demand-following than supply-leading.

Table 4.9 – Causality test between Construction sector and insurance premiums

Variable	GDP does not cause insurance premium		Insurance premium does not cause GDP	
	Short-Run	Long-Run	Short-Run	Long-Run
	$\gamma_{12}(L)=0$	$\alpha_1=0$	$\gamma_{21}(L)=0$	$\alpha_2=0$
	$F(k,n)$	$t(n)$	$F(k,n)$	$t(n)$
Life insurance-Yearly	5.68***	-	1.96	-
Life insurance-Single	1.29	-	1.01	-
Motor insurance	1.6	2.09**	4.9**	3.94***
		2.26		0.1
Accident and health	1.33	2.33**	0.55	1.84*
		1.25		0.004
Property insurance	0.36	2.11**	1.39	2.46**
		2.87		0.03
Liability insurance	4.59***	5.4***	1.06	0.96
		0.36		0.3
Pecuniary loss insurance	0.65	2.56**	1.69	0.4
		0.79		0.002
Reinsurance	2.68**	1.55	0.93	1.99*
		0.77		0.05
Marine-Aviation-Transport	0.1	2.31**	1.55	2.46**
		3.99		0.09

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of VAR and sample periods as indicated in table three. The values on the first lines are F-statistic.

Electricity, Gas and Water sector:

Short run: *This sector has a causal relationship with no insurance market, but* three insurance markets, including life insurance yearly premiums, property insurance and reinsurance have causal relationships with this sector in the short run.

Long run: There are four bilateral causal long run relationships. In all cases Granger and Lin's (1995) measure is much bigger for this sector. In addition, this sector has a causal relationship with liability and pecuniary loss insurance, while MAT insurance has a causal relationship with this sector in the long run. We conclude that the structure of insurance markets is demand-following for this sector.

Table 4.10 – Causality test between
Electricity, Gas and Water sector and insurance premiums

Variable	GDP does not cause insurance premium		Insurance premium does not cause GDP	
	Short-Run	Long-Run	Short-Run	Long-Run
	$\gamma_{12}(L)=0$	$\alpha_1=0$	$\gamma_{21}(L)=0$	$\alpha_2=0$
	$F(k,n)$	$t(n)$	$F(k,n)$	$t(n)$
Life insurance-Yearly	0.81	-	2.29*	-
Life insurance-Single	1.36	-	1.32	-
Motor insurance	1.36	2.2**	0.96	2.02*
		1.57		0.003
Accident and health	0.02	2.79**	0.05	2.4**
		3.15		0.005
Property insurance	0.03	2.05*	3.8**	4.33***
		0.97		0.002
Liability insurance	0.37	2.84**	0.83	0.79
		1.6		0.01
Pecuniary loss insurance	0.12	2.68**	0.71	0.62
		2.4		0.01
Reinsurance	0.55	1.91*	1.86*	3.49***
		2.63		0.02
Marine-Aviation-Transport	0.17	0.28	1.49	4.15***
		0.9		1.83

*, ** and *** indicates test statistic is significant at the 10%, 5% and 1% level.

The order of VAR and sample periods as indicated in table three. The values on the first lines are F-statistic.

We report panel data unit root test results in Table 4.11. Based on p–values from a PP (Phillips and Perron (1988)) test, we cannot reject the null hypothesis of the existence of unit root for all cases. Fisher's statistic for first differences implies that all variables are stationary. Considering this evidence, we assume that all variables are best characterised as being integrated of order one. However, as indicated by Pesaran (2004) in the case of panels where *N* is small (like in our study, where the number of individuals in the panel is less than 10), but the time dimension is sufficiently large, the cross correlations of the errors can be modelled using a seemingly unrelated regression equation (SURE). We also suspect common shocks in macroeconomic data, and herd behaviour in microeconomic, both being major sources of cross-sectional correlation (Bai and Kao (2005)). As we do not use Maddala and Wu's (1999) suggestion to use bootstrap methods, it is possible that our results for panel unit root tests are biased. In addition, Pedroni (2004) assumes a cross-sectional independence condition, an assumption which is often violated in our context.

Table 4.11- Panel data unit root test on levels and differences

Variable	Level	Difference
	PP	PP
Logarithm of real Agricultural GDP	8.7	165***
Logarithm of real Mining and Quarrying GDP	2.75	140.8***
Logarithm of real Manufacturing GDP	14.37	165.78***
Logarithm of real Construction GDP	13.33	66.5***
Logarithm of real Electricity, Gas and Water supply GDP	2.61	165***
Logarithm of real Service GDP	6.03	106.5***
Logarithm of insurance premia (including all insurance markets)	12.89	132.14***

*** indicates test statistic is significant at the 1% level.

We report results for panel cointegration tests in Table 4.12. Based on the results, we can reject the null hypothesis that all of the insurance markets and each sector of the panel are not cointegrated in favour of the alternative hypothesis, which indicates that a significant portion of the insurance markets are cointegrated with economic sectors. We interpret them as evidence in favour of a long-run panel cointegration relationship between sectoral GDP and insurance markets.

Table 4.12 – Panel cointegration test between economic sectors and insurance industry

test	Agriculture	Mining-Quarrying	Manufacturing	Construction	Electricity Gas Water	Service
Panel ρ – test	-1.73**	-1.71**	-1.7**	-1.66**	-1.76**	-1.69**
Panel t – test	-4.12***	-2.04**	-1.83**	-1.61**	-2.16**	-1.91**

** and *** indicates test statistic is significant at the 5% and 1% level.. Both statistics are standardized by the means and variances given in Pedroni

4.7 Summary and conclusion

Ward and Zurbruegg's (2000) study evaluated the potential relationship between growth in the insurance industry and GDP growth for some OECD countries. In the previous chapter, we examined the robustness of their results to the use of disaggregated data for insurance markets. Implementing Johansen's λ_{Trace} cointegration test, we found a long-run relationship between development in insurance market size and economic growth. In the current chapter, we extended our first study by using disaggregated data for both insurance markets and GDP (by sectors). Our empirical results provide evidence in favour of a long-run relationship in most cases, though with different levels of significance.

In addition, we use causality tests to determine the direction of causality and the underlying patterns (demand-following or supply-leading). The evidence identifies 20 bilateral and 19 one-way long-run causal relationships from GDP sectors to insurance markets (demand-following pattern), while 7 long-run causal relationships from insurance markets to GDP sectors (supply-leading pattern). In most cases of bilateral long-run relationships, Granger and Lin's (1995) strength of causality indicates that causality is much more powerful from sectoral GDP growth to insurance market development. We therefore conclude that there is a tendency for causal relationships following a demand-following pattern. To categorize supply-leading patterns, motor, property insurance and reinsurance have causal relationships with Agricultural sector, life insurance yearly premiums have causal relationships with Service and Mining and Quarrying sectors, reinsurance has a causal relationship with Construction sector, and MAT insurance has a causal relationship with Electricity, Gas and Water supply sector. The average shares of motor and property insurance in total premiums during the period were 10.5% and 10.2% respectively. On the other hand, the shares of Agricultural, Mining and Quarrying and Construction sectors in the UK's GDP were about 1%, 3% and 5.5% in 2000. Considering these facts, we conclude that the effects of the insurance industry in promoting GDP for the UK are almost nil, and at best there is weak support for the hypothesis that insurance development leads economic growth. Rather, it seems that sectors growth spurs the UK's insurance industry (there is a demand-following pattern rather than a supply-leading pattern). Finally, panel cointegration test results indicate that there is a long-run relationship between economic sectors and insurance markets, regardless of the importance of that component in the UK economy.

Still, given the limitations of the estimation techniques mentioned (Caporale and Cerrato, 2006) further empirical work remains to be done using their estimator. But this is beyond the scope of this work.

