The interaction between human capital, foreign trade and economic growth: an empirical approach.

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ABSTRACT

Along this dissertation we present five distinct studies, following different approaches but all with a common element: they take into account the impact of foreign trade on growth, the relevance of the balance-of-payments as a constraint to growth and the linkages between human capital and external trade.

The study begins with the analysis of the role of human capital and foreign trade on the growth of several sets of countries (World, high-, middle- and low-income countries, Europe, OECD and the EMU countries), between 1980 and 2000. The human capital proxies used take into account quantitative and qualitative aspects to measure their impact on growth. The degree of openness and the net foreign balance are used as proxies for external trade to reveal their importance on growth as well. The interaction between human capital and foreign trade measures allows us to investigate the existence of technology and knowledge transfers, through trade.

We also consider the EU set of countries checking for the existence of conditional convergence over the period 1980 to 2004. In this part we try to reconcile the neoclassical and Post-Keynesian theories of growth at least at the empirical level. To do so, we introduce into the neoclassical growth model the ratio of the income-elasticity of the demand for exports over that of imports, to test the importance of the balance-of-payments constraint hypothesis on growth. It is shown that this demand factor fits well into the supply-orientated growth model even for countries with a single currency and a common monetary policy implying fixed exchange rates.

The study extends the growth analysis to the regional level and focuses on Portugal over the period 1996 to 2005. The intention is to analyse the growth process among the NUTS3 regions and the relevance of human capital and regional foreign trade for regional growth. The share of employment in the main activity sectors is also considered to verify whether labour sectoral allocation is important for regional growth. Additionally, we check for the existence of joint effects between human capital and foreign trade on regional growth and examine the differences between the *Littoral* and the *Interior* zones.

Furthermore, we use the balance-of-payments constraint approach to explain the growth performance of the Portuguese economy over the last four decades. We employ "Thirlwall's Law" to predict actual growth in Portugal over the whole period and various overlapping periods and the McCombie test is implemented to test the accuracy

of the Law. Differences in the growth performance between the pre- and post-accession periods are considered and it is shown that Portugal grew slower when joined the EU. This finding is combined with a higher income-elasticity of demand for imports and a slower growth of exports in the latter period.

In the final part of the study we analyse a simultaneous equation model of growth with circular and cumulative causation characteristics. The model uses a demand-orientated approach to determine the relationships among the investment-output ratio and the growth of domestic income, exports, prices and productivity. The idea is to identify the driving forces of growth, with causal linkages that turn the process self-sustained. We are especially interested in the performance of Portugal, for the 1965-2006 period. The results show that there are three main breaks that obstruct the complete functioning of the circular and cumulative process, namely: (i) the investment-output ratio does not positively and significantly affect productivity growth; (ii) productivity growth is apparently not relevant for the growth of domestic price and (iii) price growth does not affect export growth. Therefore, there are essential links in the cumulative process that fail to generate faster growth in Portugal.

The general conclusion of the study is that foreign trade is essential for growth both at the individual country level and at the regional level. Foreign trade can be properly combined with human capital measures, and both affect the growth process significantly being in line with the knowledge and technology diffusion hypothesis. Balance-of-payments problems can also restrain growth and cannot be ignored when the aim is to explain growth. If a country wishes to growth faster it has to improve its competitiveness by turning its products more attractive, both in the domestic and external markets by improving the supply characteristics associated with the non-price features. Also, the competitiveness of an economy is highly associated with human capital qualifications.

RESUMO

Ao longo desta dissertação apresentamos cinco estudos distintos, seguindo diferentes abordagens mas com um ponto em comum: analisam o impacto do comércio externo sobre o crescimento, o papel da balança de pagamentos enquanto restrição ao crescimento e as ligações entre capital humano e comércio internacional.

Iniciamos o nosso estudo com a análise do papel do capital humano e do comércio externo no crescimento, para diversos grupos de países (Mundo, países de rendimento elevado, médio e baixo, Europa, OCDE e UEM), entre 1980 e 2000. As *proxies* de capital humano utilizadas relacionam-se quer com aspectos quantitativos, quer qualitativos, e como indicadores de comércio externo consideramos o grau de abertura e a balança comercial. A combinação de medidas qualitativas do capital humano com indicadores de comércio externo permite-nos investigar a existência de transferências de tecnologia e de conhecimento, que ocorrem através das relações comerciais.

Seguidamente, centramos a nossa análise no grupo de países da UE e averiguamos a existência de sinais de convergência condicional entre 1980 e 2004. Nesta parte, tentamos reconciliar em termos empíricos as teorias neoclássica e Pós-Keynesiana de crescimento. Com esse propósito, incluímos o rácio das elasticidades-rendimento do comércio externo na equação de crescimento, para testar a importância da hipótese da balança de pagamentos enquanto possível restrição ao crescimento.

Numa fase posterior, estendemos a análise do crescimento ao nível regional e focamo-nos em Portugal, no período 1996-2005. A intenção é analisar o processo de crescimento entre as regiões NUTS3 e a importância do capital humano e do comércio externo no crescimento regional. A percentagem de trabalhadores empregados nos principais sectores de actividade é também considerada para verificar se a afectação sectorial do emprego é importante para o crescimento regional. Adicionalmente, analisamos a existência de efeitos conjuntos do capital humano e comércio externo no crescimento regional e examinamos as diferenças entre o Litoral e o Interior.

Mais adiante no estudo, utilizamos a abordagem da balança de pagamentos enquanto restrição ao crescimento, para explicar a evolução da economia portuguesa em termos de crescimento, ao longo das últimas quatro décadas. Utilizamos a "Lei de Thirlwall" enquanto indicador para antever o crescimento no período global e em vários períodos sobrepostos e aplicamos o teste de McCombie para verificar a eficácia da Lei.

Observam-se diferenças ao nível do crescimento económico quando se comparam os períodos pré e pós-adesão à UE e mostra-se que Portugal cresceu a um ritmo menor após a adesão. Este facto conjuga-se com uma elasticidade-rendimento das importações mais elevada e um menor crescimento das exportações neste segundo período.

Na última parte do estudo analisamos um modelo de crescimento com equações simultâneas e com características de causalidade circular e cumulativa. O modelo utiliza uma abordagem centrada na procura, para determinar as relações existentes entre o rácio investimento-output e o crescimento do rendimento interno, das exportações, dos preços e da produtividade. A ideia é identificar as forças orientadoras do crescimento, com as ligações causais que tornam o processo auto-sustentado. Estamos especialmente interessados no desempenho da economia portuguesa durante o período 1965-2006. Os resultados demonstram que há três falhas essenciais que impedem o funcionamento completo do processo circular e cumulativo, a saber: (i) o rácio investimento-output não afecta de forma positiva e significativa o crescimento da produtividade; (ii) o crescimento da produtividade não é aparentemente relevante para explicar o crescimento dos preços domésticos e (iii) o crescimento dos preços não afecta o crescimento das exportações. Deste modo, há ligações no processo cumulativo que, ao falhar, não permitem atingir um maior crescimento em Portugal.

Em termos gerais, concluímos que o comércio externo é essencial para o crescimento quer ao nível nacional quer regional. O comércio externo pode ser adequadamente combinado com medidas de capital humano, com ambos a afectarem o processo de crescimento significativamente, em linha com a hipótese de difusão tecnológica e de conhecimento. A balança de pagamentos também pode funcionar como um constrangimento e não pode ser ignorada quando o objectivo é explicar o crescimento. Se um país pretende crescer mais rapidamente, tem que apostar em melhorar a competitividade, tornando os seus produtos mais atractivos quer no mercado doméstico, quer no mercado externo. Para atingir esse objectivo, terá que aperfeiçoar as características relacionadas com a oferta, associadas a aspectos não-preço. Por outro lado, a competitividade de uma economia está igualmente intimamente associada às qualificações do capital humano.

CONTENTS

LIST OF TABLES

CHAPTER 1. WHICH COMBINATION OF HUMAN CAPITAL AND FOREIGN TRADE MATTERS FOR GROWTH: EMPIRICAL EVIDENCE ACROSS COUNTRIES

CHAPTER 2. FOREIGN TRADE, HUMAN CAPITAL AND ECONOMIC GROWTH: AN EMPIRICAL APPROACH FOR THE EU COUNTRIES.

CHAPTER 3. THE IMPORTANCE OF FOREIGN TRADE ON REGIONAL GROWTH: EMPIRICAL EVIDENCE FROM PORTUGAL.

CHAPTER 4. HOW WELL THE BALANCE-OF- PAYMENTS CONSTRAINT APPROACH EXPLAINS THE PORTUGUESE GROWTH PERFORMANCE. EMPIRICAL EVIDENCE FOR THE 1965-2008 PERIOD.

CHAPTER 5. GROWTH PERFORMANCE IN PORTUGAL SINCE THE 1960's: A SIMULTANEOUS EQUATION APPROACH WITH CUMULATIVE CAUSATION CHARACTERISTICS.

LIST OF FIGURES

CHAPTER 2. FOREIGN TRADE, HUMAN CAPITAL AND ECONOMIC GROWTH: AN EMPIRICAL APPROACH FOR THE EU COUNTRIES.

CHAPTER 3. THE IMPORTANCE OF FOREIGN TRADE ON REGIONAL GROWTH: EMPIRICAL EVIDENCE FROM PORTUGAL.

CHAPTER 4. HOW WELL THE BALANCE-OF- PAYMENTS CONSTRAINT APPROACH EXPLAINS THE PORTUGUESE GROWTH PERFORMANCE. EMPIRICAL EVIDENCE FOR THE 1965-2008 PERIOD.

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INTRODUCTION

If we could resume our study in a few key-concepts, they would be *economic growth, foreign trade, human capital, balance-of-payments constraint* and *circular and cumulative causation principle.*

We start by introducing the two main theories explaining the most important determinants of growth: the supply-orientated approach related to the neoclassical and the endogenous growth models, emphasising the role of the supply of input factors for the growth process; and the demand-orientated perspective associated with the Post-Keynesian export-led growth models and the cumulative causation models, arguing that growth is limited by demand, especially external demand.

The neoclassical approach to convergence is derived from the Solow's model of the production function with diminishing marginal returns to capital and exogenous technical progress. This approach predicts that poorer economies tend to grow faster than richer ones in earlier stages of economic development and then in the long-run they all grow at similar rates. A crucial assumption of this model is the law of diminishing returns to capital, assessing that economies with lower stock of physical capital grow faster relatively to the more developed economies where capital stock is higher and the returns to investment are lower. According to this approach, convergence is assumed to be unconditional to a common steady-state for all economies and more likely to occur for a set of economies with similar economic and institutional characteristics. The neoclassical approach of absolute convergence was unable to explain the growing asymmetries between economies, except for the case of a group of economies with similar structures. Thus, the endogenous growth theories emerge as an attempt to reconcile theory with empirical evidence, dealing with a new concept of convergence – the conditional convergence.

In this case, convergence is assumed to be conditioned by some structural factors with increasing returns to scale properties, coming mostly from human and physical capital accumulation, technological progress and innovation. These factors offset the diminishing returns on physical capital and lead the economies to converge to different steady-states determined by idiosyncratic characteristics. Convergence only takes place when economies are able to develop activities with increasing returns to scale characteristics, and it is only found after differences in the steady-states across economies are controlled for.

The neoclassical approach and the endogenous growth theories have been criticised as being more consistent with a closed economy by not considering explicitly

the trade effects on growth and trade deficits as impediments to growth. In fact, endogenous growth models focus essentially on the role of human capital and technological activities and international trade plays a secondary role on growth.

Conversely, the Keynesian approach argues that it is demand that guides the economic system and supply simply adapts to it, within certain limits. The well-known export-led growth hypothesis is part of this demand-orientated approach, and it supports the notion that exports are the engine of growth. Accordingly, different growth rates are explained by dissimilar growth of demand among economies and that diversified growth behaviour is ultimately constrained by the balance-of-payments position. If a country wishes to grow faster, then it must alleviate the balance-of-payments constraint, which is the main limitation to demand's growth.

The five Chapters that form this dissertation are presented in an autonomous, though interrelated, way. In the three first Chapters our starting point is the augmented neoclassical growth equation, to which we add foreign trade and human capital indicators. In the second Chapter we include as well the income-elasticity ratio of foreign trade, in line with the demand-led growth theory. The two first Chapters deal with growth among countries and the third one, among the Portuguese regions. The fourth Chapter is entirely on "Thirlwall's Law" and the last one is about the circular and cumulative causation model, applied to Portugal and in line with the Post-Keynesian demand-driven approach to growth.

Our analysis begins in Chapter 1, with human capital and foreign trade as the main factors for explaining growth rates among countries. Our aim is to contribute to the growth debate using the augmented neoclassical growth model to investigate whether the degree of openness of a given country, as well as its net trade, contribute to economic growth.

Along with the trade variables, human capital is also taken into account to be consistent with the endogenous growth theory, due to its relevance in developing innovation and R&D activities. With respect to human capital, four measures are considered, namely: the average years of schooling of adult population, the publication rate, the patents rate and the patents/articles ratio to control for scientific production and innovation capacity. Human capital measures are important for determining the competitiveness of an economy and international trade has an important role to play in the process of technology diffusion. Therefore, the combinations of trade and human

capital indicators are important factors to differentiate the economies and to explain the path of growth and convergence.

We implement a dynamic panel data approach to a sample of 78 countries for the period 1980-2000. The full sample of countries is divided into three main sub groupings according to their per capita income level: the samples of high-, middle- and low-income countries. The scope of this partition is to check the differences among the sub groupings of countries and find which proxies of foreign trade and human capital better explain the growth path. Additionally, we analyse whether more homogeneous groups of economies like those of Europe, OECD and EMU, experience similar growth patterns.

We also check whether the knowledge and technology diffusion hypothesis is a reasonable assumption in our model, considering interaction effects between human capital and the degree of openness, for the highly-integrated groups of countries of Europe and the OECD.

In Chapter 2, we follow a similar approach, for the EU countries and during the period 1980-2004. The novelty is that now we introduce the balance-of-payments constraint hypothesis into the supply-driven neoclassical growth model, as an attempt to reconcile both theories, at least at the empirical level. To take into account the balance-of-payments constraint hypothesis, we add the income-elasticities ratio of foreign trade to the neoclassical growth equation to verify whether balance-of-payments problems are important even for countries that implement common policies, share a single currency and experience a high degree of economic integration.

Like previously, a panel data growth model is estimated using different proxies for human capital and foreign trade. Average years of schooling, as well as publications, patents and a combined patents/articles ratio, are used to capture different levels of human capital. Additionally, the degree of openness, the net foreign balance and the income-elasticity ratio with respect to exports and imports are expected to capture the effects of trade intensification and competitiveness on growth. We investigate the existence of a technology diffusion mechanism occurring through trade. Moreover, we check whether there are joint effects between openness and the income-elasticity ratio over growth, indicating in that case that balance-of-payments problems can affect the growth performance.

After showing that foreign trade is important for explaining growth rates among countries, the analysis in Chapter 3 concentrates on a regional level, with reference to

the Portuguese NUTS3 regions in the period 1996-2005. It is argued that when a region faces an external deficit, capital flows from the central government can solve this problem. We do not share this argument for the main reason that these flows can promote inefficiency in terms of the optimal reallocation of resources and cannot be sustainable in the long-term. Structural solutions are required to turn the regions more competitive, by allocating resources to sectors with increasing returns to scale properties and encouraging the production of goods with high income-elasticity of demand in international markets.

The effects of international trade on regional growth and regional trade deficits as obstacles to economic expansion have not been considered in great extent in the literature, at least to our knowledge. Therefore, our aim is to contribute to the literature, examining whether the degree of openness or the trade balance are relevant for explaining regional growth in Portugal.

Together with external trade indicators, human capital is also considered in the neoclassical growth model as a conditioning factor of growth, expressed by the rate of success in high school. Thus, we analyse whether the combination of international trade measures and human capital is relevant for explaining regional growth in Portugal and how it affects the convergence process among regions. We add interaction terms to explore the existence of different performances between the regions of the *Littoral* and the *Interior*. We also consider the share of employment in the secondary sector as a conditioning factor of growth, as an alternative to the annual population growth rate.

In Chapter 4 the purpose is to verify whether the balance-of-payments constrained growth approach from the Post-Keynesian theory is suitable for explaining the Portuguese growth performance during the last decades. For that, we adopt "Thirlwall's Law" that predicts actual growth by the ratio of the export growth relative to the income-elasticity of the demand for imports, assuming that there are no capital inflows and relative prices are constant in the long-term.

The income-elasticity of demand for imports, essential for the entire analysis, is obtained from the estimation of the import function assuming that domestic growth is endogenous, either for the whole period or for each of the overlapping periods. The McCombie test is carried out at a final stage to show how accurate is the Law. Further, we divide our analysis in two distinct phases, the pre- and post-accession periods to the EU, and make a comparative analysis regarding the evolution of the growth of income, exports, imports and relative prices.

In the last Chapter we carry out our analysis by considering a system of simultaneous equations for the Portuguese economy, for the 1965-2006 period. Our model is formed by five equations, aiming to explain: domestic income growth, export growth, domestic price growth, productivity growth and the investment-output ratio. The idea is to estimate simultaneously all equations and to detect important linkages able to generate a cumulative growth process with expanding tendencies. The multi-equation growth model is estimated by *3SLS* to capture the interrelations between the main growth forces more efficiently and to control for the endogeneity of the regressors. We check for the existence of a significant impact of the Verdoorn's effect. A special emphasis is given to the productivity gap between Portugal and the leader (the USA), capturing the possible occurrence of a catch-up in technology activities. With this model, we intend to verify whether the Portuguese economic growth can be explained by our structural model.

CHAPTER 1. WHICH COMBINATION OF HUMAN CAPITAL AND FOREIGN TRADE MATTERS FOR GROWTH: EMPIRICAL EVIDENCE ACROSS COUNTRIES. *

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1.1. INTRODUCTION

The convergence phenomenon has been highlighted by several economists trying to explain the persistence and even reinforcement of the differences in the levels of development among countries and among regions of the same nation through time (Grossman and Helpman, 1991 a).