Chapter 5

Summary and Conclusion

During the first UNCTAD conference back in 1964, national insurance and reinsurance markets were already acknowledged as an essential engine of economic growth. Despite the abundant literature on the relationship between financial markets and economic growth, research on the relationship between insurance market development and economic growth is still sparse. There are no solid theoretical grounds for the relationship between insurance market development or insurance market liberalization and economic growth. Despite of recent efforts, there is no definite empirical study of the effects of insurance market liberalization on the worldwide economy. A possible explanation for this scarcity comparing to studies on trade in goods, might be that the negotiations on trade in services return to the Uruguay Round in the 1990s, while negotiations on trade in goods return to five decades ago. In addition, the lack of data has imposed limitations on the empirical evaluation of this important question. Reliable worldwide data on insurance trade and premiums was not available until 2001. In that year, version 6 of the GTAP model was released and it was only in its latest version that insurance was added to its database. This improvement enabled us to consider, for the first time in the literature, the effects of insurance market liberalization on the different economies around the world.

Comparing the value of insurance premiums and insurance exports in the past years, we found that only about 2% of the produced insurance was traded between nations. A possible explanation for this low level of insurance trade relative to the level of premiums is that national insurance markets are closed to foreign insurance companies. We studied how opening national insurance markets can be a source of mutual benefit for the trading economies. It can expand the demand for domestic firms' goods; it may make available a range of inputs at lower prices, lowering the costs of production, and increasing competition, which may lead to improvements in the efficiency of local production, and through various channels, can affect the rate of economic growth (Stiglitz and Charlton (2005)).

Our prediction is that the EU region will gain more than the rest from insurance market liberalization. This is because most European countries have a comparative advantage in insurance services (Webster and Hardwick (2005)). However, the effects for developing and less developed countries are ambiguous. On the one hand, in middle-income and low-income countries, about 75 per cent of imported insurance is used as an intermediate input. If insurance liberalization makes available insurance services at lower prices, an overall reduction in the costs of production is to be expected. On the other hand, because these countries do not specialize in insurance, liberalization in the insurance sector may cause the loss of the overall tiny national insurance sector.

The main purpose of chapter 2 is to analyse the effects of insurance liberalization on the worldwide economy. We use a CGE model that includes 8 regions and 5 sectors. The regions include NAFTA, the EU (26 countries), Japan, Oceania, East Asia (Korea and China), and the low-income (55), middle-income (93), and high-income (22) countries. The classification into low-, middle- and high-income countries is based on World Bank definitions. Sectors include food, manufacturing, financial sector (excluding insurance), insurance, and other services (all services other than the financial sector).

Following Benjamin and Diao (2000) we consider an imperfectly competitive structure for the financial and insurance sectors. This approach enables us to assess the effects of removing insurance barriers within and across economies. The rest of the sectors are modelled as perfectly competitive. To assess the effects we considered four experiments, including:

1-Removing import tariffs in food and manufacturing sectors in all regions under IMPERFECT COMPETITION structure for insurance and financial sectors and PERFECT COMPETITION structure for the rest.

2-Removing import tariffs in food and manufacturing sectors in all regions under PERFECT COMPETITION structure for all sectors (except financial sector).

3-Removing import tariffs in food and manufacturing sectors in all regions assuming IMPERFECT COMPETITION in insurance, although the benchmark coefficients (APM) are adjusted for SPECIFIC COMMITMENTS for the insurance sector under the GATS.

4-Keep middle- and low-income and East Asia's commitments on the insurance industry unchanged, and liberalize other regions' commitments by, for example, 50%.

Results obtained from the CGE model under imperfect competition are typically compared with results generated under a standard closure (no Non Tariff Barriers), with perfectly competitive markets (Experiments 1 and 2). Comparing the difference in results between experiment 1 and experiment 2 could be interpreted as moving towards liberalization. In addition, experiment 4 evaluates whether developing countries are losers through the suspension of negotiations.

After estimating and summarising the results of different experiments, we conclude that:

If developing countries adopt a full liberalization scenario (experiment 2), they realize that this policy might reduce their welfare, although it can improve the GDP quantity index of middle-income countries. As well, a positive effect on their trade balance (except for low-income countries) and a negative effect on their net insurance exports is to be expected. It is therefore reasonable not to expect a movement in favour of full insurance liberalization among developing countries, if they consider welfare as a key objective. In contrast, developed countries (such as the EU and Japan) have comparative advantages in insurance services and also more open markets (except for Japan which is highly regulated). These regions may find it in their interest to take bigger steps towards liberalization. If during negotiations they force developing countries to accompany them, developing countries may suspend negotiations, causing a substantial welfare loss and a GDP drop across most regions. Surprisingly, it has a strong positive effect on the developing countries' balance of trade, and they may find it a useful move if their main goal is to improve the balance of payments. However it will decrease both their welfare and GDP, and is not advisable in the long run. On the other hand, the balance of trade of developed countries would worsen. We conclude that the best action that ensures that all parties benefit is to move on the basis of GATS commitments or simply negotiations. Negotiations can adjust the adverse effects of aggressive moves towards full liberalization or suspension. Developing countries are still losing welfare and GDP, albeit in smaller amounts. On the other hand, their gains in terms of the tarde balance are smaller as well. This is also true for developed countries. Negotiations adjust their gains and losses. It is in the interest of all parties to make progressive moves toward liberalization, which is the main goal of GATS.

In chapters 3 and 4, we assess the relationship between insurance market development and economic growth within the UK. In view of the important role of insurance in the economy (categorized by Goldsmith (1966) as non-money-issuing financial institutions), one would expect to find a vast literature exploring the relationship between both. However, only a few studies have focused on this relationship. Ward and Zurbruegg's (2000) study provides a useful framework within to assess the performance of the insurance industry across OECD countries. They found no long-run relationship between economic growth and insurance market development in countries such as Austria, Switzerland, the United Kingdom and the United States. In Chapter 3, we re-examine this conclusion on the basis of disaggregate data for several insurance markets. We find that Ward and Zurbruegg's (2000) findings are not robust to disaggregation (aggregation bias). Our disaggregate data for insurance covers life insurance, annuities, individual pension and other pension yearly and single premiums, motor, accident and health, liability, property, pecuniary loss, reinsurance and marine, aviation and transport (MAT).

To estimate the long run relationship, we first checked the order of co-integration of the variables. To that purpose, three unit root tests were used proposed by Dickey and Fuller (1979), Philips and Perron (1988), and Elliot, Rothenberg and Stock (1996) respectively. We then tested for co-integration on the basis of Johansen's (1988) co-integration test. However, cointegration analysis does not provide information about the two possible patterns identified by Patrick (1966) when examining causality between financial development and economic growth. In the demand-following pattern, growth in GDP causes an increase in the demand for financial services. In the supply-leading pattern, the expansion of financial services causes an increase in both the demand for services and economic growth. Consequently, we evaluate these patterns with the help of a causality test. We use Demetriades and Hussein's (1996) and Arestis and Demetriades' (1997) approach. In their method, the traditional Granger equations are re-parameterised to achieve an error correction model (ECM). We also quantify the strength of causality by using the Granger and Lin (1995) approach. This measure helps us to determine the direction and strength of causality in the case of a bilateral causal relationship.

Our findings in chapter 3 confirm the existence of a long run relationship between insurance markets development and economic growth. The results show evidence in favour of rejection of no long-run relationship and in favour of cointegration at 1% level of significance in all cases, which implies a long-run relationship between insurance market development and economic growth rather than a cyclical effect. The results of causality tests indicate that bilateral relationships between GDP growth and development in six out of nine insurance markets. However, Granger and Lin's measure shows that the strength of causality from GDP growth to insurance market development is more powerful than in the reverse direction. Although there is evidence of this reverse direction for three insurance markets, the strength of causality is almost nil. Interestingly, for 5 out of 9 insurance markets there is evidence of them causing economic growth in the short run. Based on these findings, we conclude that the structure of the UK's insurance industry tends to be demand-following rather than supply-leading, i.e. insurance market development has a small long-run effect on the UK's GDP growth, and mostly follows economic growth. At best, there is weak support for the hypothesis that insurance market development leads economic growth. However, insurance markets may have short-run effects on the economy.

Results of chapter 3 encouraged us to further inquire into the nature of the relationship on the basis of further disaggregation in both insurance markets and GDP. As a result, a novel aspect of chapter 4 resides in re-evaluating the long-run relationship between insurance markets and sectoral GDP growth within the United Kingdom. We consider the Agricultural, Hunting, Forestry and Fishing, Manufacturing, Services, Mining and Quarrying, Construction and the Electricity, Gas and Water sectors. The first three cover about 90% of the UK's GDP. Agricultural and service sectors have respectively the lowest and highest shares in GDP.

The estimation framework of chapter 4 is similar to the one described in chapter 3. Cointegration test results indicate that there are long-run relationships with different levels of significance in most cases. In addition, to identify which one is causal and which one is effect, as well as to determine possible patterns (demand-following and supply-leading), we use causality tests. There is evidence of 20 bilateral long-run and 19 one-way long run causal relationships from GDP sectors to insurance markets (demand-following pattern), and 7 long run causal relationships from insurance markets to different economic sectors (supply-leading pattern). In most cases of bilateral long-run relationships, Granger and Lin's (1995) strength of causality indicates that causality is much more powerful from economic sectors to insurance markets. For the case of supply-leading patterns, the effects are almost nil, according to the average shares of those insurance markets in total premiums and shares of economic sectors in total GDP. Considering these facts, we conclude that the effects of the insurance industry in promoting UK sectoral GDP growth are almost nil. The findings of chapter 4 are therefore consistent with those in chapter 3. Furthermore, it seems that the structure of the UK insurance industry is more likely to follow a demand-following pattern than a supply-leading pattern. Finally, we controlled for the validity and robustness of the results obtained running panel data unit root and co-integration tests. Panel unit root tests show that the variables are best characterized as being integrated of order one and panel cointegration tests indicate a long-run relationship between the UK sectoral GDP growth and insurance market development, regardless of the economic importance of the sector in the UK economy as measured by its share of total GDP.

Further work is still needed with the results in chapters 3 and 4. Single time series unit root tests, suffer from lack of power. Our findings may be sensible to this observation. On the other hand, panel data unit root and cointegration tests have higher power when compared to single time series unit root tests. However, the problem with these tests is that most of them assume cross-sectional independence, obtaining their asymptotic distribution under the assumption of no correlation between groups of observations. This assumption is often violated, causing estimates to be biased (Caporale and Cerrato (2006)).

Appendix 2.1- Regions and sectors in GTAP model

Regions

Number	Description in GTAP	Our Aggregation
1	Australia	Oceania
2	New Zealand	Oceania
3	Rest of Oceania: American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Micronesia, Federated States of, Nauru, New Caledonia, Norfolk Islands, Northern Mariana Islands, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna	Oceania
4	China	EASTASIA
5	Hong Kong	High-Income
6	Japan	Japan
7	Korea	EASTASIA
8	Taiwan	High-Income
9	Rest of East Asia: Macau, Mongolia, Korea, Democratic People's Republic of	Low-Income
10	Indonesia	Middle-Income
11	Malaysia	Middle-Income
12	Philippines	Middle-Income
13	Singapore	High-Income
14	Thailand	Middle-Income
15	Vietnam	Low-Income
16	Rest of Southeast Asia Brunei Darussalam, Cambodia, Lao People's Democratic Republic, Myanmar, Timor Leste	Low-Income
17	Bangladesh	Low-Income
18	India	Low-Income
19	Sri Lanka	Middle-Income
20	Rest of South Asia: Afghanistan, Maldives, Nepal, Pakistan, Bhutan	Low-Income
21	Canada	NAFTA
22	United States of America	NAFTA
23	Mexico	NAFTA
24	Rest of North America: Bermuda, Greenland, Saint Pierre and Miquelon	High-Income
25	Colombia	Middle-Income

26	Peru	Middle-Income
27	Venezuela	Middle-Income
28	Rest of Andean Pact: Bolivia, Ecuador	Middle-Income
29	Argentina	Middle-Income
30	Brazil	Middle-Income
31	Chile	Middle-Income
32	Uruguay	Middle-Income
33	Rest of South America Falkland Islands (Malvinas), French Guiana, Guyana, Paraguay, Suriname	Middle-Income
34	Central America: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama	Middle-Income
35	Rest of Free Trade Area of the Americas: Antigua & Barbuda, Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Haiti, Jamaica Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago, Virgin Islands, U.S.	Middle-Income
36	Rest of the Caribbean: Anguilla, Aruba, Cayman Islands, Cuba, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Turks and Caicos, Virgin Islands, British	Middle-Income
37	Austria	EU
38	Belgium	EU
39	Denmark	EU
40	Finland	EU
41	France	EU
42	Germany	EU
43	United Kingdom	EU
44	Greece	EU
45	Ireland	EU
46	Italy	EU
47	Luxembourg	EU
48	Netherlands	EU
49	Portugual	EU
50	Spain	EU
51	Sweden	EU
52	Switzerland	EU
53	Rest of EFTA:	High-Income

	Iceland, Liechtenstein, Norway	
54	Rest of Europe: Andorra, Bosnia and Herzegovina, Faroe Islands, Gibraltar, Macedonia, the former Yugoslav Republic of, Monaco, San Marino, Serbia and Montenegro	High-Income
55	Albania	Middle-Income
56	Bulgaria	Middle-Income
57	Croatia	Middle-Income
58	Cyprus	EU
59	Czech Republic	EU
60	Hungary	EU
61	Malta	High-Income
62	Poland	EU
63	Romania	Middle-Income
64	Slovakia	EU
65	Slovenia	EU
66	Estonia	EU
67	Latvia	Middle-Income
68	Lithuania	EU
69	Russian Federation	Middle-Income
70	Rest of Former Soviet Union: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Republic of, Tajikistan, Turkmenistan, Ukraine, Uzbekistan	Middle-Income
71	Turkey	Middle-Income
72	Rest of Middle East: Bahrain, Iran, Islamic Republic of, Iraq, Israel, Jordan, Kuwait, Lebanon, Palestinian Territory, Occupied, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates - Yemen	Middle-Income
73	Morocco	Middle-Income
74	Tunisia	Middle-Income
75	Rest of North Africa: Algeria, Egypt, Libyan Arab Jamahiriya	Middle-Income
76	Botswana	Middle-Income
77	South Africa	Middle-Income
78	Rest of South African Customs Union: Lesotho, Namibia, Swaziland	Middle-Income
79	Malawi	Low-Income
80	Mozambique	Low-Income

81	Tanzania	Low-Income
82	Zambia	Low-Income
83	Zimbabwe	Low-Income
84	Rest of Southern African Development Community: Angola, Congo, the Democratic Republic of the, Mauritius, Seychelles	Middle-Income
85	Madagascar	Low-Income
86	Uganda	Low-Income
87	Rest of Sub-Saharan Africa: Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Mali, Mauritania, Mayotte, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, Sudan, Togo	Low-Income

Sectors

Number	Description in GTAP	Our Aggregation
1	Paddy rice	Food
2	Wheat	Food
3	Cereal grains nec	Food
4	Vegetables, fruit, nuts	Food
5	Oil seeds	Food
6	Sugar cane, sugar beet	Food
7	Plant-based fibers	Food
8	Crops nec	Food
9	Bovine cattle, sheep and goats, horses	Food
10	Animal products nec	Food
11	Raw milk	Food
12	Wool, silk-worm cocoons	Food
13	Forestry	Manufactory
14	Fishing	Manufactory
15	Coal	Manufactory
16	Oil	Manufactory
17	Gas	Manufactory
18	Minerals nec	Manufactory
19	Bovine meat products	Food