The neoclassical approach to convergence is derived from the Solow's (1956) model of the production function with diminishing marginal returns to capital and exogenous technical progress. This approach predicts that poorer economies[1] tend to grow faster than richer ones in earlier stages of economic development and then in the long-run they all grow at similar rates. The explanation for this long-run convergence is found on the law of diminishing returns to capital, assessing that economies with lower stock of physical capital (poor economies) grow faster relatively to the more developed economies where capital stock is higher and the returns to investment are lower.

According to this approach, convergence is assumed to be unconditional (or absolute) to a common steady-state for all economies and more likely to occur for a set of economies with similar economic and institutional characteristics. Another interpretation of the absolute convergence hypothesis is that the higher the distance from the steady-state the faster the speed of convergence is expected to be found. Then, in the long-run, all economies are expected to grow at similar rates.

The neoclassical approach of absolute convergence was unable to explain the ever growing asymmetries between economies, except for the case of a group of economies with similar structures. The unsatisfactory results from absolute convergence gave rise to a new concept of convergence, known as conditional convergence developed by the theory of endogenous growth (Barro, 1991 and Sala-i-Martin, 1994, among others).[2]

Convergence is assumed to be conditioned by some structural factors with increasing returns to scale properties, coming mostly from human and physical capital

1 By economies we refer either to countries or regions.

2 Although Galor (1996) clearly argues that the neoclassical approach cannot be confounded with the absolute convergence hypothesis, for simplification purposes, and in line with most authors, we associate the neoclassical framework with absolute convergence and the endogenous growth models with the conditional convergence hypothesis.

accumulation, technological progress and innovation. Economies converge to different steady-states determined by idiosyncratic characteristics (Barro and Sala-i-Martin, 2004). Convergence is not the rule, but rather the exception, occurring when economies are able to develop activities with increasing returns to scale characteristics, and it is only found after differences in the steady-states across economies are controlled for.

In the empirical growth literature a variety of conditional factors has been tested to check its relevance on growth and some of the most important are considered to be the rates of investment, human capital, technological progress and innovation activities. Given that endogenous growth models focus essentially on the role of human capital and technological activities, international trade was not explicitly considered in growth models, at least in the initial phase. Therefore, we will give relevance to the combination of human capital and trade, arguing that they influence each other and reinforce the impact that each has on economic growth.

The purpose of this study is to contribute to the debate on the role of human capital and international trade as determinants of growth. Human capital is crucial, especially due to its impact on the rate of innovation and its role on R&D activities. Assuming that trade is one of the possible channels through which technology is transferred, it is interesting to examine whether the combination of human capital and trade openness (or net trade) enhances growth.

The outline of this Chapter is the following: in section 1.2, the importance of human capital and technology for growth is discussed. Section 1.3 explains the links between international trade and growth, and a special attention is given to the technology diffusion through trade in section 1.4. The growth model, the variables and the estimation technique are explained in section 1.5. In section 1.6 the results from the estimations are discussed and section 1.7 concludes the main outcomes.

1.2. THE ROLE OF HUMAN CAPITAL AND TECHNOLOGY ON GROWTH

The models of endogenous growth confer a special role to human capital (Barro, 1991). The influence of this variable on growth was pointed out by authors like Lucas (1988), Mankiw et al. (1992) and Islam (1995), who developed theoretical models to incorporate human capital as an additional factor of growth and tested its impact empirically. Human capital contributes to increase the productivity of both human and physical capital and may either be acquired through schooling or learning-by-doing processes (Lucas, 1988; Romer, 1990). Since economies differ in their human capital endowments, it is relevant to analyse whether it is an appropriate factor to explain disparities across economies, concerning growth paths.

Lucas (1988) and Mankiw et al. (1992) explicitly suggested the inclusion of human capital in the production function as a way to control for the high values of the elasticity of output with respect to capital found in previous studies, and to improve the fit of the growth regressions. The Solow's model was considered to be consistent with international empirical evidence, if the importance of both physical and human capital was recognised. Furthermore, about 80% of the international variation in per capita income was attributed to only three variables: the population growth rate and the rates of investment on both physical and human capital.

Barro (1991) observed that holding the flow of investment on human capital constant, the negative relationship between economic growth and the initial level of per capita income became more significant. Moreover, human capital showed to have a positive relationship with the growth of output and a negative one with fertility.[3] Whenever international mobility of capital and technology was allowed for, the tendency for poor countries to catch-up with rich ones was reinforced.

The technology's ability to grow indefinitely when compared to human capital is the reason why for some authors it is the accumulation of technological change the key factor for growth (Romer, 1986; 1990; Grossman and Helpman, 1991 a; Di Liberto, 2005). According to this approach, the human capital stock raises the rate of technological innovations (in developed countries) and increases the ability to adopt and implement new technologies from abroad (in the developing world). Thus, human capital is one of the dimensions of the social capability which may enhance a country to

3 See also Castelló-Climent (2005).

adopt foreign technology and to catch-up with the technological leader (Abramovitz, 1986; Benhabib and Spiegel, 2003).

Romer (1990) stressed the role of human capital in the research sector. In fact, it is in the R&D sector that new products and ideas are conceived to promote growth and therefore, the greater the initial stock of human capital of a country, the faster it will grow.

The non-rival property of technology implies the existence of knowledge spillovers, increasing returns and externalities.[4] The non-excludability degree depends both on the kind of knowledge produced and on the mechanisms protecting property rights. For the growth theory, it is the concept of partial excludability that matters, being closely linked to property rights protection through mechanisms like the patent. Profit incentives to the R&D sector are thus determinant for the growth rate (Grossman and Helpman, 1991b).

Sedgley (1998) considered the patent, R&D activities and the number of scientists and engineers as measures of innovation. Evidence was found of a positive impact of the innovative activity (proxied by the number of patents) on growth across the US states. However, when the human capital stock at the beginning of the period was added to the regression it lacked statistical significance and thus the author concluded for the impossibility to distinguish the stock of knowledge from the stock of human capital.

Although R&D activity encompasses a crucial role on investment, some form of decreasing returns in the R&D sector has to be assumed, to understand why the increase in human capital and research efforts during the last decades in most developed countries has not been reflected into accelerating growth rates (Di Liberto, 2005). Romer (1986) had already pointed out that the existence of diminishing returns in the production of knowledge was necessary to prevent consumption and utility from growing too rapidly.

Human capital and sources of technological progress are found to be some of the most important structural factors to differentiate the economies in their growth process. Whether they are considered in terms of growth rates or levels depends on the approach undertaken.

4 See Grossman and Helpman (1991 a) and Temple (1999).

Another relevant aspect is the importance of the quality of human capital for growth. Ciccone and Papaioannou (2006) used an index based on results in mathematics and science tests to measure labour force quality. For 37 industries in 42 countries in the 1980's, the authors concluded that quality matters more for growth in industries that use schooling intensively. Additionally, the schooling quantity interaction term becomes insignificant when human capital quality is considered. Also, in countries with low tariffs, the human capital level effect on growth is positive and highly significant when it is proxied with schooling quality.

In this study, we use different proxies to capture the efficiency of human capital related to scientific production and innovation activities. We intend to investigate whether different levels of human capital have different effects on growth depending on the level of economic development. Higher levels of human capital are expected to be more important to explain the growth rates of the more developed economies, whereas basic education levels are considered to differentiate better the growth path of the less developed ones (Soukiazis and Cravo, 2008).

1.3. THE ROLE OF INTERNATIONAL TRADE ON GROWTH

The role of international trade for a country's growth performance became visible for the first time in Adam Smith's essay on labour specialisation and it has been widely discussed by economists, especially due to the different paths of economic growth observed for several industrialised countries from the 1950's onwards. Moreover, the issue of how human capital and technology are influenced by trade openness remains a rather interesting subject in the growth literature.

Contrary to the neoclassical approach, that does not present a formal theory concerning the possible impact of the balance-of-payments on a country's growth performance, the Keynesian view asserts that variations in demand (especially external demand) are the main forces of economic growth. Demand is able to generate its own supply by encouraging investment, absorbing underemployment and raising productivity growth, among others.

According to the demand-orientated approach, differences in growth rates are explained by differences in growth of demand among economies, which in turn can be constrained by the balance-of-payments, in case of high deficits in the trade balance, thus restraining growth (Thirlwall, 1979). The analysis of the relationship between international trade affairs and growth has been carried out mainly through exports, considered to be the most important element of exogenous demand.[5] The impact of exporting activities on growth takes place by means of a virtuous cycle with cumulative characteristics, where productivity is endogenous as Myrdal (1957) early noted.

Several studies have tried to identify the sign and the direction of causality between exports and output growth.[6] A common pointed limitation to this type of studies has to do with simultaneity, which must be accounted for by the researcher.[7] Additionally, despite exports being commonly used in growth studies, the interpretation should be in terms of the relationship between trade (instead of exports) and growth (Levine and Renelt, 1991).

5 A summary of why exports are the most potent element of demand can be found in Soukiazis and Madaleno (2007).

6 Among them are the works of Thirlwall (1978), Kaldor (1980), McCombie (1981), Bairam (1988) and Léon-Ledesma (1999).

7 See Kader (1986), Serletis (1992), Marin (1992) and Atesoglu (1995).

Due to the difficulty in finding some way of quantifying trade regimes, researchers often fall back on simple proxies for openness, such as the degree of openness, given by the ratio of international trade to GDP, due to its simple computation (Temple, 1999), despite not taking into account determinants of trade intensity such as tastes, resource endowments and other natural barriers (Pan, 1999). However, it is easily computable for a variety of countries and we use this indicator in section 1.5.

There are also other trade volume measures, such as the export ratio, the import ratio, the total trade with OECD and non-OECD countries, the ratio of a country's total bilateral trade with the USA to GDP and the population density (Yanikkaya, 2003). The use of alternative indicators for trade openness becomes conditioned on the availability of data and some authors have proceeded with trade restrictions instead.[8] This is a comprehensive argument, since governments may have a role to play, either due to foreign exchange or trade policies. However, these instruments have to be dealt within a context of higher globalisation and regional integration tendencies and thus their relevance has to be analysed in that perspective. Moreover, the net foreign balance is also introduced in the growth regression to examine whether it affects growth significantly.

8 Henrekson et al. (1997), Pan (1999) and Yanikkaya (2003) are some of those authors.

1.4. TRADE OPENNESS AND TECHNOLOGY DIFFUSION

The analysis of the role of trade on growth is extremely relevant because while it enables technological spillovers that guide to convergence, it may also provoke divergence ought to specialisation by the law of comparative advantages (Di Liberto, 2005).

Trade affects growth through several channels, namely the impact on technology transfers, scale economies – by the law of comparative advantages -, innovation, R&D activities and the exchange of information and knowledge among the trading partners (Grossman and Helpman, 1991 b; Yanikkaya, 2003; Di Liberto, 2005). In fact, international trade is considered to be a privileged channel of transmission of R&D spillovers, namely through the acquisition of intermediate products and capital equipment containing foreign knowledge, learning from other countries and imitation or innovation activities (Coe et al., 1997). Despite the existence of technology transfers enabled by the human capital stock, not all countries are capable of adopting foreign technologies from abroad, due to barriers like financial constraints and trade policies.

The role of international trade in the diffusion of technology has been emphasised in several studies of economic growth (Dowrick and Nguyen, 1989; Dollar, 1992; Lin and Wong, 1997; Coe et al., 1997; Eaton and Kortum, 2004; Economidou et al., 2006; Teixeira and Fortuna, 2006; Cavallaro et al., 2008), within a perspective of increasing returns and cumulative causation (Fingleton and McCombie, 1998). Those countries trading more intensively with foreign economies are more likely to acquire know-how and reach or even surpass per capita income levels of the more advanced trading partners. Moreover, learning productivity is raised by the familiarity with the foreign economy (Goodfriend and McDermott, 1998).

Temple (1999) points out evidence in favour of decreasing income dispersion among countries linked by trade, partly due to the closing of technology gaps. Therefore, free trade is understood as affecting convergence not only through the price mechanism (Temple, 1999) but also because technologically advanced traded goods and new ideas accelerate technological diffusion among countries (Tondl, 2001).

Openness is an incentive for countries to engage in innovation activities and therefore an additional long-term growth effect is present. A link can thus be established among openness, human capital and technological change. The stock of human capital

is more likely to be engaged in R&D activities than the non-specialised workforce. The accelerating rate of innovation enabled by R&D activities is further stimulated by the existence of an international market where new products can be traded and technology diffusion promoted.

Linked to this line of research regarding connections among trade, human capital and growth stands the subject of economic integration. Economic integration with free trade of both goods and ideas and knowledge spillovers results on faster growth rates of output, due to the enlargement of the market and the increase in efficiency in the R&D sector, whenever similar economies are considered.[9] Romer (1990) had already pointed the benefits of trade among similar economies, arguing that it would promote a better reallocation of resources used in research, thus avoiding redundancy in the R&D sector.

Trade policy has been found to affect growth in the EU countries mostly through technology transfers (Henrekson et al., 1997). Considering the EU15, Borota and Kutan (2008) argue that integration leads to higher foreign direct investment inflows, which in turn are a channel for technological transfers. Moreover, the stronger the bonds among countries from the same trade bloc, the better the conditions for the growth of its members (Economidou et al., 2006).

Concerning the growth effects of the EU, there is a controversy among empirical outcomes.[10] Though there is not a consensual conclusion, the debate on the advantages and disadvantages of belonging to the Economic and Monetary Union (EMU) is rather pertinent. Most studies agree with the evidence of faster convergence during the 1960's, stagnation during the 1980's[11] and an increase in disparities in the 1990's within the EU. Sala-i-Martin (2003) referred to this as a sign of failure to achieve higher cohesion in Europe.

Ben-David (1993) attributed most of the convergence among the OECD countries after WW II to the removal of trade barriers in the EU countries. Additionally, convergence among the EU and EFTA members did not seem to follow a generalised European trend concerning income disparity reduction. Membership of both the EU and the OECD was found to increase a country's growth rate, despite the lower magnitude

9 See Romer (1990), Henrekson et al. (1997) and Di Liberto (2005).

10 See for instance Henrekson et al. (1997) – defending the existence of growth effects from EU integration – and Vanhoudt (1999) – claiming the opposite and founding only trade effects.

11 Button and Pentecost (1993) blame the Exchange Rate Mechanism for the reduction of the speed of convergence among the EU members during the 1980's.

of the impact in the latter case (Henrekson et al., 1997). Also, the evolution of technology was a crucial mechanism for convergence in the OECD countries (Di Liberto, 2005).

In the present work we are not concerned about the specific channels through which trade affects growth. Instead, we assume the existence of diffusion mechanisms occurring through trade. Furthermore, we analyse the way foreign trade interacts with human capital in the growth process. For that, we use interaction terms to ascertain whether human capital and foreign trade affect growth on an independent basis or, alternatively, whether the sign of the impact of one of the components depends on the level of the other variable.

1.5. THE DESCRIPTION OF THE MODEL, THE DATA USED AND THE ESTIMATION METHOD

For several years, cross-section studies were considered to be the most fruitful estimation procedure to test for convergence. However, several criticisms were pointed out to cross-sectional models, usually related to multicollinearity, endogeneity of the regressors, omitted variable bias, specification errors, and static specification of the models (Mankiw et al., 1992; Islam, 1995). [12] These limitations seriously affect the robustness of the convergence coefficient and other conditioning factors, leading to inconsistent conclusions.

A panel data approach reveals to be more adequate, allowing for country-specific effects and correcting the omitted variable bias.[13] Additionally, it makes it possible to integrate the process of convergence occurring over several consecutive time intervals. In practical terms, the convergence equation is reformulated assuming a dynamic form with individual effects and distinct results are achieved: on the one hand, the estimated rates of conditional convergence are higher and, on the other hand, the capital-output ratios are closer to their steady-state values (Islam, 1995). However, one of the drawbacks is that although panel estimation adjusts for time-invariant omitted variables, it does not control for omitted variables that vary over time (Forbes, 2000).

In this study we consider an alternative version of the neoclassical growth model as was adapted by Caselli et al. (1996) to panel data, to avoid omitted variable bias. Thus, along with the initial level of per capita income (predetermined), we also include the annual population growth rate, the investment ratio and various proxies for human capital and foreign trade, to differentiate countries in their growth path.

The dynamic growth equation to be estimated is the following:[14]

$$gy_{i,t} = b\ln\left(y_{i,t-5}\right) + c_1\ln(n_{i,t} + g + \delta) + c_2\ln(s_{i,t}) + c_3\ln(HC_{i,t}) + c_4\ln(FT_{i,t}) + v_{i,t} \quad ,$$

$$\text{with } v_{i,t} = \alpha_i + u_{i,t} \qquad \textbf{(1.1)}$$

12 The cross-section methodology ignores the existence of different aggregate production functions across economies. This limitation, together with the consideration of endogenous regressors, mines the cross-section evidence (Castelló-Climent, 2005).

13 For the advantages of panel data methods over cross-section studies, see Islam (1995) and Temple (1999).

14 For the deduction of the neoclassical growth equation using panel data, see the Appendix I of this Chapter.

where α_i refers to country-specific effects, reflecting, for instance, differences in the initial level of efficiency (Bond et al., 2001) or country-specific measurement errors and $u_{i,t}$ is the idiosyncratic error term.

The subscript *i* refers to countries[15] (i=1, …, 78) and *t* to time (t=1985, …, 2000). Since yearly time spans may be too short to be appropriate for studying growth convergence, we opted for five-year intervals, to avoid business cycle influences.[16]

The dependent variable is the annual growth rate of per capita income in five-year intervals. The set of explanatory variables includes: $\ln y_{i,t-5}$, the log of per capita income at the first year of each time interval; $n_{i,t}$, the annual population growth rate;[17] $s_{i,t}$, the investment share; $HC_{i,t}$, human capital and $FT_{i,t}$, some measures related to foreign trade. The variables of *HC* are: the average years of schooling of the population aged 25 or over ($HUMAN_{i,t}$);[18] the articles ratio ($art_{i,t}$) defined as the number of articles published per country's million inhabitants aged 25 or over; the patents ratio ($pat_{i,t}$) defined as the number of patents per country's million inhabitants aged 25 or over and a combined ratio ($pat/art_{i,t}$) revealing a country's ability to transform scientific research into innovation. Finally, we also consider foreign trade indicators ($FT_{i,t}$), such as the degree of openness ($op_{i,t}$), defined as the ratio of external trade to GDP and the net foreign balance ($nfb_{i,t}$), [19] as the share of net trade to GDP, to account for the impact of international trade on growth.[20]

Before we proceed, it is useful to observe **Table 1.1**, where we display descriptive statistics regarding the human capital and international trade proxies, to analyse their evolution between 1980 and 2000.