20	Meat products nec	Food
21	Vegetable oils and fats	Food
22	Dairy products	Food
23	Processed rice	Food
24	Sugar	Food
25	Food products nec	Food
26	Beverages and tobacco products	Food
27	Textiles	Manufactory
28	Wearing apparel	Manufactory
29	Leather products	Manufactory
30	Wood products	Manufactory
31	Paper products, publishing	Manufactory
32	Petroleum, coal products	Manufactory
33	Chemical, rubber, plastic products	Manufactory
34	Mineral products nec	Manufactory
35	Ferrous metals	Manufactory
36	Metals nec	Manufactory
37	Metal products	Manufactory
38	Motor vehicles and parts	Manufactory
39	Transport equipment nec	Manufactory
40	Electronic equipment	Manufactory
41	Machinery and equipment nec	Manufactory
42	Manufactures nec	Manufactory
43	Electricity	Other Services
44	Gas manufacture, distribution	Other Services
45	Water	Other Services
46	Construction	Other Services
47	Trade	Other Services
48	Transport nec	Other Services
49	Water transport	Other Services
50	Air transport	Other Services
51	Communication	Other Services
52	Financial services nec	Financial
53	Insurance	Insurance
54	Business services nec	Other Services

55	Recreational and other services	Other Services
56	Public Administration, Defence, Education, Health	Other Services
57	Dwellings	Other Services

Appendix 2.2 - Glossary of GTAP notation

Variable	Explanation	Sub
$VOA(i,r)$	Value of non saving commodity i output or supplied in region r evaluated at agent's prices	$\forall i \in NSAV\_COMM$ $\forall r \in REG$
$PTAX(i,r)$	Producer tax on commodity i in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VOM(i,r)$	Value of non saving commodity i output or supplied in region r evaluated at market prices	$\forall i \in NSAV\_COMM$ $\forall r \in REG$
$VDM\ (i,r)$	Value of domestic sales of tradable commodity i in region r evaluated at market prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VXMD\ (i,r,s)$	Value of exports of tradable commodity i from source r to destination s evaluated at (exporter's) market prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$VST\ (i,r)$	Value of sales of tradable commodity i to the international transport sector in region r evaluated at market prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VDPM\ (i,r)$	Value of expenditure on domestic tradable commodity i by private household in region r evaluated at market prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VDGM\ (i,r)$	Value of expenditure on domestic tradable commodity i by government in region r evaluated at market prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VDFM\ (i,j,r)$	Value of purchases of domestic tradable commodity i by firms in sector j of region r evaluated at market prices	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$XTAXD(i,r,s)$	Exports tax on tradable commodity i from source r to destination s	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$VXWD(i,r,s)$	Value of exports of tradable commodity i from source r to destination s evaluated at world (FOB) prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$VTWR(i,r,s)$	Value of transportation services associated with the shipment of tradable commodity i from source r to destination s (fob-cif margin)	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$VIWS(i,r,s)$	Value of imports of tradable commodity i from source r to destination s evaluated at world (cif) prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$MTAX(i,r,s)$	import tax on tradable commodity i from source r to destination s	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$

$VIMS(i,r,s)$	Value of imports of tradable commodity i from source r to destination s evaluated at (importer's) market prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$VIM(i,r)$	Value of aggregate imports of tradable commodity i in region r evaluated at market price	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VIPM(i,r)$	Value of expenditure on imported tradable commodity i by private household in region r evaluated at market prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VIGM(i,r)$	Value of expenditure on imported tradable commodity i by government in region r evaluated at market prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VIFM(i,j,r)$	Value of expenditure on imported tradable commodity i by firms in sector j of region r evaluated at market prices	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$VPA(i,r)$	Value of private household expenditure on tradable commodity i in region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VDPA(i,r)$	Value of expenditure on domestic tradable commodity i by private household in region r evaluated at agent prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VIPA(i,r)$	Value of expenditure on imported tradable commodity i by private household in region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$DPTAX(i,r)$	Private household tax on commodity i in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$IPTAX(i,r)$	Private household tax on composite imported commodity i in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VGA(i,r)$	Value of government household expenditure on tradable commodity i in region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VDGA(i,r)$	Value of expenditure on domestic tradable commodity i by government household in region r evaluated at agent prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VIGA(i,r)$	Value of expenditure on imported tradable commodity i by government household in region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$DGTAX(i,s)$	Government household tax on commodity i in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$

$IGTAX(i,s)$	Government household tax on composite imported commodity i in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$VFA(i,j,r)$	Value of purchases of demanded commodity i by firms in sector j of region r evaluated at agent's prices	$\forall i \in DEMD\_COMM$ $\forall j \in TRAD\_COMM$ $\forall r \in REG$
$VDFA(i,j,r)$	Value of purchases of domestic tradable commodity i by firms in sector j of region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$VIFA(i,j,s)$	Value of purchases of imported tradable commodity i by firms in sector j of region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$DFTAX(i,j,r)$	Tax on purchases of domestic tradable commodity i by firms in sector j of region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$IFTAX(i,j,r)$	Tax on purchases of imported tradable commodity i by firms in sector j of region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$ETAX(i,j,s))$	Tax on purchases of primary factors i by firms in sector j of region r evaluated at agent's prices	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$VFM(i,j,r)$	Value of purchases of endowment commodity i by firms in sector j of region r evaluated at market prices	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$HTAX(i,r)$	Tax on household income from selling endowment commodity I in region r	$\forall i \in ENDW\_COMM$ $\forall r \in REG$
$QO\ (i,r)$	Quantity of non saving commodity i output or supplied in region r	$\forall i \in NSAV\_COMM$ $\forall r \in REG$
$QDS\ (i,r)$	Quantity of domestic sales of tradable commodity i in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QST\ (i,r)$	Quantity of sales of tradable commodity i to the international transport sector in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QXS\ (i,r,s)$	Quantity of exports of tradable commodity i from source r to destination s	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$tradslack\ (i,r)$	Slack variable in MKTCLTRD equation (exogenous as long as price of tradable PM(i,r) is endogenous)	$\forall i \in TRAD\_COMM$ $\forall r \in REG$

$QIM(i,r)$	Quantity of aggregate imports of tradable commodity i demanded by region r using market price as weights	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QPM(i,r)$	Quantity of imported tradable commodity i demanded by private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QGM(i,r)$	Quantity of imported tradable commodity i demanded by government household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QFM(i,j,r)$	Quantity of imported tradable commodity i demanded by firms in sector j in region r	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$QFD(i,j,r)$	Quantity of domestic tradable commodity i demanded by firms in sector j of region r	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$QFE(i,j,r)$	Quantity of endowment commodity i demanded by firms in sector j of region r	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$endwslack(i,r)$	Slack variable in MKTCENDWN and ENDW_SUPPLY equations (exogenous as long as primary factor rental rates, PM(i,r) and PMES(I,j,r) are endogenous)	$\forall i \in ENDW\_COMM$ $\forall r \in REG$
$QOES(i,j,r)$	Quantity of sluggish endowment commodity i supplied to firms in sector j of region r	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$PFE(i,j,r)$	Demand price of endowment commodity i for firms in sector j of region r	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$profitslack(j,r)$	Slack variable in ZEROPROFITS equation (exogenous as long as output QO(j,r) is endogenous)	$\forall j \in PROD\_COMM$ $\forall r \in REG$
VT	Value of total international transportation services (sum of fob-cif margins across all commodities and all routs)	
PT	Price of global transport services supplied	
$PM(i,r)$	Market price of non saving commodity i in region r	$\forall i \in NSAV\_COMM$ $\forall r \in REG$
$PRIVEXP(r)$	Private household expenditure in region r evaluated at agent's price	$\forall r \in REG$
$YP(r)$	Percentage change in private household expenditure in region r (is identical to linearized from of PRIVEXP(r)	$\forall r \in REG$
$INCOME(r)$	Expenditure in region r that equals net income (net of capital depreciation)	$\forall r \in REG$
$SAVE(r)$	Price of composit capital good supplied to savers by global bank	$\forall r \in REG$
$PSAVE(r)$	Price of composit capital good supplied to savers by global bank	$\forall r \in REG$
$QSAVE(r)$	Quantity of composit capital good supplied to savers by global bank	$\forall r \in REG$