15 For a detailed description of countries, see the Appendix II of this Chapter.

16 Islam (1995), Caselli et al. (1996) and Castelló-Climent (2005) use the same specification.

17 To the annual population growth rate $n_{i,t}$ we added (g+δ)=0.05, with *g* the rate of technological progress and δ the rate of (human and physical) capital depreciation, equal across countries and through time (Islam, 1995).

18 This indicator is used to express basic levels of education but lacks of measuring the efficiency of the education system. Being an indicator of the quantity of schooling, it is limited in the sense that it does not allow us to understand the efficiency of human capital in a broader sense.

19 The terms net foreign balance and net foreign trade will be used indifferently and refer to net exports of goods and services. Net foreign balance (*nfb*) is the only variable not expressed in logarithms since in some occasions it displays negative figures.

20 For a detailed description of the variables and data sources, see the Appendix III of this Chapter.

Table 1.1. Summary statistics of the human capital and international trade proxies, 1980 and 2000.

Groups	HUMAN		art		pat		pat/art		op		nfb	
	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000
World	4.96	6.52	242.10	494.13	36.10	84.08	0.08	0.08	56.18	75.70	-9.34	-2.49
High-income countries	7.94	9.31	629.05	1297.77	101.18	239.61	0.15	0.18	49.31	89.33	-1.37	2.23
Middle-income countries	4.40	6.27	57.54	104.95	2.97	3.12	0.07	0.04	54.02	72.37	-9.29	-0.20
Low-income countries	2.23	3.67	14.42	27.86	0.17	0.19	0.02	0.01	66.34	64.10	-18.34	-10.38
Europe	7.38	8.83	546.68	1231.62	84.52	166.00	0.12	0.11	47.42	88.56	-0.73	0.94
OECD	7.97	9.30	639.43	1322.52	112.02	234.77	0.16	0.18	42.88	78.06	-0.53	1.46
EMU	6.95	8.34	454.43	1118.45	65.64	152.69	0.13	0.12	48.00	93.20	-1.76	0.91

Data sources: see the Appendix III of this Chapter.

Regarding the human capital proxies, we observe that both in 1980 and 2000 the OECD and high-income countries' samples display the highest (and very similar)[21] figures. Conversely, the low-income countries' group presents the lowest records. The most positive evolutions between 1980 and 2000 are those of the low-income countries (in the average years of schooling, *HUMAN*), the EMU sample (in the articles ratio, *art*) and the high-income countries (both in the patents, *pat*, and the patents/articles ratio, *pat/art*).[22]

Concerning foreign trade, the degree of openness, *op*, does not show many disparities in 1980, among groups. However, there is an interesting aspect: its highest figure is for low-income countries and the lowest, for OECD (includes USA, Turkey and Japan, all with degrees of openness lower than 16%). In 2000 the picture is rather different: EMU countries present the highest degree of openness and the low-income countries, the lowest. In fact, it was in these two groups that occurred (respectively) the most positive and negative evolutions during the period. As for the net foreign balance, *nfb*, whereas in 1980 all groups displayed deficits (ranging from -18.34% in the low-income countries to -0.53% in the OECD), in 2000 the deficits are reduced and in some

21 From the OECD members, only Turkey is not a high-income country. On the other hand, in the sample of high-income countries there are economies that do not belong to OECD – Hong Kong, Israel, Korea, Mauritius and Trinidad and Tobago. Therefore, although similar, the two sub-groupings are distinct.

22 The reduction observed, in some samples, for the (*pat/art*) variable between 1980 and 2000 is because articles grow more than patents, thus resulting in a decrease in the corresponding ratio.

occasions, transformed into surpluses, with the highest belonging to the high-income countries (2.23%).

Since different groups of countries display dissimilar levels of human capital and foreign trade standards and also exhibit diverse evolutions regarding those indicators, it is reasonable to consider several samples and diversified combinations of the mentioned indicators on the estimation of the growth equation.

Although, in principle, a better-educated and well-trained workforce can be expected to exert a positive effect on growth,[23] results have sometimes shown a different pattern, with the impact of human capital on growth being negative and/or statistically insignificant, especially in panel data studies (Islam, 1995). The explanation for such an unexpected result can be the use of poor quality data and inadequate proxies to capture qualitative rather than quantitative aspects of human capital. Still, we expect human capital proxies to exert a positive impact on growth. As for the international trade variables, we expect them to have a positive effect on growth. In fact, several studies point to openness as fostering growth (Wacziarg, 1998; Pan, 1999; Frankel and Romer, 1999) and trade balance deficits restrain growth, according to the Post-Keynesian approach. About the role of the population growth rate on economic growth, Mankiw et al. (1992) argued that population growth contributes negatively to income growth since the available capital must be spread more thinly over the working age population. Temple (1999), contributing to the discussion, stressed that while population growth is economically harmful (the Malthusian hypothesis), it can also affect demand and the final impact on growth is not as clear as Mankiw et al. (1992) defined. Therefore, the final impact depends on which of the two effects prevails.[24] Physical capital is considered to positively influence growth, due to its impact on the steady-state level of output per capita and hence, on the growth of output - the neoclassical view - or due to spillover effects and economies of scale - the endogenous growth approach (Economidou et al., 2006). Moreover, whenever the convergence factor demonstrates a negative and significant value it indicates the existence of conditional convergence.

23 For studies on the positive impact of human capital on income, see Söderbom and Teal (2003) and Ciccone and Papaioannou (2006).

24 Temple (1999) argued that the negative impact attributed to the population growth rate over income growth was not as straightforward as it had been advocated till that point.

Several estimation techniques are possible within a panel data framework, depending on the way the error term is modelled. The most commonly used are regressions with fixed effects or random effects which produce inconsistent estimates when the lagged dependent variable enters as a regressor. In case of a dynamic panel data specification, the lagged dependent variable will be correlated with the country-specific time-invariant term (α_i), producing biased and inconsistent estimates, even if the error process is *iid* – homoscedastic both across units and over time (Baum, 2006). Therefore, the *GMM* (Generalised Method of Moments) is the adequate estimation procedure of a dynamic panel modelling, resolving the endogeneity problem of the regressors.[25]

There are two types of *GMM* estimators: the difference and the system *GMM*. The original Arellano-Bond estimator (difference *GMM* estimator) specified the model as a system of equations, one per period and thus the number of instruments applicable to each one may differ. The set of instruments includes all available lags of the levels of endogenous variables and strictly exogenous regressors, which all enter the differenced equation (Arellano and Bond, 1991; Baum, 2006). The estimator was later modified to include not only lagged levels as instruments in the differenced equation but also lagged differences in the levels equation – the system *GMM* estimator (Arellano and Bover, 1995; Blundell and Bond, 1998). This expanded estimator is proclaimed to be more efficient than the former, since it uses a broader range of information (Baum, 2006).

The difference *GMM* method is the estimation technique from which we obtained the most reasonable results for most of the regressions ran.[26] We are dealing with a short panel and the use of lagged levels as instruments enables us to maximize the sample size. Moreover, as Baltagi (2005) points out, those estimators using instruments in levels have much smaller variances and are thus recommended. We may opt between one-step or two-step estimates: the one-step estimator assumes errors to be *iid*, whereas the two-step estimator allows for heteroscedasticity of errors. Both estimators are asymptotically equivalent if the idiosyncratic error terms are *iid* in levels.

In our study we report the most reasonable estimates for each regression ran. In order to check for the validity of the orthogonality conditions, the Arellano and Bond test of error autocorrelation (*AR2 test*) is reported (Arellano and Bond, 1991). In fact,

25 For an explanation on the option for the *GMM* estimation method, see the Appendix IV of this Chapter.

26 The estimations were run by Stata.

the consistency of the *GMM* estimators depends on the assumption of the absence of second-order serial autocorrelation of error terms in differenced form. Otherwise, some lags are considered invalid as instruments. In order to verify the validity of the instruments and moment restrictions, the *Hansen J-test* of over-identifying restrictions - a robust version of the Sargan test - is displayed (*Hansen J-test*). The null hypothesis is the absence of correlation between instruments and errors (Arellano and Bond, 1991).

Following Roodman (2006), we report the instruments count in all estimations. Whenever it is necessary, lags length are reduced and the instruments are collapsed, thus diminishing the width of the instruments matrix. In small samples the collapse option is extremely useful because it prevents the number of instruments from exceeding the number of individuals and the consequent bias that emerges from there.

1.6. EMPIRICAL EVIDENCE

The study carried out throughout this section considers a global sample of 78 countries, that later on is divided into different sub groupings (according to income level, geographical location and EMU and OECD membership) in order to detect whether there are different performances and also which variables exert a significant impact on growth, depending on the type of set considered.

Next, we present the main findings concerning growth regressions. Only the most significant estimation results are presented, but in some cases less coherent findings may also be included for comparison.

1.6.1. EMPIRICAL EVIDENCE FROM THE WORLD SAMPLE

For the whole sample of 78 countries (World), we estimate the growth equation (1.1) combining alternatively each of the human capital proxies with the international trade indicators. The lagged per capita income (convergence factor), the annual growth rate of population and the investment ratio are also considered in each regression, to avoid omitted variable bias.

Additionally, countries are ranked according to their income level, in terms of their real GDP per capita in the last year (2000). [27] Three subsets come up - high, middle and low-income countries -, the first two with 27 countries each and the third with 24. Moreover, it is assumed that a country belongs to the same group throughout the total period considered.[28] This may be a controversial point, though some studies point to the low mobility of countries across groups in what concerns income levels (Quah, 1992).

Only for the World and the high-income group it was possible to determine the major factors of economic growth. However, we also present the results for the other sets for comparison purposes (**Table 1.2**).

27 See the Appendix V of this Chapter for this division.

28 Considering the three groups drawn and comparing their compositions to those resulting from the rank of the income values in 1980, only twelve countries change groups between 1980 and 2000: Argentina and Venezuela (from high to middle-income countries), Mauritius and Korea (from middle to high-income countries), Guatemala, Jordan, Philippines and Zimbabwe (from middle to low-income countries), Thailand, Egypt, Sri Lanka and China (from low to middle-income countries).

Table 1.2. Estimation results for the World, high-, middle- and low-income countries, 1980-2000.

	World		High-income countries		Middle-income countries		Low-income countries	
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
$\ln(y_{i,t-5})$	-0.1344***	-0.0284**	-0.0940**	-0.0653**	-0.0385**	-0.0399*	-0.0271	-0.0979*
	(-3.76)	(-2.59)	(-2.78)	(-2.09)	(-2.15)	(-1.95)	(-1.06)	(-1.89)
$\ln(n_{i,t}+g+\delta)$	0.0166	0.0030	-0.0962*	-0.1076	-0.0503	0.0434	0.0100	0.0173
	(0.49)	(0.19)	(-1.97)	(-1.22)	(-0.63)	(0.63)	(0.53)	(0.77)
$\ln(s_{i,t})$	0.0038	0.0509***	0.0484	0.1527***	0.0359**	0.0667***	0.0229	0.0223
	(0.13)	(3.14)	(1.40)	(3.80)	(2.24)	(3.65)	(0.78)	(0.64)
$\ln(HUMAN_{i,t})$		0.0454***	0.1009**	0.0861*		0.0409	0.0411*	0.0390*
		(4.29)	(2.17)	(2.03)		(1.26)	(2.04)	(2.07)
$\ln(art_{i,t})$	0.0246**				0.0029			
	(2.58)				(0.25)			
$\ln(op_{i,t})$	0.0417**		0.0421**		0.0213**		-0.0184	
	(2.59)		(2.27)		(2.13)		(-0.58)	
$nfb_{i,t}$		0.0006**		0.0030**		0.0015*		0.0007***
		(2.19)		(2.23)		(1.92)		(3.11)
Constant			0.1235		0.0180	0.2328	0.2145	
			(0.43)		(0.067)	(1.35)	(0.92)	
Observations	234	234	108	81	108	108	96	72
No. of countries	78	78	27	27	27	27	25	24
No. of instruments	30	30	21	12	21	21	21	15
Hansen J-test	34.11	35.18	18.79	9.96	16.32	15.16	18.76	13.78
p-value	0.106	0.085	0.224	0.444	0.361	0.440	0.225	0.183
AR2 test	0.039	-0.67	-0.097	0.35	-1.12	-1.73	-0.05	0.02
p-value	0.969	0.506	0.923	0.729	0.265	0.083	0.962	0.985

Notes:

The dependent variable is the average annual growth rate of per capita income for each 5-year interval.
Columns (1) and (2) are two-step difference *GMM* estimations with robust standard errors.
Columns (3), (5) and (7) are two-step system *GMM* estimations with robust standard errors, using the option "collapse".
Column (4) is one-step difference *GMM* estimation with robust standard errors, using the option "collapse".
Column (6) is one-step system *GMM* estimation with robust standard errors, using the option "collapse".
Column (8) is two-step difference *GMM* estimation with robust standard errors, using the option "collapse".

Numbers in brackets are t-ratio.

* Coefficient significant at the 10% level;** Coefficient significant at the 5% level; *** Coefficient significant at the 1% level.

Hansen J-test is the test of over-identifying restrictions in the *GMM* estimation.
AR2 test is the Arellano and Bond test for second-order serial autocorrelation in first differences.

Firstly, it is important to note that no reasonable results emerge from the World sample when we use the degree of openness as a proxy for international trade. Column

(1) presents the results for the only case where we could find significance both in the human capital proxy (in this case, the articles ratio) and the openness variable. However, the investment ratio - a robust variable for the explanation of growth - is not statistically significant and that weakens the global results.

The most admissible results for the World sample are the ones from the combination of the average years of schooling and the net foreign trade in column (2). Therefore, trade balance proves in this case to be a relevant factor of growth. All coefficients present their expected signs, and they are statistically significant at the conventional levels, except that of the population growth rate, a common finding in growth regressions. The negative sign of the initial per capita income confirms the convergence hypothesis, conditioned mostly on physical capital, human capital and trade. Considering a 5% significance level, both the *Hansen J-test* and the *AR2 test* [29] lead us to conclude that the instruments used are valid and the estimators are thus consistent.

Turning to the results of the high-income countries, once again the degree of openness behaves poorly and it rarely proves to be significant in the estimations run. In column (3) we present the only case where we could find simultaneously statistical significance in the referred foreign trade proxy and the human capital variable (the average years of school attainment). However, like in the whole sample, the investment ratio is not statistically significant. It is the use of net foreign trade for the high-income set that yields the best results as column (4) shows, when combined with average years of schooling. However, like previously, the reported outcome is the only case where both proxies are statistically significant at the same time. All coefficients present their expected sign, but population growth is once more, statistically insignificant. The impact of both human capital and international trade proxies is higher when compared to that of the World sample.

Concerning middle-income countries in columns (5) and (6), our results show that foreign trade either in the form of the degree of openness or the net foreign trade is more relevant than human capital in explaining growth performance of these countries. It seems that international trade performance is apparently more important for per capita

29 In fact, as Caselli et al. (1996) demonstrate, when dealing with 5-year intervals we are actually testing the existence of 10th order autocorrelation in the differenced equation, i.e. we are checking if errors are (or not) 5th order uncorrelated in levels. However, we keep the notation *AR2 test* and refer to it as a test of second-order serial correlation in differenced form, to be coherent with the terminology used in other studies.

income growth in the sense that it enables to differentiate better the steady-states of these countries.

Finally, concerning low-income countries, the pattern is different: apparently, the average years of schooling is more relevant than the other human capital variables as column (7) shows, despite the lack of significance of the convergence factor. Combining human capital and international trade in the form of net foreign balance in column (8), both factors are shown to be significant in explaining per capita income growth, but the investment share is not. This can be taken as evidence that low-income countries are highly dependent from abroad in terms of foreign aid, foreign direct investment and capital equipment, which are fundamental for enabling economic growth and development.

1.6.2. EMPIRICAL EVIDENCE FROM EUROPE

The next step consists in running growth regressions for a sample of 20 European countries, globally denominated Europe (**Table 1.3**).[30] The reason to consider this specific set of European countries is to explore the idea that countries of the same geographical area trade more intensively with each other because of the reduction on transport and communication costs. Special trade agreements and higher factor mobility also contribute to higher exchange of goods and services and easier diffusion of knowledge and technology.

As **Table 1.3** shows, the degree of openness is more relevant to explain the growth performance of the European countries. The three first regressions of **Table 1.3** clearly show the positive and statistically significant impact of openness on growth implying that the more open the European countries are the more growth is achieved. An interesting aspect to notice is that in these regressions the variables capturing the efficiency of human capital, namely the patents ratio and the patents to publication ratio related to R&D activities are also statistically significant with a positive impact on growth, as expected. Given these two effects, it is reasonable to presume the existence of knowledge and technology diffusion effects through trade. The more open the

30 Initially, the division consisted in four main groups - Europe; America; Asia, Oceania and Middle East and Africa -, to investigate whether countries spatially close to each other experience similar growth rates and what are the main determinants to those processes. No plausible results were obtained for some of the groupings and therefore the option was to focus only on Europe.

economies, the higher the transfer of technology and the gains from positive externalities steaming from R&D activities, and consequently, the faster the growth.

Table 1.3. Estimation results for Europe (20 countries), 1980-2000.

Variables	(1)	(2)	(3)	(4)
$\ln(y_{i,t-5})$	-0.0657***	-0.0638***	-0.0782**	-0.0512**
	(-3.41)	(-4.15)	(-2.84)	(-2.19)
$\ln(n_{i,t}+g+\delta)$	0.0815*	0.1214	-0.011	-0.1205
	(1.85)	(1.61)	(-0.18)	(-0.96)
$\ln(s_{i,t})$	0.0412***	0.0407***	0.0536***	0.0648***
	(3.35)	(5.22)	(5.47)	(3.98)
$\ln(pat_{i,t})$	0.0159**			0.0205***
	(2.26)			(5.84)
$\ln(pat/art_{i,t})$		0.0171**	0.0244***	
		(2.41)	(2.94)	
$\ln(op_{i,t})$	0.0220**	0.0415***	0.0451***	
	(2.64)	(5.46)	(3.55)	
$nfb_{i,t}$				0.0018*
				(2.09)
Constant	0.6172***	0.7409**		
	(4.31)	(2.33)		
Observations	80	80	60	60
No. of countries	20	20	20	20
No. of instruments	16	16	15	15
Hansen J-test	15.42	10.32	14.59	16.43
p-value	0.118	0.413	0.148	0.088
AR2 test	1.84	1.75	1.47	1.13
p-value	0.066	0.081	0.141	0.261

Notes:

The dependent variable is the average annual growth rate of per capita income for each 5-year interval.
Columns (1) and (2) are two-step system *GMM* estimations with robust standard errors, using the options "collapse" and "lag (1 2)".
Column (3) is one-step difference *GMM* estimation with robust standard errors, using the option "collapse".
Column (4) is two-step difference *GMM* estimations with robust standard errors, using the option "collapse".
For further notes – see **Table 1.2**.

The last column of **Table 1.3** contains the results from the regression combining the net foreign trade with the patents ratio. All the significant variables display the expected impact on growth, but net foreign trade is significant at the 10% level only. The relevance of the net trade for growth is also an encouraging result, suggesting that balance-of-payments problems can be harmful for growth and should thus be avoided.

1.6.3. EMPIRICAL EVIDENCE FROM THE OECD COUNTRIES

There are 23 OECD countries in the sample that have become members earlier and up to 1980. Countries that joined later are not considered in the group. The estimation results for this set are reported in **Table 1.4.**

Table 1.4. Estimation results for the OECD countries (23), 1980-2000.

Variables	(1)	(2)	(3)	(4)
$\ln(y_{i,t-5})$	-0.0973***	-0.0902***	-0.1837**	-0.1171***
	(-3.93)	(-3.71)	(-2.66)	(-3.68)
$\ln(n_{i,t}+g+\delta)$	-0.0409	-0.0572	0.0700	0.0068
	(-0.72)	(-0.98)	(0.49)	(0.062)
$\ln(s_{i,t})$	0.0351**	0.0429**	0.0487**	0.1324***
	(2.46)	(2.45)	(2.36)	(4.84)
$\ln(pat_{i,t})$	0.0166***			0.0304***
	(3.51)			(5.95)
$\ln(pat/art_{i,t})$		0.0181**	0.0187**	
		(2.64)	(2.80)	
$\ln(op_{i,t})$	0.0374***	0.0544***	0.0933**	
	(4.01)	(5.28)	(2.45)	
$nfb_{i,t}$				0.0048***
				(3.06)
Constant	0.5248**	0.4325*		
	(2.45)	(2.04)		
Observations	92	92	69	69
No. of countries	23	23	23	23
No. of instruments	21	21	15	15
Hansen J-test	20.87	18.45	12.13	16.67
p-value	0.141	0.240	0.276	0.082
AR2 test	1.56	1.29	0.37	1.92
p-value	0.118	0.199	0.710	0.054

Notes:

The dependent variable is the average annual growth rate of per capita income for each 5-year interval.
Column (1) is one-step system *GMM* estimation with robust standard errors, using the option "collapse".
Column (2) is two-step system *GMM* estimation with robust standard errors, using the option "collapse".
Column (3) is two-step difference *GMM* estimation with robust standard errors, using the option "collapse".
Column (4) is one-step difference *GMM* estimation with robust standard errors, using the option "collapse".
For further notes – see **Table 1.2.**

Firstly, it is important to note that when the degree of openness is considered, it is best associated with the patents ratio (column (1)) and the patents/articles ratio (columns (2) and (3)). The effect of foreign trade is higher when it is combined with the

patents/articles ratio in column (3). Moreover, the impact of the patents/articles ratio on growth is, in itself, superior to that of the patents ratio.

The results are comparable to those of Europe (**Table 1.3**, columns (1) to (3)). In fact, 18 out of the 23 OECD members considered are European countries. On the other hand, Hungary and Romania, two European countries, are non-OECD members. Generally, the impacts of both the human capital and the international trade variables are more pronounced in the OECD set. The reason may lay in a higher association among OECD members than that of European countries and thus, despite the OECD set including mostly high-income countries, shows higher convergence coefficients.

The last column (column (4)) displays the results when net foreign trade is used, combined with the patents ratio through the one-step difference *GMM* estimation. It is again shown that higher levels of human capital (the patents ratio) and the net foreign balance are relevant for growth. Attention has to be paid to the *p-value* associated both with the *Hansen J-* and the *AR2 tests* when interpreting results, since they are favourable only in marginal terms.

1.6.4. EMPIRICAL EVIDENCE FROM THE EMU COUNTRIES

EMU members are those EU countries that have adopted the Euro currency, thus constituting the Economic and Monetary Union (EMU).[31] The idea to estimate the growth equation for the sample of the EMU countries is to isolate highly integrated countries that trade with each other intensively. Therefore, convergence is expected to be higher, due to the greater homogeneity on their structural characteristics and the implementation of common policies. We also want to check whether these countries, that adopted the single currency in 1999, are dependent on the openness measure as well as on the trade balance performance, during the 20-year-period that preceded that historical moment (1980-2000). The results of the estimation of the growth equations are displayed in **Table 1.5**.

The regression from column (1) reveals that when the degree of openness is included, the patents/articles ratio is the most proper human capital variable with which it is combined. All coefficients display their expected signs and are statistically significant, except that of the population growth rate. The evidence from this regression

31 The 11 EMU countries considered are the EU members who joined until 1995, excluding Denmark, Sweden and the UK.

is similar to the previous case of the set of European countries but the convergence coefficient is higher in absolute terms, as expected.

Table 1.5. Estimation results for the EMU countries (11), 1980-2000.

Variables	(1)	(2)	(3)	(4)
$\ln(y_{i,t-5})$	-0.1139*	-0.1144***	-0.1153**	-0.0972***
	(-2.05)	(-4.16)	(-2.79)	(-3.59)
$\ln(n_{i,t}+g+\delta)$	0.0281	0.0386	0.0135	-0.0521
	(0.36)	(0.42)	(0.14)	(-0.70)
$\ln(s_{i,t})$	0.0850**	0.1913***	0.1834***	0.1568***
	(3.09)	(6.48)	(9.31)	(4.32)
$\ln(HUMAN_{i,t})$		0.1367**		
		(2.84)		
$\ln(art_{i,t})$			0.0262**	
			(2.40)	
$\ln(pat_{i,t})$				0.0348**
				(3.14)
$\ln(pat/art_{i,t})$	0.0461***			
	(3.26)			
$\ln(op_{i,t})$	0.0754***			
	(3.64)			
$nfb_{i,t}$		0.0057***	0.0052***	0.0046**
		(5.99)	(7.11)	(3.09)
Observations	33	33	33	33
No. of countries	11	11	11	11
No. of instruments	10	10	10	10
Hansen J-test	3.39	7.12	5.44	4.98
p-value	0.641	0.212	0.365	0.418
AR2 test	0.77	-0.364	0.09	-0.15
p-value	0.442	0.716	0.924	0.878

Notes:

The dependent variable is the average annual growth rate of per capita income for each 5-year interval. Columns (1) to (4) are one-step difference *GMM* estimations with robust standard errors, using the options "collapse" and "lag (1 2)".
For further notes – see **Table 1.2**.

When the net foreign balance is considered, several human capital proxies are relevant: the average years of schooling in column (2), reflecting the stock of human capital, the articles ratio in column (3), representing scientific production, and the patents ratio, expressing the capacity to innovate in column (4). All these proxies of human capital have an individual positive and statistically significant impact on growth at the 5% conventional significance level. Therefore, all the human capital measures are

suitable to differentiate properly the steady-states of the EMU economies, only depending on the kind of foreign trade indicator considered.

From the results displayed in **Table 1.5**, we are also able to conclude that trade balance exerts a meaningful influence on growth, at least in the period preceding the adoption of the Euro. The net foreign balance reflects the competitiveness of the economies and affects positively the growth rates of the EMU countries, revealing that balance-of-payments problems are also important for countries that move towards a single currency. This is an important insight indicating that real competitiveness is crucial for growth, even when nominal exchange rates variations are eliminated.

Finally, when human capital qualifications and competitiveness measures are controlled for in the growth equation of the EMU countries, the convergence coefficient is higher in absolute terms. This is an expected result, explained by the high degree of integration and the effort made to meet the Maastricht rules associated to nominal convergence targets.

1.6.5. EMPIRICAL EVIDENCE USING INTERACTION TERMS

In order to ascertain how the degree of openness interacts with the human capital proxies in the growth process, exogenous[32] interaction terms are added to the estimation of the growth equation. In this way, the impact of the degree of openness on growth depends not only on itself but also on the human capital variable attached to it, and vice-versa. The idea is to confirm the argument that international trade is a privileged channel for the transmission of knowledge and technology. Higher levels of human capital reflect the efficiency of the educational system, as well as of the research and innovation activities. Human capital is intimately linked to technology and more specifically, to technology transfers, being a pre-requisite for its effectiveness on growth. Assuming that the diffusion of technology occurs through international trade, we expect both human capital and the degree of openness to affect growth in an interrelated way. The regression results of the growth equations with interaction terms between human capital and the degree of openness are reported in **Table 1.6**.

32 The exogeneity was verified through the *Difference-in-Hansen test*.

Table 1.6. Growth regressions with interaction terms, 1980-2000.

	Europe			OECD			
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
$\ln(y_{i,t-5})$	-0.0963***	-0.1842***	-0.1329***	-0.1462***	-0.1279***	-0.2150***	-0.2469***
	(-3.03)	(-4.76)	(-4.54)	(-3.29)	(-2.90)	(-5.89)	(-4.60)
$\ln(n_{i,t}+g+\delta)$	-0.0469	0.0297	0.0332	0.0395	-0.0549	0.1083	0.1988**
	(-0.59)	(0.30)	(0.68)	(0.43)	(-0.64)	(1.52)	(2.25)
$\ln(s_{i,t})$	0.0660***	0.0633***	0.0504***	0.0680***	0.0587***	0.0565***	0.0474**
	(5.18)	(5.81)	(4.53)	(3.78)	(3.78)	(2.86)	(2.36)
$\ln(HUMAN_{i,t})$	-0.2615***			-0.2133***			
	(-3.02)			(-3.93)			
$\ln(art_{i,t})$		-0.0961***			-0.0870***		
		(-3.64)			(-4.15)		
$\ln(pat_{i,t})$						-0.0305*	
						(-2.06)	
$\ln(pat/art_{i,t})$			-0.0495**				-0.0605*
			(-2.75)				(-1.76)
$\ln(op_{i,t})$	-0.1495**	-0.1744**	0.1149***	-0.1156**	-0.1324**	0.0638***	0.1729***
	(-2.71)	(-2.36)	(5.52)	(-2.74)	(-2.32)	(2.95)	(4.56)
$\ln(op_{i,t})*\ln(HUMAN_{i,t})$	0.0853***			0.0788***			
	(3.26)			(4.76)			
$\ln(op_{i,t})*\ln(art_{i,t})$		0.0328***			0.0269***		
		(3.57)			(3.79)		
$\ln(op_{i,t})*\ln(pat_{i,t})$						0.0096**	
						(2.79)	
$\ln(op_{i,t})*\ln(pat/art_{i,t})$			0.0169***				0.0173**
			(4.12)				(2.14)
Observations	60	60	60	69	69	69	69
No. of countries	20	20	20	23	23	23	23
No. of instruments	16	16	16	16	16	16	16
Hansen J-test	15.78	15.39	15.95	14.92	16.82	11.34	7.96
p-value	0.106	0.118	0.101	0.135	0.078	0.332	0.633
AR2 test	1.15	0.62	1.04	0.65	0.31	-0.03	-0.76
p-value	0.249	0.535	0.300	0.516	0.756	0.980	0.448

Notes:

The dependent variable is the average annual growth rate of per capita income for each 5-year interval.
Columns (1) to (7) are one-step difference *GMM* estimations with robust standard errors, using the options "collapse".
For further notes – see **Table 1.2**.

First of all, the most satisfactory results come from the set of European and OECD countries. [33] This is an expected outcome, for three main reasons: first, there is a high degree of integration and cooperation between these countries, making the transfer of knowledge and technology easier; second, human capital qualifications are higher

33 EMU estimations with interaction terms become limited to the difference *GMM* approach, given the small number of countries involved and the proximity to the number of instruments used.

allowing for inter-country technological and knowledge diffusion; third, these are relatively high-income countries investing more on education and R&D activities. Therefore, the interaction between trade and human capital is a plausible outcome affecting growth considerably.

The three first columns of **Table 1.6** show the regression results for Europe. Although in column (1) the average years of schooling is the appropriate proxy for human capital, in columns (2) and (3) measures of the efficiency of human capital also prove to be relevant, namely the articles ratio and the patents/articles ratio. The interaction terms are highly significant with the expected positive impact on growth.

In what concerns the combination of the articles ratio and the openness variable in column (2), we may conclude that the impact of this human capital proxy on growth is positive as far as the degree of openness is higher than 18.73%.[34] Thus, the more open a European economy is, the more effective is the impact of the scientific research on growth. Alternatively, the impact of openness on a country's growth remains positive as long as the publication ratio remains superior to 204 (per million inhabitants).[35] Therefore, the more scientific work is produced, the more successful becomes the trade openness for a country's growth, through improvements in competitiveness. This reinforces in a more explicit way the conclusions obtained from the growth regressions of **Table 1.3**, considering the set of European countries without the interaction terms. A similar analysis can be done for the regressions of columns (1) and (3), where the average years of schooling and the ratio of patents/articles are considered as proxies for human capital.

The second part of **Table 1.6**, columns (4) to (7), reports the growth regressions for the OECD countries, and the same picture is obtained. All combinations of interaction terms between trade openness and human capital qualifications are statistically significant with the expected positive effect on growth. More specifically, concerning the interaction between the articles ratio and openness in column (5), the conclusion is that although the thresholds are different, the signs of the impacts are the

34 The cut-off point is obtained from:

$$\frac{\partial gy}{\partial \ln(art)} = 0 \Leftrightarrow -0.0961 + 0.0328\ln(op) = 0 \Leftrightarrow \ln(op) = 0.0961/0.0328 \qquad \Rightarrow op = \exp(0.0961/0.0328) = 18.73$$

35 The cut-off point is obtained from:

$$\frac{\partial gy}{\partial \ln(op)} = 0 \Leftrightarrow -0.1744 + 0.0328\ln(art) = 0 \Leftrightarrow \ln(art) = 0.1744/0.0328 \qquad \Rightarrow art = \exp(0.1744/0.0328) \approx 204$$

same. Hence, for the articles ratio (scientific production) to be effective on growth, the degree of openness must be higher than 25.39%. On the other hand, the impact of openness on growth is positive as long as the articles ratio is superior to 137 (per million of inhabitants) and it becomes more effective the more scientific research is produced.

1.7. CONCLUSION

The purpose of the first Chapter was to estimate an augmented neoclassical growth model adding different proxies of human capital and foreign trade as conditioning factors to growth. Bearing in mind the problem of the endogeneity of the regressors, we applied the *GMM* estimation method to a dynamic panel data growth model where all regressors are assumed endogenous. The whole sample consisted of 78 countries for the period 1980-2000, making special reference to the sets of European, EMU and OECD countries.

Concerning the sample of the World (78 countries), we obtained evidence of convergence only when the net foreign trade was combined with the average years of schooling. The net foreign balance can be taken as an indicator of trade competitiveness, affecting growth significantly. The average years of schooling, in turn, performed better in a global sample, where the quantification of the years of schooling prevails over efficiency measurements of human capital.

When countries were divided according to their income level, only for high-income countries (27) was it possible to achieve plausible outcomes. Once more, it was the net foreign balance combined with the average years of schooling that proved to be relevant in explaining the growth performance of these countries.

In the set of middle-income countries, international trade proxies were more important than human capital for the explanation of annual growth in per capita income, whereas in the low-income group both human capital and net foreign trade were relevant factors for growth, the former being more robust. International competitiveness seems to be a crucial determinant for growth in the developing and less-developed countries.

The set of 20 European countries was considered as a special case to test whether geographical characteristics matter for growth. The idea was that countries of the same spatial block trade more intensively, enjoy special trade agreements, benefit from higher factor mobility and more intensive transfer of knowledge and technology, all of which are thought to foster growth and convergence. In fact, the growth regressions for the set of European countries showed that both the patents and the patents/articles ratio, together with the degree of openness, were the most relevant conditioning factors to growth. The patents ratio (as well as the patents/articles ratio), is

the type of human capital reflecting innovation activities, responsible for the production of new products and ideas, turning the economies more competitive. Knowledge and technology diffusion are highly related to this level of human capital and the degree of openness makes knowledge transfers and technology developments easier. Our regressions showed that due to higher levels of human capital and the degree of openness, convergence across the European countries was more evident.

Turning to the 23 OECD countries, the patents and the patents/articles ratios combined with the openness variable proved to be reasonable factors for growth. The same conclusion can be drawn for the combination between the net foreign balance and the patents ratio. When compared to Europe's outcomes, the impact of human capital and foreign trade are higher, as well as convergence.

Another special case considered was the set of 11 EMU countries characterised by a high degree of economic integration and implementing policies with the aim of adopting a single currency. The idea was to examine whether balance-of-payments problems are important even for countries that plan to adopt a fixed exchange rate regime. Our regressions showed that in fact net foreign balance is relevant for the growth of these countries and it is successfully combined with most of the human capital variables, either with average years of schooling or with indicators of human capital efficiency expressed by scientific production (articles ratio) or by innovation activities (patents ratio). When the foreign trade performance and human capital qualifications are controlled for in the growth equations there is evidence of convergence between the EMU countries, which can be explained by the effort made to meet the Maastricht criteria established in 1992 to achieve the monetary union by 1999.

The inclusion of interaction terms in the growth regressions apparently reflects the existence of combined effects from human capital and international trade on growth. In fact, only for Europe and OECD was it possible to compute reasonable results and this can be taken as evidence of knowledge and technology diffusion occurring through trade. The more open an economy is, the more effective is the impact of human capital on growth. Likewise, the more human capital an economy accumulates, the higher its contribution to a positive impact of openness on growth, possibly due to improvements in competitiveness. A country lying behind the cut-off points either of human capital or openness will face adverse impacts on growth. Therefore, openness seems to exert a positive impact on growth, amplified by the way it interacts with human capital.