$PG(i,r)$	Demand price of composite tradable commodity i demanded by government household in regionr	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QG(i,r)$	Quantity of composite tradable commodity i demanded by government household in regionr	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$Y(r)$	Percentage change in regional household income in region r (is identical to linearized from of INCOME(r))	$\forall r \in REG$
$PS(i,r)$	Supply price of non saving commodity i in region r	$\forall i \in NSAV\_COMM$ $\forall r \in REG$
$VDEP(r)$	Value of capital depreciation expenditure in region r	$\forall r \in REG$
$PCGDS(r)$	Proce of investment good in region r (equals PS("cgds",r)	$\forall r \in REG$
$KB(r)$	Quantity of beginning-of-period capital stock in region r	$\forall r \in REG$
$PMES(i,r)$	Market price of endowment commodity i for firms in sector j of region r	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$PIM(i,r)$	Market price of aggregate imports of tradable commodity i in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$PFD(i,j,r)$	Demand price of domestic tradable commodity i for firms in sector j of region r	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$PPM\ (i,r)$	Demand price of imported tradable commodity i for private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$PPD(i,r)$	Demand price of domestic tradable commodity i for private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QPD(i,r)$	Quantity of domestic tradable commodity i for private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$PGM(i,r)$	Demand price of imported tradable commodity i for government household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$PGD(i,r)$	Demand price of domestic tradable commodity i for private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QGD(i,r)$	Quantity of domestic tradable commodity i for government household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$PFOB(i,r,s)$	World (fob) price of tradable commodity i exported from source r to destinations s (prior to including transport margin)	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$PMS(i,r,s)$	Market price by source of tradable commodity i imported from source r to destinations s	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$PSIF(i,s,r)$	World (cif) price of tradable commodity i exported from source r to destinations s (after including transport margin)	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$incomeslack(r)$	Slack variable in REGIONALINCOME equation (is exogenous as long as regional household income, Y(r) is endogenous)	$\forall r \in REG$
$KE(r)$	Quantity of end-of-period capital stock in region r	$\forall r \in REG$
$INVKERATIO(r)$	Ratio of gross investment to end-of-period capital stock in region r	$\forall r \in REG$
$REGINV(r)$	Gross investment in region r that equals value of output of sector ("cgds")	$\forall r \in REG$

$GLOBINV$	Global net investment	
$walras\_sup$	Quantity supplied in the ommited market	
$walras\_dem$	Quantity demanded in the ommited market	
$walraslack$	Slack variable in the WALRAS equation (is exogenous as long as price of saving PSAVE is endogenous)	
$TO(i,r)$	Power of the tax on output (or income) of non savings commodity i in region r	$\forall i \in NSAV\_COMM$ $\forall r \in REG$
$TF(i,j,r)$	Power of the tax on endowment commodity i demanded by firms in sector j region r	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$PMES(i,j,r)$	Market price of sluggish endowment commodity i supplied to firms in sector j of region r	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$TPD(i,r)$	Power of the tax on domestic tradable commodity i demanded by private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$TFD(i,j,r)$	Power of the tax on domestic tradable commodity i demanded by private household in region r	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$TPM(i,r)$	Power of the tax on imported tradable commodity i demanded by private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$TGM(i,r)$	Power of the tax on imported tradable commodity i demanded by government household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$TFM(i,j,r)$	Power of the tax on imported tradable commodity i demanded by firms in sector j of region r	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$TM(i,s)$	Power of the variable import tax (levy) on imports of tradable commodity i in region r – source generic	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$TMS(i,r,s)$	Power of the tax on imports of tradable commodity i from source r to destination s (levied in region s)	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$FOBSHR(i,r,s)$	Share of fob price in the cif price for tradable commodity i exported from source r to destination s	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$TRNSHR(i,r,s)$	Share of transport price in the cif price for tradable commodity i exported from source r to destination s	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$TX(i,r)$	Power of the variable export tax on exports of tradable commodity i from region r-destination-generic	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$TXS(i,r,s)$	Power of the tax on export tax of tradable commodity i from source r to s	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$
$MSHRS(i,r,s)$	Market share of source r in the aggregate imports of tradable commodity i in region s evaluated at market price	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$

$FMSHR(i,j,r)$	Share of imports in the composite for tradable commodity used by firms in sector j of region r evaluated at agent's price	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$PFM(i,j,r)$	Demand price of imported tradable commodity i for firms in sector j of region r	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$QF(i,j,s)]$	Quantity of composite tradable commodity i demanded by firms in sector j of region r	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$PVA(j,r)$	Price of value-added in sector j of region r	$\forall j \in PROD\_COMM$ $\forall r \in REG$
$SVA(i,j,r)$	Share of primary factor I in sector j of region r s in the total cost of value-added	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$AFE(i,j,r)$	Primary factor i augmenting technical change in sector j of region r	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$QVA(j,r)$	Quantity index of value-added (land, labour composite) in frims of sector j in egion r	$\forall j \in PROD\_COMM$ $\forall r \in REG$
$AO(j,r)]$	Output augmenting technical change in sector j of region r	$\forall j \in PROD\_COMM$ $\forall r \in REG$
$AF(i,j,r)$	Composite intermediate input i augmenting technical change in sector j of region r	$\forall i \in TRAD\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$U(r)$	Per capita utility from aggregate household expenditure in region r	$\forall r \in REG$
$PRIVEXP(r)$	Private household expenditure in region r evaluated at agent's price	$\forall r \in REG$
$UP(r)$	Per capita utility from private household expenditure in region r	$\forall r \in REG$
$GOVEXP(r)$	government household expenditure in region r evaluated at agent's price	$\forall r \in REG$
$UG(r)$	Aggregate utility from government household expenditure in region r	$\forall r \in REG$
$POP\ (r)$	Population in region r	$\forall r \in REG$
$saveslack(r)$	Slack variable in the SAVING equation(is exogenous as long as saving QSAVE(r) is endogenous)	$\forall r \in REG$
$PGOV(r)$	Price index for government household expenditure in region r	$\forall r \in REG$
$govslack(r)$	Slack variable in the GOVERTU equation(is exogenous as long as government purchase UG(r) is endogenous)	$\forall r \in REG$

$GMSHR(i,r)$	Share of imports in the composite for tradable commodity i used by government household in region r evaluated at agent's price	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$CONSHR(i,r)$	Budget share of the composite for tradable commodity i in private household expenditure in region r evaluated at agent's price	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$INCPAR(i,r)$	Income parameter of tradable commodity i in the CDE minimum expenditure function of region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$PP(i,r)$	Demand price of composite tradable commodity i for private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$QP(r)$	Quantity of composite tradable commodity i for private household in region r	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$PMSHR(i,s)$	Share of imports in the composite for tradable commodity i used by private household in region r evaluated at agent's price	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
$REVSR(i,j,r)$	Share of endowment commodity i used by firms in sector j of region r evaluated at market price	$\forall i \in ENDW\_COMM$ $\forall j \in PROD\_COMM$ $\forall r \in REG$
$DEPR(r)$	Depreciation rate of capital in region r	$\forall r \in REG$
$RORC(r)$	Current net rate of return on capital stock in region r	$\forall r \in REG$
$RENTAL(r)$	Rental rate on capital stock in region	$\forall r \in REG$
$GRNERATIO(r)$	Ratio of gross to net rate of return on capital in region r	$\forall r \in REG$
$RORFLEX(r)$	Flexibility of expected net rate of return on capital stock in region r with respect to investment	$\forall r \in REG$
$RORE(r)$	Expected net rate of return on capital stock in region r	$\forall r \in REG$
$RORG$	Global net rate of return on capital stock	$\forall r \in REG$
$NETINV(r)$	Net investment in region r	$\forall r \in REG$
$VDEP(r)$		
$RORDELTA$	Binary coefficient that determines the mechanism of allocating investment across regions	
$VST(i,r)$	Value of sales of tradable commodity i to the international transport sector in region r evaluated at market price	$\forall i \in TRAD\_COMM$ $\forall r \in REG$
QT	Quantity of global transport services supplied	
$ATR(i,r,s)$	Technical change in the transportation of tradable commodity i from source r to destination s	$\forall i \in TRAD\_COMM$ $\forall r \in REG$ $\forall s \in REG$