In general, the patents and the patents/articles ratios, indicators of the efficiency of the educational system, have shown to be proper proxies for human capital, when combined either with the degree of openness or the net foreign trade. Also, the average years of schooling appeared to be relevant in some reported results, though not always related to countries with lower levels of development. The net foreign trade is shown to be an important determinant for growth, suggesting that trade balance problems can be harmful for growth. The combination of human capital proxies and foreign trade indicators can be assumed as important conditioning factors to growth and should not be omitted from growth equations.

APPENDIX I

Deduction of the growth model using panel data

The idea of absolute convergence emerged from the Solow's growth model based on the Cobb-Douglas production function incorporating a labour-augmenting technological progress of the type:

$$Y(t) = K(t)^{\alpha} \left[A(t)L(t)\right]^{1-\alpha}, \quad 0<\alpha<1, \qquad \textbf{(I.1)}$$

where Y is output, K and L are capital and labour, respectively, A is technology and α the elasticity of output with respect to capital.[36]

In this model L and A are assumed to grow exogenously at rates *n* and *g*, respectively, so that: $L(t) = L(0)\,e^{nt}$ and $A(t) = A(0)\,e^{gt}$.

The model also assumes that *s* is the constant fraction of output that is saved and invested (s=S/Y) and defines output and capital stock per unit of effective labour as $\hat{y} = \frac{Y}{AL}$ and $\hat{k} = \frac{K}{AL}$, respectively. Then the fundamental dynamic equation for the growth of $\hat{k}$ is given by:

$$\dot{\hat{k}}(t) = s\,\hat{k}(t)^{\alpha} - (n + g + \delta)\hat{k}(t), \qquad \textbf{(I.2)}$$

with δ the constant rate of capital depreciation, *n* the population growth rate[37] and *g* the growth rate of technological progress, all exogenously given.

Since at steady-state the growth rate of capital stock per unit of effective labour is constant, $\dot{\hat{k}} = 0$, $\hat{k}^{*}$ meets the condition $s\,\hat{k}^{*}(t)^{\alpha} = (n + g + \delta)\hat{k}^{*}(t)$. Hence, the steady-state expression for $\hat{k}$ is given by $\hat{k}^{*} = \left(\frac{s}{n + g + \delta}\right)^{\frac{1}{1-\alpha}}$, and consequently, the output value at steady-state[38] is $\hat{y}^{*} = \left(\frac{s}{n + g + \delta}\right)^{\frac{\alpha}{1-\alpha}}$.

36 α - elasticity of output with respect to capital - should not be confused with α_i - country-specific effects -, from equation (1.1).

37 According to the neoclassical growth theory, population and labour grow at the same rate.

38 By definition, $\hat{y}(t) = \hat{k}(t)^{\alpha}$.

From the definition of output per unit of effective labour, $\hat{y} = \frac{Y}{AL}$, and the expression of steady-state output, it is possible to define per capita income at the steady-state as:[39]

$$\ln\left[\frac{Y(t)}{L(t)}\right] = \ln A(0) + gt + \left(\frac{\alpha}{1-\alpha}\right)\ln(s) - \left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta) \qquad \textbf{(I.3)}$$

In equation (I.3) *gt* is a constant (technological progress is assumed to be the same for all economies and *t* is fixed). *A(0)* reflects not only the technological level but also resource endowments, legal system and institutions, among others, and so it may be different across economies (Mankiw et al., 1992). Therefore, the term $\ln A(0) = a + \varepsilon$ can be decomposed into two parts: one is constant (*a*) and the other is random (ε), representing a stochastic shock or an economy-specific change.

Substituting this expression on equation (I.3) and inserting *gt* into the constant term, we get:

$$\ln\left[\frac{Y(t)}{L(t)}\right] = a + \left(\frac{\alpha}{1-\alpha}\right)\ln(s) - \left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta) + \varepsilon \qquad \textbf{(I.4)}$$

In this equation, it is difficult to accept that *s* and *n* are independent from the error term (ε), although it is a necessary assumption for cross-section regressions. The panel approach takes care of the specific differences among economies and provides a better control for the error term ε.

To show that, we consider the equation describing per capita income out of steady-state and then we analyse the pace of convergence towards the steady-state, given by:

$$\frac{d\ln\hat{y}(t)}{dt} = \beta\left[\ln\left(\hat{y}^{*}\right) - \ln\left(\hat{y}(t)\right)\right] \qquad \textbf{(I.5)}\ ^{40}$$

where β represents the convergence rate, dependent on the population growth rate (*n*), the rate of technological progress (*g*), the depreciation rate (δ) and the elasticity of output with respect to capital (α). This equation further implies that:

$$\ln\hat{y}(t_2) = \left(1-e^{-\beta T}\right)\ln\hat{y}^{*} + e^{-\beta T}\ln\hat{y}(t_1) \qquad \textbf{(I.6)}$$

---

39 Analytically:

$$\ln\left[\frac{Y(t)}{L(t)}\right] - \ln A(t) = \left(\frac{\alpha}{1-\alpha}\right)\ln(s) - \left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta) \Leftrightarrow$$

$$\Leftrightarrow \ln\left[\frac{Y(t)}{L(t)}\right] - [\ln A(0) + gt] = \left(\frac{\alpha}{1-\alpha}\right)\ln(s) - \left(\frac{\alpha}{1-\alpha}\right)\ln(n+g+\delta)$$

40 See Barro and Sala-i-Martin (2004).

where $\hat{y}(t_1)$ is per worker income at the initial period and T is the time-span, T=(t_2-t_1). Subtracting $\ln \hat{y}(t_1)$ from both sides and rearranging terms, we obtain the following partial adjustment equation:

$$\ln \hat{y}(t_2) - \ln \hat{y}(t_1) = \left(1 - e^{-\beta T}\right)\left[\ln \hat{y}^{*} - \ln \hat{y}(t_1)\right] \quad \textbf{(I.7)}$$

In this model, the optimal value of the dependent variable is determined by the difference of income per worker in the initial period t_1 to its steady-state value. Since $\hat{y}^{*}$ depends on *s* and *n*, and these parameters remain constant during the time period T, the value of income per worker in the steady-state also depends on the current values of the explanatory variables. Substituting $\hat{y}^{*}$ in the above equation, we get the following expression:

$$\ln \hat{y}(t_2) - \ln \hat{y}(t_1) = \left(1 - e^{-\beta T}\right)\left[\left(\frac{\alpha}{1-\alpha}\right)\ln(s) - \left(\frac{\alpha}{1-\alpha}\right)\ln(n + g + \delta) - \ln \hat{y}(t_1)\right] \quad \textbf{(I.8)}$$

Equation (I.8) can be formulated in terms of income per capita instead of income per effective worker and thus reveals more clearly the correlation between *A(0)* and the observed included variables.

Defining output per effective worker as $\hat{y}(t) = \frac{Y(t)}{A(t)L(t)} = \frac{Y(t)}{L(t)A(0)e^{gt}}$ and taking logs, we get: $\ln \hat{y}(t) = \ln\left[\frac{Y(t)}{L(t)}\right] - \ln A(t) \Leftrightarrow \ln \hat{y}(t) = \ln y(t) - \ln A(0) - gt$. Substituting for $\hat{y}(t)$ into equation (I.8) we get the dynamic panel data model, given by:

$$\begin{aligned} \ln y(t_2) - \ln y(t_1) = {} & \left(1 - e^{-\beta T}\right)\frac{\alpha}{1-\alpha}\ln(s) - \left(1 - e^{-\beta T}\right)\frac{\alpha}{1-\alpha}\ln(n + g + \delta) - \\ & - (1 - e^{-\beta T})\ln y(t_1) + \left(1 - e^{-\beta T}\right)\ln A(0) + g\left(t_2 - e^{-\beta T}t_1\right) + u_{i,t} \end{aligned} \quad \textbf{(I.9)}$$

where $\left(1 - e^{-\beta T}\right)\ln A(0)$ is the time-invariant individual effect term reflecting country-specific effects and $u_{i,t}$ is the error term that varies across countries and time periods. Estimating equation (I.9) by panel data techniques is the way to control for the individual country effects.

The main problem with the cross-sectional regressions is that the individual specific effects of the aggregate production function are ignored. The use of panel data allows to take care of the variable omission problem and to test for convergence in a more consistent way.[41]

41 For the advantages of panel data methods over cross-section studies, see Mankiw et al. (1992), Islam (1995), Temple (1999) and Billmeier and Nannicini (2007).

APPENDIX II

List of the countries and samples

World (78)		OECD (23)	Europe (20)	EMU (11)
Algeria	Kenya	Australia	Austria	Austria
Argentina	Korea	Austria	Belgium	Belgium
Australia	Lesotho	Belgium	Denmark	Finland
Austria	Malawi	Canada	Finland	France
Bangladesh	Malaysia	Denmark	France	Germany
Belgium	Mali	Finland	Germany	Greece
Benin	Mauritius	France	Greece	Ireland
Bolivia	Mexico	Germany	Hungary	Italy
Brazil	Mozambique	Greece	Iceland	Netherlands
Cameroon	Nepal	Iceland	Ireland	Portugal
Canada	Netherlands	Ireland	Italy	Spain
Chile	New Zealand	Italy	Netherlands	
China	Niger	Japan	Norway	
Colombia	Norway	Netherlands	Portugal	
Costa Rica	Pakistan	New Zealand	Romania	
Denmark	Panama	Norway	Spain	
Dominican Republic	Paraguay	Portugal	Sweden	
Ecuador	Peru	Spain	Switzerland	
Egypt	Philippines	Sweden	Turkey	
El Salvador	Portugal	Switzerland	UK	
Finland	Romania	Turkey		
France	Rwanda	UK		
Germany	South Africa	USA		
Ghana	Spain			
Greece	Sri Lanka			
Guatemala	Sweden			
Honduras	Switzerland			
Hong Kong	Syria			
Hungary	Thailand			
Iceland	Togo			
India	Trinidad Tobago			
Indonesia	Tunisia			
Iran	Turkey			
Ireland	UK			
Israel	USA			
Italy	Uruguay			
Jamaica	Venezuela			
Japan	Zambia			
Jordan	Zimbabwe			

APPENDIX III

Description of the variables and data sources

- $y_{i,t}$ - real GDP per capita (Laspeyres), RGDPL – dollars in 2000 constant prices
- population - thousands of inhabitants
- $s_{i,t}$ - the investment share– percentage of GDP in 2000 constant prices
- $op_{i,t}$ - degree of openness defined as exports plus imports to real GDP – percentage in 2000 constant prices

These data were collected from Heston et al. (2006), available at http://pwt.econ.upenn.edu/.

- $HUMAN_{i,t}$ - the average years of schooling of population aged 25 or over

The average years of schooling and the figures on adult population were collected from Barro and Lee (2000), available at http://www.cid.harvard.edu/ciddata/ciddata.html.

- $art_{i,t}$ - articles ratio, is the number of articles published per million of inhabitants aged 25 or over (excluding papers from arts and humanities).

Data on the number of publications was collected from the Institute for Scientific Information (ISI) – Science Citation Index, available at http://isi15.isiknowledge.com.

- $pat_{i,t}$ - the patents ratio, is the number of patents per million of inhabitants aged 25 or over. The "utility patent" applications are registered on the residence of the first-named inventor. Since some countries have no patents in certain years, it was added 0.1 to avoid missing data when log transformation was implemented.

Data on the number of patents was collected from the U.S. Patent and Trademark Office (USPTO), available at http://www.uspto.gov.

- $pat/art_{i,t}$ - the patents/articles ratio, was computed by the author from the ratio between the number of patents and the number of publications.
- $nfb_{i,t}$ - the net foreign balance, is the share of net exports of goods and services to real GDP and it was computed by the author, subtracting from 100 the consumption, investment and government shares of RGDPL - percentage in 2000 constant prices.
- $n_{i,t}+g+\delta$ - the average annual growth rate of population, was computed by the author from the population figures, to which was added 0.05, for the rate of technical progress plus capital depreciation.

APPENDIX IV

GMM in dynamic panel data models

For a short and dynamic panel data model, the lagged dependent variable will be correlated with the error term and thus its estimated coefficient will be biased, even if the error process is *iid*.

In an illustrative manner, we can demonstrate why the *GMM* procedure is the best econometric technique to apply to our model. Thus, starting from the growth equation:[42]

$$gy_{i,t} = b \ln y_{i,t-1} + c_j \ln X^{j}_{i,t} + \underbrace{\alpha_i + u_{i,t}}_{v_{i,t}} \qquad \textbf{(I.A)}$$

Lagging one period:

$$gy_{i,t-1} = b \ln y_{i,t-2} + c_j \ln X^{j}_{i,t-1} + \underbrace{\alpha_i + u_{i,t-1}}_{v_{i,t-1}} \qquad \textbf{(I.B)}$$

Taking first differences of (I.A):

$$\Delta gy_{i,t} = b \Delta \ln y_{i,t-1} + c_j \Delta \ln X^{j}_{i,t} + \Delta u_{i,t} \qquad \textbf{(I.C)}$$

It can thus be noticed that:

- $\text{cov}(\Delta \ln y_{i,t-1}, \Delta u_{i,t}) \neq 0$.

$\Delta \ln y_{i,t-1} = \ln y_{i,t-1} - \ln y_{i,t-2}$ depends on $u_{i,t-1}$, which is part of $\Delta u_{i,t}$, the error term of (I.C): $\Delta u_{i,t} = u_{i,t} - u_{i,t-1}$. => *Regressor-error correlation (endogeneity)*.

- $\text{cov}(\Delta u_{i,t}, \Delta u_{i,t-1}) \neq 0$, despite $u_{i,t}$ being *iid*. In fact, both differenced error terms contain a common component, $u_{i,t-1}$. => *Serial correlation in the error term.*

From (I.B), $gy_{i,t-1}$ is correlated with α_i (individual effect). Therefore, since $\ln y_{i,t-1}$ is part of $gy_{i,t-1}$ and is a regressor in (I.A), it can be confirmed that $\text{cov}(\ln y_{i,t-1}, \alpha_i) \neq 0$, i.e., there is endogeneity.

The strength of the *GMM* approach in the context of the empirical growth literature has to do with the potential for obtaining consistent parameter estimates even in the presence of measurement error and endogenous right-hand side variables (Bond et al., 2001).

42 This approach follows Baltagi (2005) and Baum (2006).

APPENDIX V

RGDPL – ranking according to income in 2000

units: PPP constant dollars in 2000

High-income countries (27)		Middle-income countries (27)		Low-income countries (24)	
USA	34364.50	Chile	11430.19	Jordan	3901.84
Norway	33092.15	Malaysia	11405.50	Guatemala	3859.47
Switzerland	28831.25	Hungary	11382.95	Philippines	3825.62
Denmark	27827.28	Argentina	11331.96	Indonesia	3771.86
Hong Kong	27236.15	Uruguay	10739.74	Zimbabwe	3255.93
Austria	26999.77	Costa Rica	8341.47	Bolivia	2929.19
Canada	26820.73	South Africa	8226.06	India	2643.85
Netherlands	26293.09	Mexico	8082.09	Pakistan	2477.13
Australia	25834.54	Panama	7934.80	Cameroon	2471.73
Iceland	25794.63	Venezuela	7322.97	Honduras	2239.66
Sweden	25231.77	Brazil	7193.60	Syria	2000.89
Germany	25061.34	Tunisia	6993.31	Bangladesh	1851.16
France	25044.54	Dominican Republic	6497.37	Lesotho	1833.90
Ireland	24947.55	Thailand	6473.60	Nepal	1421.01
UK	24666.41	Colombia	6079.68	Ghana	1392.20
Belgium	24661.91	Iran	6045.53	Kenya	1267.72
Japan	23970.56	Algeria	5753.12	Benin	1251.47
Finland	22740.69	Turkey	5714.59	Mozambique	1093.18
Italy	22487.21	Romania	5211.11	Mali	1046.72
Israel	22236.90	Paraguay	4965.41	Rwanda	1018.07
New Zealand	20422.92	El Salvador	4732.13	Zambia	865.65
Spain	19536.38	Egypt	4535.83	Malawi	838.99
Portugal	17323.14	Jamaica	4520.84	Togo	823.17
Korea	15702.27	Ecuador	4314.44	Niger	807.45
Mauritius	15121.01	Peru	4204.50		
Trinidad &Tobago	14770.03	Sri Lanka	4046.63		
Greece	13982.39	China	4001.82		

Data source: Heston et al. (2006).

CHAPTER 2. FOREIGN TRADE, HUMAN CAPITAL AND ECONOMIC GROWTH: AN EMPIRICAL APPROACH FOR THE EU COUNTRIES. *

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2.1. INTRODUCTION

As we referred before, it is possible to distinguish two main theories explaining the impact of international trade on economic growth, namely the supply-orientated approach associated with the neoclassical theory of growth and the demand-orientated approach associated with the Keynesian perspective. The former does not offer a formal theory for the possible impact of a country's balance-of-payments on its growth performance. The general idea is that the accumulation of exogenous inputs (especially of capital) is the only way through which an economy can expand. When balance-of-payments problems occur, prices adjust automatically to restore equilibrium.

Opposing the supply-orientated approach stands the Keynesian view, which states that demand (especially external demand) guides the economic system and that supply, within certain limits, simply adapts to it. The well-known export-led growth hypothesis[43] associated with "Thirlwall's Law" is part of this demand-orientated approach, and it supports the notion that exports are the engine of growth.

The denominated new theory of endogenous growth, which attributes a special role to human capital, aims at reducing the differences between the two main views. However it remains essentially a supply–orientated approach and most importantly, it does not take into account the fact that growth can be constrained by external demand.[44]

Recent studies by Santos-Paulino and Thirlwall (2004), Pacheco-López and Thirlwall (2006), Vera (2006), Porcile et al. (2007), among others, make clear how balance-of-payments problems can constrain growth in developing countries as a result of trade liberalisation. Some examples for particular EU countries are those from Léon-Ledesma (1999) for Spain, Kvedaras (2006) for the Central and Eastern European countries, Garcimartín et al. (2008) for Ireland and Antunes and Soukiazis (2009 a) for Portugal. In these studies, it is shown that actual growth can accurately be predicted by the balance-of-payments equilibrium growth rate given by "Thirlwall's Law". However, all these studies are strictly demand-orientated with growth being determined by

43 Thirlwall (1979), Bairam (1988), Marin (1992), Muscatelli et al. (1994), Atesoglu (1995) and McCombie (1997) are some of the studies that have been carried out on export-led growth.

44 Romer (1986) and Lucas (1988) point out the positive effects of international trade on growth, whereas Rodriguez and Rodrik (2000) question the sign and the significance of such impact.

demand forces (especially external demand) and supply adjusting to the demand requirements.

The aim of this Chapter is to include empirically demand and supply forces into the same growth model. To do that we introduce factors related to external trade and external demand into the supply-driven growth model and we test empirically their relevance on growth. The above variables can be combined with different proxies for human capital and alternative interaction terms can be employed to check their validity on growth. In doing so, we try to specify a more complete growth equation that explicitly takes into account the strength of external demand and investigate how the latter interacts with different levels of human capital and foreign trade variables. These are the main aspects that distinguish this analysis from previous studies. As far as we know, Barro's type growth models have not previously taken the balance-of-payments constraint hypothesis into consideration.

Our empirical analysis estimates the growth equations by considering a sample of 14 EU countries over the period 1980-2004, using panel data regressions. The variables to express foreign trade are the degree of openness and the net foreign balance (as a percentage of GDP). Additionally, the income-elasticity ratio of foreign trade (measuring non-price competitiveness) is used as the key factor of the balance-of-payments constraint hypothesis derived from the well-known "Thirlwall's Law".

The variables related to human capital are: the average years of schooling of the adult population, which represents basic levels of human capital qualifications; the publication rate, which measures the efficiency of human capital reflecting scientific production; the patents rate as an approximation for innovation and R&D activities; and the combined patents/articles ratio, which aims to measure the ability of transforming scientific production into innovation.

Comparing to the previous Chapter, the innovation lies on the fact that we introduce demand factors represented by the income-elasticities ratio of foreign trade into the neoclassic growth model. In doing so, we bring together demand and supply forces in the growth model, to verify their relevance. Since this Chapter is closely related to the previous one, some of the theoretical considerations presented before are preserved.

The Chapter is organised as follows: following the Introduction, section 2.2 explains the theoretical aspects of the model to estimate and discusses the relevance of human capital, foreign trade and external demand on growth. Some statistical data on

international trade performance, human capital differences between countries and the variables used in the estimation approach are explained in section 2.3. The empirical results obtained from the panel data regressions are analysed and discussed in section 2.4. The final section concludes the main findings of this study.

2.2. THEORETICAL ASPECTS OF THE MODEL

The model used in the empirical approach is based on the conditional convergence hypothesis developed and tested empirically by Barro and Sala-i-Martin (2004). The model is an extension of the Solow's (1956) growth model with human capital and technical progress endogenously determined and increasing returns to scale stemming from both to compensate for the diminishing returns on physical capital that were assumed in the neoclassical theory. The model predicts conditional convergence in per capita income or product per head among economies when differences in the steady-states are controlled for. Human and physical capital along with technical progress and innovation are found to be some of the most important determinants of growth. Economies converge to different steady-states of per capita income which are characterised by the above conditioning factors.

The convergence issue is particularly important at the EU level, given the increasing integration and the goals of social and economic cohesion. There has been extensive research in this field, following different methodologies and several approaches. The discussion is far from being consensual and Borota and Kutan (2008) offer an overview on the convergence issue across the EU, arguing that economic integration had positive growth effects in Europe.

Our study contributes to the large literature on convergence in the EU. We find evidence of convergence when human capital and foreign trade are taken into account in the growth equation. In addition, the inclusion of interaction terms highlights the importance of considering joint effects of human capital and foreign trade and the existence of technological diffusion stimulated by trade. Also, the income-elasticity ratio of foreign trade proves to be relevant for growth. The interaction term between the elasticity ratio and the degree of openness reveals the existence of interdependences between non-price competitiveness and trade intensification.

2.2.1. THE ROLE OF HUMAN CAPITAL AND TECHNOLOGY ON GROWTH

Endogenous growth models can be grouped in two main streams: the first is closer to the neoclassical perspective, and gives emphasis to the accumulation of a broader concept of capital which is not subject to decreasing returns. The second

underlines the endogenous development of knowledge or R&D as the key factors of growth (Aghion and Howitt, 1998; Turnovsky, 2001).

In the first group of models, a broader version of capital, including both physical and human capital, is considered as an input into the production function (Lucas, 1988; Mankiw et al., 1992). In this context, human capital is regarded as a measure of the ability and skills of the labour force and it is evaluated by the formal education or the job learning accumulated experience. The common finding is that most models demonstrate the existence of a positive correlation between human capital accumulation and growth. The second group is made up of models that focus on the importance of technological change as the engine of growth (Romer, 1986). In these studies, human capital plays a relevant role in enabling innovation and R&D activities in developed countries. In less developed countries, human capital is important for assimilating new technologies developed by advanced countries and transferred through trade.

In this study, similarly to what we did in the last Chapter, we use four main variables to measure the different levels of human capital: the average years of schooling, the publication rate, the patents rate and the combined patents/articles ratio. It is to be expected that higher levels of human capital related to scientific production and innovation differentiate the steady-states of the EU countries in the growth equation more properly.

2.2.2. THE BALANCE-OF-PAYMENTS CONSTRAINED GROWTH RATE

Both the neoclassical and the endogenous growth theories concentrate on the supply side of the economy. After specifying the functional form of the aggregate production function, the growth of output is explained by the growth of certain input factors such as labour, a broader concept of capital and total factor productivity. Although, according to this approach, different growth rates can be explained by differences in factor supplies and productivity, it is not clear why the growth of factor supplies may vary between countries. Furthermore, with this approach, relative price adjustments and exchange rate flexibility can bring the economy back to equilibrium when foreign trade imbalances occur. No special role is attributed to trade and most importantly, growth is not constrained by external demand.

Within the framework of the demand-orientated approach, where income adjusts to preserve equilibrium, stands Thirlwall's "fundamental law". Thirlwall (1979)

developed an export-led growth model where the performance of the balance-of-payments (on current account) matters for the long-term growth. According to Thirlwall, a persistent balance-of-payments deficit can constrain domestic demand and retard growth in the long-run. He established a simple rule that determines the rate of growth of domestic output as being consistent with the balance-of-payments equilibrium. This rule (known as "Thirlwall's Law") states that a country's balance-of-payments equilibrium growth rate is given by the ratio of export growth (x) over the income-elasticity of demand for imports (π), assuming that relative prices remain constant in the long-term.[45] Thirlwall's rule can be expressed in the following way:[46]

$$y_{BP,t} = \frac{\varepsilon(z)_t}{\pi} \qquad \textbf{(2.1a)} \qquad \text{or} \qquad y_{BP,t} = \frac{x_t}{\pi} \qquad \textbf{(2.1b)}$$

Equation (2.1a) determines the rate of growth of domestic income consistent with the balance-of-payments equilibrium (on current account), denoted by $y_{BP,t}$. This relation stresses both the positive impact of increasing external demand (z_t) and the inverse impact of higher import penetration (π) on the growth of domestic income. Equation (2.1b) is known as "Thirlwall's Law" or the dynamic Harrod's foreign trade multiplier obtained by assuming that $x_t = \varepsilon(z)_t$ when relative prices remain constant. Equation (2.1a) can also be written as:

$$\frac{y_{BP,t}}{z_t} = \frac{\varepsilon}{\pi} \qquad \textbf{(2.2)}$$

This expression determines a country's relative growth rate with respect to the rest of the world (or a group of other countries) and is given by the ratio of its income-elasticity of demand for exports relative to its income-elasticity of demand for imports. This is an interesting relation predicting that a country will experience faster growth than the rest of the world ($y_{BP,t} \rangle z_t$) as long as its income-elasticity of demand for exports is greater than its income-elasticity of demand for imports ($\varepsilon > \pi$). This is an important condition for a country to grow faster without deteriorating its balance-of-payments performance. Therefore, the ratio of the income-elasticity of foreign trade

45 This hypothesis is reasonable for the EU countries with free trade and towards a fixed exchange rate over the period considered, aiming to adopt a single currency by 1999.

46 For an explanation on how to get to this final expression, see the Appendix I of this Chapter.

(ε/π)[47] can be seen as reflecting the balance-of-payments constraint hypothesis. Considering the case where $\pi>\varepsilon$, signifying that imports penetration in domestic market is higher than export penetration in external markets, "Thirlwall's Law" predicts that the country will be constrained by external demand in the long-term and will thus grow at a lower rate than the rest of the world.

In this study, apart from the balance-of-payments constraint factor (ε/π), some other aspects related to trade will also be considered in the growth equation. These include the degree of openness, which has great relevance to the EU countries in expressing trade intensification, and the net foreign balance, which expresses trade competitiveness.

Indirect effects of international trade have also been found in the empirical literature, which explain the channels through which trade affects growth. Levine and Renelt (1991) provide evidence that free international trade affects growth indirectly through investment. Owen (1999) asserts that openness has a positive effect on enrolment ratios in countries with lower human capital stocks. Harrison (1991) argues that trade policy affects growth through its impact on technological change. Scale economies, comparative advantages, availability of intermediate products and capital equipment, exchange of information and knowledge, new production and organisational methods and technological diffusion are all referred to as additional channels to growth through trade (Grossman and Helpman, 1991 a; Di Liberto, 2005).

47 The income-elasticity ratio with respect to exports (ε) and imports (π) captures the non-price characteristics of the goods produced and traded associated with quality, design, durability, confidence, innovation, marketing and sales efficiency. These are known as the supply characteristics.

2.3. HISTORICAL EVIDENCE AND THE VARIABLES USED IN THE MODEL

Our sample consists of a set of 14 EU members [48] and covers the time span from 1980 to 2004. The reason for selecting this particular sample is to ascertain whether the balance-of-payments constraint hypothesis (through the income-elasticities of external trade) and the degree of openness are important determinants of growth for this set of countries, characterised by a high degree of economic integration implying free trade, free factor mobility and the adoption of common policies. It is argued that capital transfers will solve the problem of payments of external imbalances due to highly integrated capital markets, and that there is no need for foreign currency reserves to pay external transactions within the Union. However, according to the demand-orientated approach, balance-of-payments problems are structural in nature, associated with non-price competitiveness. Persistent trade imbalances will affect the long-term economic performance, retard growth and increase unemployment. This is the essence of the balance-of-payments constraint hypothesis, which we introduce into the growth equation (expressed by the income-elasticity ratio of exports relative to imports (ε/π)) to test its impact on growth. [49]

As our interest lies on measuring the impact of foreign trade on growth, it is convenient to analyse the differences among countries in terms of the degree of openness (defined as the ratio of external trade to GDP) and the net foreign balance (the share of net trade to GDP) over this period. This historical evidence is given in **Table 2.1** and illustrated in **Figures 2.1** and **2.2**, respectively.

48 The set is made up by Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the UK.

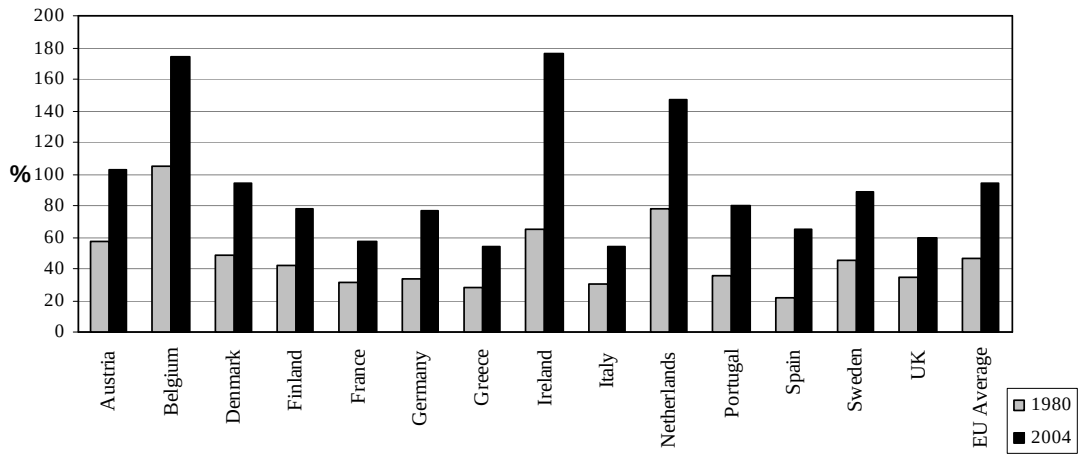
49 A detailed description of the variables and data sources is provided in the Appendix II of this Chapter.

Table 2.1. Degree of openness and net foreign balance for the 14 EU countries, 1980 and 2004.

Country	Degree of openness (%)		Net foreign balance (%)	
	1980	2004	1980	2004
Austria	57.461	102.948	-2.964	3.976
Belgium	104.360	173.987	-1.403	4.204
Denmark	48.588	94.516	1.804	4.686
Finland	42.668	77.906	-0.031	9.126
France	31.622	57.467	-1.008	-0.795
Germany	33.743	76.569	-2.277	4.274
Greece	28.111	54.260	-0.417	-10.060
Ireland	65.101	176.668	-9.312	18.047
Italy	30.180	54.526	0.475	-0.212
Netherlands	77.730	146.847	-1.101	6.757
Portugal	35.612	79.891	-3.081	-9.959
Spain	21.463	65.119	1.751	-6.578
Sweden	44.977	88.911	-2.647	10.391
UK	34.819	59.906	2.499	-4.630
EU Average	**46.888**	**93.537**	**-1.265**	**2.088**

Data source: Heston et al. (2006).

Figure 2.1. Degree of openness for the 14 EU countries, 1980 and 2004.

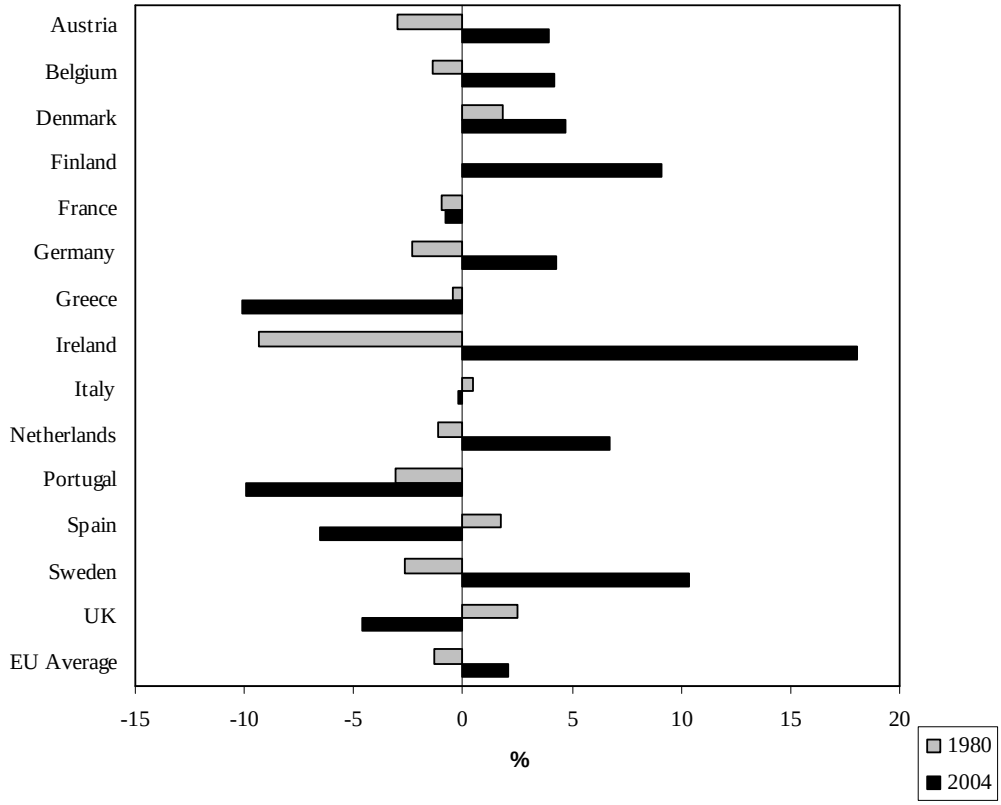


Data source: Heston et al. (2006).

As we can see in **Table 2.1,** the degree of openness in all fourteen countries increased substantially from 1980 to 2004 as a result of trade intensification. Ranking the countries in descending order for 1980, the highest rates are those of Belgium (104.4), the Netherlands (77.7), Ireland (65.1) and Austria (57.5). Only Belgium shows a ratio higher than 100%. The top-down countries are France, Italy, Greece and Spain (all bellow 32%). In 2004 Ireland appears in first place (176.7), followed by Belgium

(174.0), the Netherlands (146.9) and Austria (103.0) - all with ratios higher than 100%. The less open economies are at this time the UK, France, Italy and Greece, all with ratios lower than 60%. The biggest changes in the degree of openness between 1980 and 2004 occurred, in descending order, in Spain, Ireland, Germany and Portugal and the less pronounced increases were those of Italy, Austria, the UK and Belgium. The degree of openness of the EU average doubled within the period, from 47% to 94%.

Figure 2.2. Net foreign balance for the 14 EU countries, 1980 and 2004.



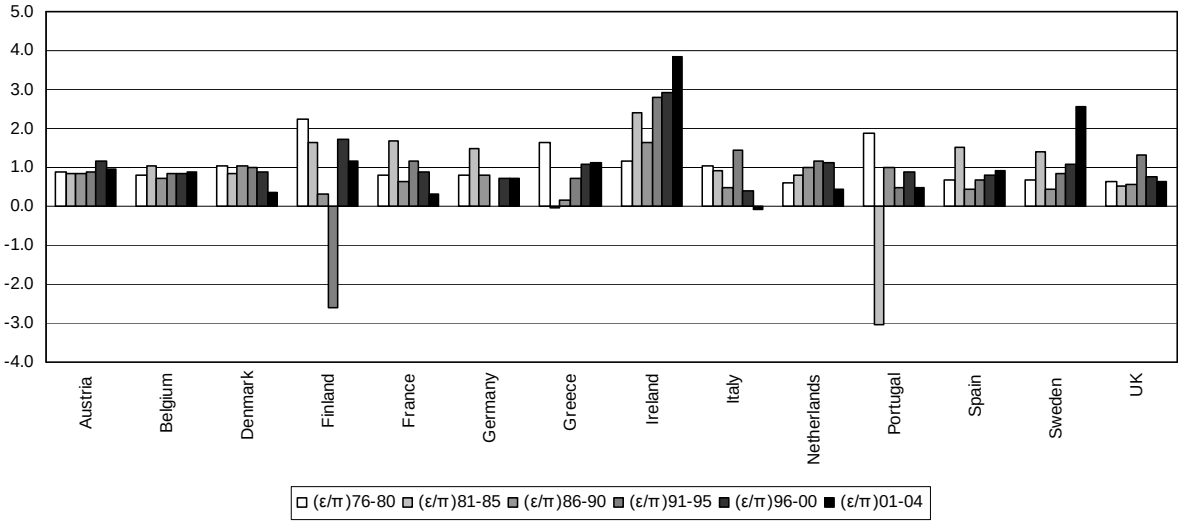
Data source: Heston et al. (2006).