Appendix 2.3 - Equations for investment and global transportation

Two alternative investment components were incorporated into the model and it depends on the user to choose which theory to employ. The first enforces a close link between regional rates of return on capital, and the second is based on the assumption that the regional composition of global capital stock will be left unaltered in the simulation. GTAP incorporates the two alternative investment components into a single set of composite equations.

It is assumed that the productive capacity of capital declines geometrically over time, with depreciation rate. Consequently, the end-of-period capital stock is equal to the beginning-of-period capital stock, multiplied by one minus depreciation rate and augmented by gross investment:

$$KE(r) = KB(r) * [1 - DEPR(r)] + REGINV(r) \quad (2.3.1)$$

By differentiating both sides, we have:

$$dKE(r) = dKB(r) * [1 - DEPR(r)] + dREGINV(r) \quad (2.3.2)$$

By rearranging the above equation and having rewritten it in terms of percentage change, we obtain the equation below:

$$ke(r) = [1 - DEPR(r)] * [KB(r) / KE(r)] * kb(r) + [REGINV(r) / KE(r)] * qcgds(r) \quad (2.3.3)$$

GTAP defines the ratio of investment end-of-period capital stock as follows:

$$INVKERATIO(r) = REGINV(r) / KE(r) \quad (2.3.4)$$

By using equation 2.3.4, the first part of the first term of equation 2.3.3 can be written as:

$$[1 - DEPR(r)] * [KB(r) / KE(r)] = 1 - INVKERATIO(r) \quad (2.3.5)$$

If we substitute equations 2.3.4 and 2.3.5 into equation 2.3.3, we have:

$$ke(r) = [1 - INVKERATIO(r)] * kb(r) + INVKERATIO * reginv(r) \quad (2.3.6)$$

Then GTAP defines the current net rate of return on fixed capital in region r as the ratio of the rental for capital services to the purchase price of capital goods, less the rate of depreciation:

$$RORC(r) = RENTAL(r) / PCGDS(r) - DEPR(r) \quad (2.3.7)$$

Again, as GTAP uses equations in terms of percentage change, we have:

$$rorc(r) = [RENTAL(r) / (RORC(r) * PCGDS(r))] * [rental * r) - pcgds(r)] \quad (2.3.8)$$

Note that:

$$RENTAL(r)/(RORC(r)*PCGDS(r)) = [RORC(r)+DEPR(r)]/RORC(r) \qquad (2.3.9)$$

The ratio of gross returns to net return is defined as:

$$GRNERATIO(r) = [RORC(r)+DEPR(r)]/RORC(r) \qquad (2.3.10)$$

By substituting equations 2.3.9 and 2.3.10 into equation 2.3.8, we have:

$$rorc(r) = GRNERATIO(r)*[rental(r)-pcgds(r)] \qquad (2.3.11)$$

For the rate-of-return investment component, it is assumed that investors are cautious in assessing the effects of net investment in a region. They behave as if they expect the region's rate of return in the next period to decline with positive additions to the capital stock. The rate at which this decline is expected is a function of the flexibility parameter:

$$RORE(r) = RORC(r)[KE(r)/KB(r)]^{-RORFLEX(r)} \qquad (2.3.12)$$

Therefore the elasticity of RORE(r) with respect to KE(r) is equal to minus RORFLEX(r). The percentage change of equation 2.3.12 is given by:

$$rore(r) = rorc(r) - RORFLEX*[ke(r)-kb(r)] \qquad (2.3.13)$$

Then GTAP assumes that investors behave in such a way that changes in regional rates of return are equalized across regions:

$$rore(r) = rorg \qquad (2.3.14)$$

where rorg is the percentage change in a global rate of return.

The second investment component adopts an extreme position in which GTAP assumes that the regional composition of capital stocks will not change at all, so that regional and global net investment moves together:

$$globalcgds = [REGINV(r)/NETINV(r)]*qcgds(r) - [VDEP(r)/NETINV(r)]*kb(r) \qquad (2.3.15)$$

In the above equation, globalcgds is the percentage change in the global supply of new capital goods. In this case, the percentage change in the global rate of return on capital variable is computed as a weighted average of regional variables:

$$rorg = \sum_{r \in REG}[NETINV(r)/GLOBINV]*rore(r) \qquad (2.3.16)$$

and:

$$NETINV(r) = (REGINV(r) - VDEP(r)) \qquad (2.3.17)$$

Equation 2.3.14 represents a rate-of-return component approach to investment, and equations 2.3.16 and 2.3.17 represent an alternative component approach to investment. Two approaches are combined in the equations below by employing a binary parameter which takes the values 0 and 1. When the parameter (RORDELTA) equals one, we obtain rate-of-return model, and for value zero, the model is the alternative model.

$$RORDELTA * rore(r) + (1 - RORDELTA) * \{[REGINV(r) / NETINV(r)] * qcgds(r) - [VDEP(r) / NETINV(r)] * kb(r)\} = RORDELTA * rorg + (1 - RORDELTA) * globalcgds \qquad (2.3.18)$$

and:

$$RORDELTA * globalcgds + (1 - RORDELTA) * rorg = RORDELTA * \sum_{r \in REG} \{[REGINV(r) / GLOBINV] * qcgds(r) - [VDEP(r) / GLOBINV] * kb(r)\} + (1 - RORDELTA) * \sum_{r \in REG} [NETINV(r) / GLOBINV] * rore(r) \qquad (2.3.19)$$

Now, we consider international transport services. A Cobb-Douglas production function is employed for this reason. GTAP combines transport services into a single composite international transport good, VT.

$$VT * pt = \sum_{i \in TRAD} \sum_{r \in REG} VST(i,r) * pm(i,r) \qquad (2.3.20)$$

Equation 2.3.20 provides the composite price index. Conditional demands for the inputs to the shipping service sector are derived in the equation below. It is assumed that the share of each region in the global industry is constant (Cobb-Douglas technology):

$$qst(i,r) = qt + [pt - pm(i,r)] \qquad (2.3.21)$$

Equilibrium in the global services market requires that:

$$\sum_{i \in TRAD} \sum_{r \in REG} \sum_{s \in REG} QTS(i,r,s) = QT \qquad (2.3.22)$$

In equation 2.3.22, QTS is the amount of the homogenous product QT used in shipping one unit of commodity i from r to s.

Proportionally differentiating equation 2.3.22 gives:

$$\sum_{i \in TRAD} \sum_{r \in REG} \sum_{s \in REG} QTS(i,r,s) * qts(i,r,s) = QT * qt \qquad (2.3.23)$$

By multiplying some factors and rearranging equation 2.3.23, we reach equation 2.3.24.

$$VT * qt = \sum_{i \in TRAD} \sum_{r \in REG} \sum_{s \in REG} VTWR(i,r,s) * [qts(i,r,s) - atr(i,r,s)] \qquad (2.3.24)$$

The presence of atr in equation 2.3.24 permits us to introduce commodity/route-specific technical change in international transport services. This also requires us to modify the fob/cif price linkage equation to reflect the fact that an increase in efficiency along a particular route will lower cif values, for a given fob price.

$$pcif(i,r,s) = FOBSHR(i,r,s) * pfob(i,r,s) + TRNSHR(i,r,s) * [pt - atr(i,r,s)] \qquad (2.3.25)$$

References

Acemoglu, D., and Zilibotti, F. (1997) Was Prometheus Unbound by Chance? Risk, Diversification, and Growth, *Journal of Political Economy,* 105(4): 709-751.