As for net foreign balance, only four countries registered a surplus in 1980 – the UK, Denmark, Spain and Italy. In contrast, in 2004 eight countries registered a positive net trade i.e. Ireland, Sweden, Finland, the Netherlands, Denmark, Germany, Belgium and Austria. On the other hand, Italy and France reported a negative, although close to zero, net trade. It can also be seen that trade performance in Greece, Italy, Portugal, Spain and the UK deteriorated during the period under study. This is an interesting result showing that the southern countries of the EU, being less competitive, did not benefit much from the free single market. As we already know, large financial transfers

from the EU were given to those countries to compensate the large deficits. In the UK, the explanation also lies on competitiveness and structural problems regarding the balance-of-payments performance.[50] As a whole, the EU average went from a deficit in 1980 to a surplus of 2% in 2004. Thus, during the period between 1980 and 2004 some relevant changes have occurred both in the degree of openness and the balance of trade in the core of the EU countries. These changes need to be taken into account in the growth process.

In **Figure 2.3** we can see how the income-elasticity ratio with respect to exports and imports (ε/π) performed over the five-year intervals, between 1976 and 2004.

Figure 2.3. Income-elasticity ratio (ε/π) **over five-year intervals, from 1976 to 2004.**



Data sources: Author's computation using OECD (2006a; 2006b).

As it can be observed, Ireland is the only country in which the ratio is always greater than one, showing that exports penetration is higher in foreign markets than imports penetration in the domestic market. Another consequence of this high ratio is that the products produced and traded in this country are competitive both in foreign and domestic markets. According to "Thirlwall's Law", Ireland has the advantage of being able to grow relatively faster without incurring balance-of-payments problems. The experience of the other countries is mixed, with the income-elasticity ratio varying between countries and over the time periods considered. In general, the higher the income-elasticity ratio of foreign trade the higher the country's relative growth rate is

50 For a detailed analysis of the balance-of-payments problems in the UK, see Thirlwall and Gibson (1992).

expected to be. With a privileged value higher than one, a country has the ability to grow faster than other trade partners.

Moreover, we can see from **Figure 2.3** that there are five results showing negative income-elasticity ratios, which contradict the conventional trade theory. These cases can be explained by considering various special circumstances that were apparent in some countries during particular periods of time. For example, Finland (1991-1995) lost its principal trade partner due to the collapse of the former USSR; Germany (1991-1995) faced the costs of the unification process; Greece (1981-1985) had adaptation problems in the first years of its adhesion to the former EEC because of its low competitiveness; Italy (2001-2004) suffered lack of growth and political instability; and Portugal (1981-1985) faced the severe problem of the external debt payment and the restrictive measures imposed by the IMF in that period. All of these situations seriously affected external competitiveness, creating balance-of-payments problems that reflected themselves in the poor growth performances of these countries in the referred periods.

Differences on human capital performances are also significant between the European countries. Four proxies were used to account for different levels of human capital: the average years of education of the population aged 25-64 (*educ*),[51] which aims to encompass the basic level of education; the articles ratio (*art*) defined as the number of articles published per country's million inhabitants aged 25 or over, which represents a proxy for scientific production; the patents ratio (*pat*) defined as the number of patents per country's million inhabitants aged 25 or over, which aims to encompass higher levels of human capital associated with R&D activities; and a combined ratio (*pat/art*) revealing a country's ability to transform scientific research into innovation (Soukiazis and Cravo, 2008). All these statistics on human capital are shown in **Table 2.2**. As it can be seen, average years of education have been improved in all countries, but Portugal, Spain and Italy still remain behind the others. The same tendency is apparent regarding scientific production (measured by the articles ratio) and innovation activities (patents ratio), where the Southern countries show again relatively lower levels on these measures of human capital. A less expressive result is on the patents/articles ratio, which on average remained constant over the period between 1980 and 2004, with the majority of countries showing a decline in this indicator (a more

51 This indicator is a direct measure of the stock of human capital (Islam, 1995). However, it is limited in the sense that it does not allow us to understand the efficiency of human capital in a broader sense.

pronounced increase in the number of articles than in the number of patents results in a declining ratio).

Table 2.2. Statistical data on human capital for the 14 EU countries, 1980 and 2004.

Country	educ		art		pat		pat/art	
	1980	**2004**	**1980**	**2004**	**1980**	**2004**	**1980**	**2004**
Austria	10.4	12.4	526.1	1286.5	86.2	172.0	0.164	0.134
Belgium	9.3	11.2	551.2	1457.5	62.0	178.5	0.113	0.122
Denmark	10.6	11.7	925.2	2069.8	66.0	243.2	0.071	0.118
Finland	9.5	12.0	754.5	1999.2	84.8	572.9	0.112	0.287
France	9.5	11.0	655.1	1096.5	99.9	163.4	0.152	0.149
Germany	11.4	12.8	589.2	1038.4	190.8	325.7	0.324	0.314
Greece	7.9	10.7	118.6	790.0	3.7	7.7	0.031	0.010
Ireland	8.5	10.8	728.8	1735.7	24.4	156.4	0.033	0.090
Italy	7.3	9.9	235.2	792.1	42.6	67.8	0.181	0.086
Netherlands	10.1	12.1	664.8	1658.3	120.1	269.5	0.181	0.162
Portugal	7.2	8.1	32.5	636.2	1.3	4.0	0.039	0.006
Spain	6.3	9.2	142.6	818.7	6.6	22.3	0.046	0.027
Sweden	10.1	12.1	1028.1	2273.4	217.2	359.1	0.211	0.158
UK	10.1	12.1	964.3	1628.0	117.2	188.4	0.122	0.116
EU Average	**9.2**	**11.2**	**565.4**	**1377.2**	**80.2**	**195.1**	**0.127**	**0.127**

Data sources: see the Appendix II of this Chapter.

Notes:
educ is the average years of education of the population aged 25-64.
art is the number of articles published per country's million inhabitants aged 25 or over.
pat is the number of patents per country's million inhabitants aged 25 or over.

These preliminary findings regarding foreign trade and human capital performances justify our interest in measuring the impact of these variables on economic growth. For this purpose, a general specification of the "Barro growth regression" was employed. This regression relates the growth of per capita income to a set of explanatory variables that includes: the lagged level of per capita income (the convergence factor); the annual growth rate of population *n;* the investment ratio *s;* the different levels of human capital *HC*; and measures related to foreign trade *FT*.

Taking into consideration the discussion presented in the previous section regarding the role of human capital and foreign trade on growth, we expect them to have a positive impact.[52] The annual population growth rate is expected to have a negative

52 It is necessary to bear in mind the arguments presented in section 1.5, calling the attention for the possibility of a negative or a statistically insignificant impact of human capital on growth. Moreover, Rodriguez and Rodrick (2000) were not very optimistic about the positive impact of trade on growth.

impact on economic growth, because the available capital must be spread more thinly over the population of working age.[53] However, a positive impact is not out of question, since the population growth may reflect itself in a more prosperous demand. Physical capital is believed to influence the rate of growth of output positively and the reasons where already explained in section 1.5.

The inclusion of the income-elasticity ratio in the growth regression represents an attempt to insert the export-led growth hypothesis of the demand-orientated approach into the endogenous supply-driven growth model. It is expected that this ratio will have a positive effect on growth, as the increase in the ratio, due to a higher income-elasticity of the demand for exports (ε) relatively to the income-elasticity of the demand for imports (π), puts an economy in a more favourable position with the rest of the world in terms of competitiveness. Finally, interaction terms are also included in the growth regression.[54] Several hypotheses were alternatively tested, i.e. the interaction between foreign trade and human capital variables or between the income-elasticity ratio and either the foreign trade measures or the human capital proxies. No viable results emerged, however, from the latter. If the (ε/π) ratio appears as an important factor in the growth equation for the set of the EU countries under study (either isolated or combined with other variables), then we may infer that the balance-of-payments constraint hypothesis of the demand-orientated approach is relevant in the endogenous growth model. The empirical analysis is based on the panel data regressions described in the following section.

53 For this argument see Mankiw at al. (1992).

54 The exogeneity of interaction terms was tested by the use of the *Difference-in-Hansen test*.

2.4. EMPIRICAL EVIDENCE FROM GROWTH REGRESSIONS

The dynamic panel data specification is the most suitable approach for analysing growth dynamics while taking into account country-specific effects. The estimation method most commonly applied to dynamic equations with panel data and a lagged dependent variable is the *GMM* (Generalised Method of Moments), which uses a set of instrumental variables to solve the problem of the endogeneity of the regressors. Both types of *GMM* estimators (the difference and the system *GMM*) can be considered in the regressions, in both their one-step and two-step versions. The set of instruments of the difference *GMM* estimator includes all available lags of the levels of endogenous variables and strictly exogenous regressors (Arellano and Bond, 1991; Baum, 2006). The system *GMM* estimator considers not only the instruments from the difference *GMM* estimator, but also the lagged differences of the explanatory variables in levels (Arellano and Bover, 1995; Blundell and Bond, 1998).

In this study, proper results were found using either the difference *GMM* or the system *GMM*, with the former method appearing more frequently in the tables. The reason for this could be the relatively short panel employed: in this case, the use of lagged levels as instruments enables the maximization of the sample size. The considerations made in section 1.5 regarding the *GMM* estimation are maintained here.

In our empirical analysis we consider the growth model as was adapted by Caselli et al. (1996) to panel data to avoid omitted variable bias. The general specification of the growth equation (with no interaction terms) is as follows:

$$gy_{i,t} = b\ln(y_{i,t-5}) + c_1\ln(n_{i,t} + g + \delta) + c_2\ln(s_{i,t}) + c_3\ln(HC_{i,t}) + c_4\ln(FT_{i,t}) + v_{i,t}$$

where $v_{i,t} = \alpha_i + u_{i,t}$ **(2.3)**

Like in section 1.5, in this equation, α_i refers to country-specific effects such as differences in the initial level of efficiency or country-specific measurement errors (Bond et al., 2001) and $u_{i,t}$ is the idiosyncratic error term. The subscript *i* refers to countries (i=1,…, 14) and *t* to time (t=1985,…,2004). We consider, once more, five-

year time-intervals, since the error terms are then less likely to be correlated than with yearly data.[55]

The dependent variable is the annual growth rate of per capita income at five-year intervals. The growth regressions can be adapted to take into account each of the four human capital proxies separately, combining them alternatively with the international trade variables. Following this approach, the most plausible outcomes are shown in **Table 2.3**. The proxies for human capital (*HC*) used are the average years of schooling of the adult population (*educ*), the articles ratio (*art*), the patents ratio (*pat*) and the patents/articles ratio (*pat/art*). As foreign trade variables, we have the degree of openness (*op*), the net foreign balance (*nfb*)[56] and the income-elasticity ratio of exports to imports (ε/π). The latter reflects non-price competitiveness and illustrates the strength of demand on growth.

As a preliminary note, we wish to clarify that the lagged per capita income ($y_{i,t-5}$), the annual growth rate of population ($n_{i,t}$)[57] and the investment ratio ($s_{i,t}$) are common to all of the growth regressions that we ran. As for the remaining variables, we tested their relevance assuming alternative combinations between the human capital and foreign trade proxies.

In column (1) of **Table 2.3**, the combination of the patents/articles ratio (measuring the ability to transform scientific work into innovation) with the degree of openness appears to explain satisfactorily the growth process of the EU economies. Both factors have positive and statistically significant impacts on the growth of per capita income as might be expected. Our results thus show that higher trade intensification and increased innovation capability are beneficial in inducing faster economic growth in the EU countries under study. As for the innovation proxy, our results confirm the idea that higher levels of human capital are more appropriate in differentiating the steady-states of countries with higher levels of development. On the other hand, the coefficient of the lagged per capita income is negative, which confirms the hypothesis of conditional convergence and the impact of the investment ratio on the growth equations is positive as expected, both being statistically significant at the 1% level.

55 There are several growth studies based on five-year intervals, among them those of Islam (1995), Caselli et al. (1996), Söderbom and Teal (2003) and Economidou et al. (2006).

56 No significant results were obtained from its inclusion in the regression.

57 Once more, we add 0.05 to the annual population growth rate $n_{i,t}$. See footnote 17, in section 1.5.

Table 2.3. Panel data growth regressions for the 14 EU countries, 1980-2004.

Variables	(1)	(2)	(3)
$\ln(y_{i,t-5})$	-0.1423***	-0.1638***	-0.1412***
	(-5.29)	(-4.99)	(-4.76)
$\ln(n_{i,t}+g+\delta)$	0.1071	0.1087	-0.0452
	(1.36)	(0.91)	(-0.41)
$\ln(s_{i,t})$	0.0865***	0.1118***	0.0944***
	(4.44)	(3.59)	(5.85)
$\ln(pat/art_{i,t})$	0.0426***		0.0341*
	(3.25)		(2.14)
$\ln(op_{i,t})$	0.0777***	-0.2882**	0.0596***
	(4.64)	(-2.16)	(3.03)
$\ln(educ_{i,t})$		-0.5272**	
		(-2.52)	
$\ln(op_{i,t})*\ln(educ_{i,t})$		0.1524**	
		(2.76)	
$(\varepsilon/\pi)_{i,t}$			-0.0820*
			(-1.98)
$\ln(op_{i,t})*(\varepsilon/\pi)_{i,t}$			0.0225**
			(2.18)
Observations	56	56	56
No. of countries	14	14	14
No. of instruments	10	11	13
Hansen J-test	3.562	5.370	5.977
p-value	0.614	0.372	0.426
AR2 test	0.429	-0.589	0.241
p-value	0.668	0.556	0.810

Notes:

The dependent variable is the average annual growth rate of per capita income for each 5(4)-year interval.
Column (1) is two-step difference *GMM* estimations with robust standard errors, using the options "collapse" and "lag (1 2)".
Columns (2) and (3) are one-step difference *GMM* estimations with robust standard errors, using the options "collapse" and "lag (1 2)".

Numbers in brackets are t-ratio.

* Coefficient significant at the 10% level;** Coefficient significant at the 5% level; *** Coefficient significant at the 1% level.

Hansen J-test is the test of over-identifying restrictions in the *GMM* estimation.
AR2 test is the Arellano and Bond test for second-order serial autocorrelation in first differences.

Moreover, in terms of statistical significance, no other human capital proxy performed better when combined with the openness variable. However, when human capital was removed from the regressions the results improved: all coefficients had the expected signs and were statistically significant (independently of the *GMM* approach

used). It was not possible to combine the net foreign balance with any of the four human capital proxies in the growth regression (in any of the four versions of the *GMM* method), but in each case, when human capital was excluded, the results improved and the remaining coefficients had their expected signs and were statistically significant.[58]

The growth regression in column (2) includes the average years of education (*educ*), the degree of openness (*op*), and an exogenous interaction term between them. The impact of human capital on growth is positive as long as the degree of openness is higher than 31.8%.[59] Countries that fall behind this cut-off point need to take precautions regarding economic growth. Conversely, the impact of openness is only positive if the average years of education is higher than 6.6. These conclusions derived from the interaction between the level of education and trade intensification seem to support the idea of knowledge and technology diffusion, arguing that technology transferred through trade can only be absorbed and developed through higher levels of education.

The knowledge/technology diffusion hypothesis is also supported in column (3), where higher levels of human capital efficiency, expressed by the patents/articles ratio and the degree of openness, are considered. Both factors have a positive impact on growth as expected and are statistically significant (the patents/article ratio only at the 10% level). Reasonable results were also obtained from the interaction between the income-elasticity ratio (ε/π) and the openness factor. This specification was supposed to investigate whether the impact of foreign trade on growth depends on an economy's relative position regarding (non-price) competitiveness towards the rest of the world. Our evidence suggests that the impact of the income-elasticity ratio on growth is expected to be positive whenever the degree of openness is higher than 38%. In fact, trade intensification and economic competitiveness are important determinants for growth.

Table 2.4 shows alternative panel regressions using exogenous interaction terms whose results become reasonable after removing the variables with coefficients displaying no statistical significance.