Andrews, D. W. K., and Monahan J. C. (1992) An Improved Heteroskedasticity and Autocorrelation Consistent Covariance Matrix, *Econometrica*, 60: 953-966.

Arestis, P., and Demetriades, P. (1997) Financial Development and Economic Growth: Assessing the Evidence, *Economic Journal*, 107(442): 783-799.

Arrow, K.J., Chenery, H.B, Minhas, B.S., and Solow, R.M. (1961) Capital-Labour Substitution and Economic Efficiency, *Review of Economics and Statistics,* 43: 225-250.

Bai, J., and Kao, C. (2005) On the Estimation and Inference of a Panel Cointegration Model with Cross-Sectional Dependence, Centre for Policy Research Working Papaer, 75.

Bai, J., and Ng, S. (2004) A Panic Attack on Unit Roots and Cointegration, *Econometrica,* 72(4): 1127-77.

Beck, T., Levine, R., and Loayza, N. (2000) Finance and the Sources of Growth, *Journal of Financial Economics*, 58(1): 261-300.

Beenstock, M., Dickinson, G. and Khajuria, S. (1988) The Relationship between Property-Liability Insurance Premia and Income: An International Analysis, *Journal of Risk and Insurance*, 55(2): 259-272.

Bencivenga, V. R., and Smith, B. D. (1991) Financial Intermediation and Endogenous Growth, *Review of Economic Studies,* 58: 195-209.

Benjamin, N., and Diao, X. (2000) Liberalization Services Trade in APEC: A General Equilibrium Analysis with Imperfect Competition, *Pacific Economic Review,* 5(1): 49-75.

Berthelemy, J. C., and Varoudakis, A. (1996) Economic Growth, Convergence Clubs, and the role of Financial Development, *Oxford Economic Papers,* 48: 300-328.

Breusch, T.S., and Pagan, A.R. (1980) The Lagrange Multiplier Test and its Application to Model Specifications in Econometrics, *Review of Economic Studies,* 47:239-53.

Browne, M. J., and Kim, K. (1993) An International Analysis of Life Insurance Demand, *Journal of Risk and Insurance*, 60(4): 616-634.

Caporale, G.M., and Cerrato, M. (2006) Panel Data Tests of PPP: a Critical Overview, *Applied Financial Economics,* 16: 73-91.

Caporale, G.M., Howells, P., and Soliman, A.M. (2004) Stock Market Development and Economic Growth: The Causal Linkage, *Journal of Economic Development,* 29(1): 33-50.

Caporale, G.M., Howells, P., and Soliman, A.M. (2005) Endogenous Growth models and Stock Market Development: Evidence from Four Countries, *Review of Development Economics,* 9(2): 166-176.

Caporale, G.M., and Williams, G. (2001) Monetary Policy and Financial Liberalization: The Case of United Kingdom Consumption, *Journal of Macroeconomics,* 23(2): 177-197.

Curwen, P. (1994) *Understanding the UK Economy* (The Macmillan Press Ltd).

Dawson, P. J. (2003) Financial Development and Growth in Economics in Transition, *Applied Economics Letters,* 10: 833-836.

De Gregorio, J. (1992) Economic Growth in Latin America, *Journal of Development Economics,* 39: 445-502.

De Gregorio, J., and Guidotti, P. (1995) Finance Development and Economic Growth, *World Development,* 23: 433-448.

Deidda, L., and Fattouh, B. (2002) Non-linearity between Finance and Growth, *Economic sLetters,*74: 339-345.

Demetriades, P. O., and Hussein, K. A. (1996) Does Financial Development Cause Economic Growth? Time Series Evidence from 16 Countries, *Journal of Development Economics*, 51(2):387-411.

Dickey, D. A., and Fuller, W. A. (1979) Distribution of the Estimation for Autoregressive Time Series with a Unit Root, *Journal of the American Association*, 74: 427-431.

Dickey, D. A., and Fuller, W. A. (1981) Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root, *Econometrica*, 49: 1057-1072.

Elliot, G., Rothenberg, T. J, and Stock, J. H. (1996) Efficient Tests for an Autoregressive Unit Root, *Econometrica*, 64(4): 813-836.

Engle, R.F., and Granger, C.W. (1987) Cointegration and Error Correction: Representation, Estimation and Testing, *Econometrica,* 55: 251-276.

Fisher, R. A. (1932) *Statistical Methods for Research Workers* (Edinburgh: Oliver & Boyd).

Francois, J. F. (1995) Dynamic Effects of Trade in Financial Services, *International Economic journal*, 9(3): 1-14.

Fuller, W. A. (1976) *Introduction to statistical time series* (New York: Wiley).

Gabriele, A. (2002) Export of Services, Export of Goods, and Economic Growth in Developing Countries, 6th Annual Conference on Global Economic Analysis, the Hague, the Netherlands.

Gabriele, A. (2004) International Trade in Services and the Evolving position of Developing Countries, *Journal of Economic Integration*, 19(4): 780-803.

Goldsmith, R. W. (1969) *Financial Structure and Development* (New Haven, CN: Yale University Press).

Gortz, M., and Hansen, P. K. (1999) Regulation of Danish Energy Markets with Imperfect Competition, Working Paper 1999:2, Danish Economic Council.

Granger, C. W. J. (1990) Aggregation in Time Series Variables: a Survey. In T. Barker and M. W. Pesaran (eds.), *Disaggregation in economic modelling* (London: Routledge).

Granger, C. W. G, and Lin, J. L. (1995) Causality in the Long Run, *Econometric Theory*, 11(1): 530-536.

Greenwood, J., and Jovanovic, B. (1990) Financial Development, Growth, and the Distribution of Income, *Journal of Political Economy*, 98: 1076-1107.

Hall, A. (1994) Testing for a Unit Root in Time Series with Pretest Data-Based Model Selection, *Journal of Business and Economics Statistics*, 12: 461-470.

Hamilton, J. (1983) Oil and Macroeconomy since World War II, *Journal of Political Economy*, 91: 228-248.

Harrison, W. J., Pearson, K. R. (1996) Computing Solutions for Large General Equilibrium Models Using GEMPACK, *Computational Economics*, 9: 83-127.

Haug, A. A. (1996) Test for Cointegration, A Monte Carlo Comparison, *Journal of Econometrics*, 71: 89-115.

Hausman, J. A. (1978) Specification Test in Econometrics, *Econometrica*, 46(6): 1251-1272.

Holyoake, J. (2002) *Insurance* (Financial World Publishing).

Hertel, T. W. (1997) *Global Trade Analysis: Modelling and Application* (Cambridge: Cambridge University Press).

Im, K. S., Pesaran, M. H., and Shin, Y. (1997) *Testing for Unit Roots in Heterogeneous Panels*, Department of Applied Econometrics, University of Cambridge.

Imbs, J., and Wacziarg, R. (2003) Stages of Divercification, *The American Economic Review,* 93(1): 63-86.

Jacob, V., Sharma, S. C., and Grabowski, R. (1997) Capital Stock Estimates for Major Sectors and Disaggregated Manufacturing in Selected OECD Countries, *Applied Economics,* 29: 563-579.

Johansen, S. (1988) Statistical Analysis of Cointegration Vectors, *Journal of Economic Dynamic and Control*, 12: 231-54.

Johansen, S. (1992) Determination Cointegration Rank in the Presence of a Linear Trend, *Oxford Bulletin of Economics and Statistics*, 54: 383-397.

Johansen, S., and Juselius, K. (1990) Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money, *Oxford Bulletin of Economics and Statistics*, 52: 169-210.

Karlsson, S., and Lothgren, M. (2000) On the Power and Interpretation of Panel unit Root Tests, *Economics Letters,* 66:249-55.

King, R. G., and Levine, R. (1993) Finance and Growth: Schumpeter Might Be Right, *Quarterly Journal of Economics,* 108: 717- 737.

Konan, D. E., and Maskus K. E. (2006) Quantifying the Impact of Services Liberalization in a Developing Country, *Journal of Development Economics,* 81: 142- 162.

Larsson, R., Lyhagen, J., and Lothgran, M. (2001) Likelihood-based Cointegration Tests in Heterogeneous Panels, *Econometrics Journal,* 4: 109-41.

Levin, A., and Lin, C. F. (1993) *Unit Root Test in Panel Data: New Results,* University of California at San Diego, Discussion Paper No. 93-56.

Levine, R., Loayza, N. and Beck, T. (2000) Financial Intermediation and Growth: Causality and Causes, *Journal of Monetary Economics*, 46: 31-77.

Levine, R. and Zervos, S. (1998) Stock Market, Banks, and Economic Growth, *American Economic Review,* 88: 537-558.

Maddala, G. S., and Kim, I. (1998) *Unit roots, Cointegration and Structural Change* (Cambridge: Cambridge University Press).

Maddala, G. S., and Wu, S. (1999) A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test, *Oxford Bulletin of Economics and Statistics*, 61, 631-652.

Manning, M.J. (2002) Finance Causes Growth: Can We Be So Sure?, *Contribution to Macroeconomics,* Vol. 3 : Issue 1, Article 12.

Matto, A., Rathindran, R., and Subramanian, A. (2006) Measuring Services Trade Liberalization and its Impact on Economic Growth: an Illustration, *Journal of Economic Integration*, 21(1): 64-98.

McCaig, B., and Stengos, T. (2005) Financial Intermediation and Growth: Some Robustness Results, *Economics Letters,* 88: 306-312.

McCoskey , S., and Kao, C. (1998) A Residual-Based Test of the Null of Cointegration in Panel Data, *Econometric Reviews,* 17, 57-84.

Merkin, R., and Rodger, A. (1997) *EC Insurance Law* (New York: Addison Wesley Longman).

Moran, P.A.P. (1948) The Interpretation of Statistical Maps, *Biometrika,* 35: 255-60.

Nelson, C. R., and Plosser, C. I. (1982) Trends and Random Walks in Macroeconomic Time Series: Some Evidence and Implications, *Journal of Monetary Economics*, 10(2): 139-162.

Neusser, K., and Kugler, M. (1998) Manufacturing Growth and Financial Development: Evidence from OECD Countries, *Review of Economics and Statistics*, 80(4): 638-646.

Newey, W. K., and West, K. D. (1994) Automatic Lag Selection in Covariance Matrix Estimation, *Review of Economic Studies*, 61(4): 631-653.

Ng, S., and Perron, P. (1995) Unit Root Test in ARMA Models with Data-Dependent Methods for the Selection of the Truncation Lag, *Journal of the American Statistical Association*, 90: 268-281.

Ng, S., and Perron, P. (2001) Lag Length and the Construction of Unit Root Tests with Good Size and Power, *Econometrica*, 69(6): 1519-1554.

Nomura, K. (2004), *Measurement of Capital and Productivity*, (Keio University Press, Page 633).

Obstfeld, M. (1994) Risk-Taking, Global Diversification, and Growth, *American Economic Review,* 84(5): 1310-1329.

Osterwald-Lenum, M. (1992) A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics, *Oxford Bulletin of Economics and Statistics*, 54(3): 461-472.

Outreville, J. F. (1990) The Economic Significance of Insurance Markets in Developing Countries. *Journal of Risk and Insurance*, 57(3): 487-498.

Patrick, H. (1966) Financial Development and Economic Growth in Underdeveloped Countries, *Economic Development and Cultural Change*, 14: 174-189.

Pedroni, P. (1997) Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests, with an Application to the PPP Hypothesis: New Results, Working Paper, Indiana University, April.

Pedroni, P. (1999) Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors, *Oxford Bulletin of Economics and Statistics,* Special issue, 0305-9049.

Pedroni, P. (2004) Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis, *Econometric Theory*, 20: 597-625.

Perron, P., and Campbell, J. Y. (1993) A Note on Johansen's Cointegration Procedure When Trends Are Present, *Empirical Economics*, 18: 777-789.

Pesaran, M.H. (2004) General Diagnostic Tests for Cross Section Dependence in Panels, *Cambridge Working Papers in Economics,* 0435.

Phillips, P. C. B., and Perron, P. (1988) Testing for a Unit Root in Time Series Regression, *Biometrika,* 75(2): 335-346.

Pyo, H. K. (1988) Estimates of Capital Stock and Capital/Output Coefficients by Industries: Korea (1953-86), *International Economic Journal,* 2(3): 79-121.

Robinson, S., Wang, Z., and Martin W. (2002) Capturing the implications of Services Trade Liberalization, *Economics System Research*, 14(1): 3-33.

Roson, R. (2006) *Introducing Imperfect Competition in CGE Models: Technical Aspects and Implications*, Fondazione Eni Enrico Mattei working papers, 2006.3.

Said, S. E., and Dickey, D. A. (1984) Testing for Unit Roots in Autoregressive Moving-average Models of Unknown Order. *Biometrika*, 71(3): 599-607.

Sargan, J.D., and Bhargava, A. (1983) Maximum Likelihood Estimation of Regression models with First Order Moving Averages Errors when the Roots Lies on the Unit Circle, *Econometrica,* 51: 799-820.

Shan, J. (2005) Does Financial Development lead Economic Growth? A Vector Auto-regression Appraisal, *Applied Economics,* 37: 1353-1367.

Shan, J., Morris, A. G., and Sun, F. (2001) Financial Development and Economic Growth: An Egg-and-Chicken Problem? *Review of International Economics,* 9: 443-454.

Shan, J., and Morris, A. G. (2002) Does Financial Development lead Economic Growth?, *International Review of Applied Economics,* 16: 153-168.

Skipper, H. D. (1998) *International risk and insurance: An environmental-managerial approach* (McGraw-Hill).

Skipper, H. D. (2001) *Insurance in the general agreement on trade in services* (American Enterprise Institute).

Stiglitz, J. E. and Charlton, A. (2005) *Fair Trade for All* (Oxford: Oxford University Press).

Taylor, M.P., and Sarno, L. (1998) The Behaviour of Real Exchange Rates During the Post Bretton Woods Period, *Journal of International Economics,* 56: 281-312.

Toda, H. Y., and Yamamoto, T. (1995) Statistical Inference in Vector Autoregressive with possibly Integrated Process, *Journal of Econometrics*, 66:225-250.

Trew, A. (2006) Finance and Growth: A Critical Survey, *The Economic Record*, 82(259): 481-490.

Truett, D.B., and Truett, L.J. (1990) The Demand for life insurance in Mexico and the United States: a comparative study, Journal of Risk and Insurance, 57: 321–328.

Verbeek, M. (2004) *A guide to modern econometrics* (John Wiley and Sons Ltd Publishers).

Verikios, G. and Zhang, X., (2003) Liberalising Trade in Financial Services: Global and regional Economic Effects, *Journal of Economic Integration*, 18(2): 307-335.

Ward, D., and Zurbruegg, R. (2000) Does Insurance Promote Economic Growth? Evidence from OECD Countries, *Journal of Risk and Insurance*, 67(4): 489-506.

Webster, A. and, Hardwich, P. (2005) International Trade in Financial Services, *The Service Industries Journal*, 25(6): 721-746.