58 These results are not given here but are available from the author on request.

59 The cut-off points are obtained from:

$$\frac{\partial gy}{\partial \ln(educ)} = 0 \Leftrightarrow -0.5272 + 0.1524\ln(op) = 0 \Leftrightarrow \ln(op) = 0.5272/0.1524 \qquad \Rightarrow op = \exp(0.5272/0.1524) = 31.8$$

$$\frac{\partial gy}{\partial \ln(op)} = 0 \Leftrightarrow -0.2882 + 0.1524\ln(educ) = 0 \Leftrightarrow \ln(educ) = 0.2882/0.1524 \qquad \Rightarrow educ = \exp(0.2882/0.1524) = 6.6$$

Table 2.4. Panel data growth regressions for the 14 EU countries, 1980-2004. Additional results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(y_{i,t-5})$	-0.1100***	-0.1353***	-0.0889***	-0.1350***	-0.0493***	-0.0939*
	(-3.65)	(-5.78)	(-3.16)	(-5.13)	(-3.11)	(-1.76)
$\ln(n_{i,t}+g+\delta)$	-0.2191**	0.0463	-0.0496	0.1074	-0.2558*	-0.3830*
	(-2.39)	(0.68)	(-0.72)	(1.19)	(-1.79)	(-1.88)
$\ln(s_{i,t})$	0.1104***	0.1229***	0.0952***	0.0900***	0.1303***	0.1035**
	(5.30)	(9.24)	(3.64)	(3.66)	(4.53)	(2.23)
$\ln(pat_{i,t})$	-0.0586**	-0.0690***				
	(-2.76)	(-3.49)				
$\ln(op_{i,t})*\ln(pat_{i,t})$	0.0149**	0.0169***				
	(2.95)	(4.37)				
$\ln(op_{i,t})$			0.0511**	0.0958***		
			(2.60)	(4.37)		
$\ln(op_{i,t})*\ln(pat/art_{i,t})$			0.0029***	0.0070**		
			(3.44)	(2.46)		
$(\varepsilon/\pi)_{i,t}$					-0.0953**	-0.2487**
					(-2.50)	(-2.19)
$\ln(op_{i,t})*(\varepsilon/\pi)_{i,t}$					0.0237**	0.0632**
					(2.68)	(2.21)
Constant	0.0947		0.2720		-0.6533	
	(0.44)		(1.04)		(-1.17)	
Observations	70	56	70	56	70	56
No. of countries	14	14	14	14	14	14
No. of instruments	10	9	10	9	10	9
Hansen J-test	4.827	3.308	5.722	5.005	6.638	2.301
p-value	0.306	0.508	0.221	0.287	0.156	0.681
AR2 test	-0.855	0.528	1.248	0.126	-1.593	-1.007
p-value	0.393	0.598	0.212	0.900	0.111	0.314

Notes:
Columns (1), (3) and (5) are two-step system *GMM* estimations with robust standard errors, using the options "collapse" and "lag (1 1)".
Columns (2) and (6) are one-step difference *GMM* estimations with robust standard errors, using the options "collapse" and "lag (1 2)".
Column (4) is two-step difference *GMM* estimations with robust standard errors, using the options "collapse" and "lag (1 2)".

For further notes – see **Table 2.3**.

The two first columns of **Table 2.4** display the results of the combination of the patents ratio with the degree of openness and the corresponding interaction term. As foreign trade does not appear individually significant it was removed from the growth regression and the results improved. Once more, the interaction between trade intensification and higher levels of human capital associated with innovation appear to be relevant for growth. The general conclusions are similar, whether the two-step system (column (1)) or the one-step difference *GMM* (column (2)) is employed. In the

former, the impact of innovation activities on growth is expected to be positive as long as the degree of openness is higher than 51% while in the latter case, the threshold rate goes up to 59%. This evidence suggests a kind of interrelation between trade and innovation that significantly affects the pattern of growth.

Columns (3) and (4) of **Table 2.4** show that when openness is linked with the patents/articles ratio, the results are also reasonable. The difference between the two regressions lies in the estimation method (the two-step system in column (3) and the two-step difference in column (4)). In both cases the impact of openness on growth is always positive, because the condition on the patents/articles ratio is always attained. Furthermore, the impact of foreign trade on growth of the EU countries during the period considered is always as desired because human capital does not constitute a limitation to obtaining the benefits from international trade. This is an interesting result suggesting an important link between the efficiency of innovation, trade and economic growth.

The two last columns of **Table 2.4** give significant evidence of the link between trade (through openness) and non-price competitiveness, which is given by the ratio of the income-elasticity of exports and imports. We can see that the impact of the income-elasticity ratio on growth is positive whenever the degree of openness is above 56% (column (5)) or 51% (column (6)). This is also an interesting result which indicates the importance of competitiveness to growth when trade intensification occurs. The income-elasticity ratio measures the non-price competitiveness and is a crucial parameter in export-led growth and the balance-of-payments constraint hypotheses. Our results highlight the relevance of these factors to growth.

Generally, the panel data regression analysis suggests that when human capital is combined or interacted with foreign trade (especially openness) the result is positive on growth as long as a minimum threshold level is attained. There is a connection between human capital qualifications and trade performance. Another issue arising from the regression analysis is that balance-of-payments problems, which are reflected in low competitiveness, may be harmful to growth and this effect depends on the degree of openness.

2.5. CONCLUSION

We have argued in this Chapter that the neoclassical approach to growth does not attribute a special role to foreign trade. Moreover, and most importantly, that the supply-orientated view, which includes both the neoclassical and endogenous growth approaches, does not take into account that foreign trade imbalances might constrain domestic demand and retard growth. Price flexibility will bring the economy back to equilibrium whenever a shock occurs. Although the endogenous growth theory recognises the importance of trade, especially through the process of technological transfer and diffusion, it still remains a supply-orientated approach not giving an important consideration to external demand as a possible constraint to growth.

On the other hand, the demand-orientated approach, through the export-led growth and the balance-of-payments constraint hypotheses, highlights the importance of external demand as the key factor to domestic growth and of foreign trade imbalances as a serious impediment to growth.

In this study an attempt was made to reconcile these two views by introducing factors related to foreign trade and external demand into the growth model. Thus, a more complete model of growth was estimated using different proxies for human capital and foreign trade to differentiate the EU countries more efficiently. Additionally, the income-elasticities ratio of foreign trade (obtained under the balance-of-payments constraint hypothesis) was also included in the estimations. Interaction terms were used as well to detect the existence of important links between human capital and foreign trade, and also between (non-price) competitiveness and trade intensification. The aim was twofold: to examine if it was reasonable to assume the existence of technology transfers occurring through trade and if the elasticities ratio's impact on growth depended on the degree of openness of the economy.

The empirical analysis estimated growth equations by using a panel data approach for a set of the early European Union members, over the period 1980-2004. Conditional convergence was found between the EU countries, being reinforced when human capital, foreign trade and (non-price) competitiveness were controlled for in the growth model. In particular, our empirical results are encouraging, showing that human capital (especially quality-related) and foreign trade (mostly through openness) or the interactions between them were all important determinants to growth. Important links

were found between human capital, trade and economic growth supporting the idea of knowledge and technology diffusion. The hypotheses of export-led growth and balance-of-payments constrained growth have also been highlighted in the empirical approach through the interaction between openness and competitiveness.

We came to the conclusion that the constraining element to growth may either be foreign trade, human capital, or both. Policy recommendation is self-explained from the empirical analysis, proposing improvements in human capital qualifications and developing innovation activities with the aim to turn the economies more competitive abroad. Moreover, the linkages between human capital and foreign trade should also be taken into account in sketching the policies.

APPENDIX I

Deduction of "Thirlwall's Law"

The original model with variables in levels (upper case letters) is the following:

$$M_t = aY_t^{\pi}\left(\frac{PD}{E * PF}\right)_t^{\psi}$$ Import demand function **(A)**

$$X_t = bZ_t^{\varepsilon}\left(\frac{PD}{E * PF}\right)_t^{\eta}$$ Export demand function **(B)**

$$PD_t * X_t = PF_t * E_t * M_t$$ Equilibrium in trade balance **(C)**

Taking logs and computing the derivates with respect to time, we get to the corresponding expressions, expressed in growth rates (lower case letters):

$$m_t = \pi y_t + \psi\left(pd_t - pf_t - e_t\right)$$ Import demand function **(A')**

$$x_t = \varepsilon z_t + \eta\left(pd_t - pf_t - e_t\right)$$ Export demand function **(B')**

$$pd_t + x_t = pf_t + e_t + m_t$$ Equilibrium in trade balance **(C')**

Substituting equations (A') and (B') into (C') and solving for y_t, we obtain the economy's rate of growth consistent with the balance-of-payments equilibrium $y_{BP,t}$, given by:

$$y_{BP,t} = \frac{(1+\eta-\psi)(pd_t - pf_t - e_t) + \varepsilon(z_t)}{\pi} \quad \textbf{(D)}$$

Assuming that relative prices remain unchanged in the long-run, that is, $pd_t - pf_t - e_t = 0$, the expression simplifies to:

$$y_{BP,t} = \frac{\varepsilon(z_t)}{\pi} \quad \textbf{(E1)} \qquad \text{or} \qquad y_{BP,t} = \frac{x_t}{\pi} \quad \textbf{(E2)}$$

APPENDIX II

Description of the variables and data sources

- $y_{i,t}$ - real GDP per capita (Laspeyres), RGDPL – dollars in 2000 constant prices
- population - thousands of inhabitants
- $s_{i,t}$ - the investment share – percentage of GDPL in 2000 constant prices
- $op_{i,t}$ - degree of openness defined as exports plus imports to real GDP – percentage in 2000 constant prices

These data were collected from Heston et al. (2006), available at http://pwt.econ.upenn.edu/.

- $educ_{i,t}$ - the average years of education of population aged 25-64, collected from Arnold et al. (2007).
- $art_{i,t}$ - the articles ratio, is the number of articles published per million of inhabitants aged 25 or over (excluding papers from arts and humanities).

Data on the number of publications was collected from the Institute for Scientific Information (ISI) – Science Citation Index, available at http://isi15.isiknowledge.com. Data on the number of inhabitants aged 25 or over was collected from LABORSTA, Economically Active Population Estimates and Projections 1980-2020, Topic: Population and Economically Active Population (version 5), available at: http://laborsta.ilo.org/.

- $pat_{i,t}$ - the patents ratio, is the number of patents per million of inhabitants aged 25 or over. The "utility patent" applications are registered on the residence of the first-named inventor.

Data on the number of patents was collected from the U.S. Patent and Trademark Office (USPTO), available at: http://www.uspto.gov.

- $pat/art_{i,t}$ - the patents/articles ratio, was computed by the author from the ratio between the number of patents and the number of publications.
- $nfb_{i,t}$ - the net foreign balance, is the share of net exports of goods and services to real GDP and it was computed by the author, subtracting from 100 the consumption, investment and government shares of RGDPL - percentage in 2000 constant prices.
- $n_{i,t}+g+\delta$ - the average annual growth rate of population, was computed by the author from the population figures, to which was added 0.05 for the rate of technical progress plus capital depreciation.
- $(\varepsilon/\pi)_{i,t}$ - is the income-elasticity ratio of demand for exports and imports. The elasticity was computed by the author, using the first difference of the logarithm of the variable of interest to compute the corresponding annual growth rate. The average annual growth rate was then

computed for the following five-(four-) year intervals: 1976-1980, 1981-1985, 1986-1990, 1995-2000 and 2001-2004. Lastly, the ratio between the average growth rate of exports (imports) and external (internal) income provided us with the income-elasticity of demand for exports (imports) for the 6 time-intervals required for panel data estimation. The computation of the income-elasticity of demand for exports (and imports) thus required the previous calculation of the growth rate of the following variables:

x – Exports of goods and services in volume index (2000=100) (OECD, 2006 a)
z – GDP of OECD in volume index (2000=100) (OECD, 2006 b)
m - Imports of goods and services, volume index (2000=100) (OECD, 2006 a)
y – Country's real GDP, volume index (2000=100) (OECD, 2006 b)

CHAPTER 3. THE IMPORTANCE OF FOREIGN TRADE ON REGIONAL GROWTH: EMPIRICAL EVIDENCE FROM PORTUGAL. *

* A first version of this Chapter is available as the Discussion Paper no. 13-2010 by GEMF, FEUC.

3.1. INTRODUCTION

The convergence phenomenon has been largely discussed in the economic literature, especially since the 1980's, trying to explain differences in the growth patterns between rich and poor economies. Different approaches were used to test the convergence hypothesis, the most common being the conditional convergence developed by Barro and Sala-i-Martin (1991). According to this approach, growth is conditioned by structural factors such as human capital accumulation, technical progress, innovation, among others, with increasing returns to scale characteristics. Differences on these structural factors characterise properly the steady-states of the economies and explain the capability of the backward economies to grow faster than the advanced ones.

Several studies have been carried out at the European level to analyse the convergence phenomenon among regions, using different approaches, samples and time periods. For example, in Cappelen et al. (1999) a comparison was made between the behaviour of EU9 and EU12 and the conclusion was that the convergence process in per capita income among European regions had slowed down over the last years. This was essentially due to a lack of convergence among regions from a given member-State, despite the transfers of Structural Funds to the poorest regions. Battisti and Di Vaio (2008) analysed the EU15 and EU25 regions for the period 1980-2002 and concluded that only some of them presented a significant convergence tendency, while the majority displayed slow convergence and in some cases there was no convergence at all. Meliciani and Peracchi (2006) considered the existence of spatial correlation and heterogeneity. The authors used a set of 95 European regions during the period 1980-2000 and observed a convergence rate lower than the 2% usually found, being in some occasions close to zero. In a study for Central and Eastern Europe, Herz and Vogel (2003) found a reduction in regional disparities during the first half of the 1990's and stability in the following years.

As examples of studies of regional convergence within a given country, we underline that of Kangasharju (1998), who studied regional convergence in Finland during the period 1934-1993. The author found that regional convergence in per capita income ran at an annual 2% rate for the whole period, despite the greater instability of

the convergence coefficient in the short-term. For the same country but from a different perspective, Pekkala (2000) showed that the probability of convergence was higher during periods of economic expansion, whereas during recession a tendency for regional divergence was more likely to occur.

De la Fuente (2002) observed a decrease in disparities among 17 Spanish regions for the period 1964-1991, especially motivated by a technological catch-up process, greater homogeneity in education and regional redistribution of employment. Vittorio (2009) analysed 20 Italian regions in the period 1980-2007 and found a weak convergence in per capita income but a significant convergence in productivity. The impact of public expenditure on growth varied according to the regional area considered. While in the northern more developed regions there was a positive correlation between capital expenditure and regional growth, in the southern less developed areas the positive correlation found was associated with current expenditure.

In Michelis et al. (2004) the convergence among the 51 NUTS3 Greek regions was investigated, for the period 1981-1991. Apart from the convergence factor (initial level of per capita income), the authors included physical and human capital and other control variables such as the number of unemployed, the area of the region, the taxes paid, a dummy to capture regional investment policies and another for the islands. The authors observed convergence running at an annual rate lower than 2%.

For Portugal, Crespo and Fontoura (2006) analysed information at the municipal level, excluding the islands of Azores and Madeira. They observed that the more central areas, closer to the location of economic activity, displayed higher levels of per capita income and human capital. Structural similarity among municipalities was thought to lead to real convergence and in that context, Crespo and Fontoura (2009) verified that such a similarity was stronger among regions sharing a common border and showing analogous patterns of physical and human capital, economic centrality and market size.

Testing the hypothesis of convergence in per capita income among the Portuguese NUTS2 regions for the period 1981-1996, Soukiazis (2003) concluded that when the sectoral employment share was considered, the speed of convergence increased. This fact can be explained by the reallocation of labour resources from less productive (agriculture) to more dynamic sectors (industry and services) and therefore by the concentration of economic activity in the latter, characterised by increasing returns to scale. In the same line, Antunes and Soukiazis (2006) showed that Structural Funds (European Regional Development Fund) received from the EU had contributed to

a higher convergence of the Portuguese NUTS3 regions and Soukiazis and Proença (2008) provided empirical evidence showing that tourism was a factor of regional convergence.

In the above-mentioned studies foreign trade is not considered as a factor of convergence. It is argued that when a region faces an external deficit, capital flows from the central government can solve this problem.[60] We do not share this view for several reasons: regional external deficits reflect lack of economic competitiveness which can constrain local growth and increase unemployment (Thirlwall,1980); capital transfers from the central government to the deficit regions are not sustainable in the long-term and can create budget deficits that affect the whole economy; capital transfers from the central government to less competitive regions can be inefficient in terms of the optimal reallocation of resources; the reallocation of resources to less competitive regions to finance external regional deficits can increase regional inequality, since they could be invested in other regions in a more productive way. In our opinion, regional trade competitiveness is as important for local growth as it is for the whole economy, and capital flows are not a sustainable solution in the long-term.[61] Structural solutions are needed to turn the regions more competitive by allocating resources to sectors with increasing returns to scale properties and encouraging the production of goods with high income-elasticity of demand in international markets.

The aim of the present study is to test the convergence hypothesis of per capita income among the Portuguese NUTS3 regions for the period 1996-2005, taking into account that foreign trade is important for regional growth and convergence. Together with international trade measures, we include other structural factors such as the employment share in the main economic sectors of activity and human capital, to test their relevance in the convergence process. The existence of different behaviours between the *Littoral* (coastal areas) and the *Interior* (inland zones) is also investigated. Above all, our study focuses on foreign trade and its impact on regional growth, an issue that to our knowledge has not been explicitly considered at the regional level, at least for Portugal. Following the previous Chapters, we now extend the notion of

60 Ramos (2007) in line with other authors like Bayoumi and Rose (1993), Helliwell and McKitrick (1999) and Decressin and Disyatat (2000), argues that regions can run external imbalances in a greater scale than countries and since they do not face sustainability constraints they may even benefit from those imbalances.

61 Vickers (2001) argues that convergence should not rely on regional transfers, since they are not a structural solution in the long-term in terms of growth and convergence.

conditional convergence to the regional level, to analyse if the same conclusions can be drawn when the geographical unit is reduced. Moreover, we investigate the existence of differences between two major areas: the *Littoral* and the *Interior*. Finally, we include, in substitution of the annual growth rate of the population, the industrial employment share as a more reasonable variable to explain Portuguese growth at the regional level.

This Chapter is organised as follows: in section 3.2 the convergence issue is discussed and the importance of trade for growth is explained. In section 3.3 the convergence model is adapted to include trade as a conditioning factor of growth. Section 3.4 provides statistical information on the NUTS3 regions showing the differences on per capita income, income dispersion, foreign trade movements, educational standards and employment structure. In section 3.5 the conditional convergence model is estimated and the results are discussed. The last section summarises the most relevant outcomes from the study.

3.2. THE DEBATE ON GROWTH AND CONVERGENCE

The origin of the studies on economic growth and convergence is found in the neoclassical growth theory and the Solow's (1956) growth model. According to this theory, factors of production face diminishing returns and technological progress is exogenous. The marginal productivity of capital is higher in regions with a lower capital/labour ratio. Capital flows to less developed economies where capital stock and wages are lower thus taking advantage of higher profitability. Technology is a public good freely available to everyone, thus facilitating the technological diffusion process, with no additional costs for the less developed economies. Full mobility of reproducible factors as well as the homogeneity of preferences and savings (investment) rates are additional assumptions for growth. Under these circumstances, convergence in per capita income will occur, indicating that poorer economies grow faster than the richer ones. Empirically, this tendency is confirmed by the negative correlation between the growth of per capita income and its initial level (absolute convergence). In the long-term, all economies will grow at similar rates and converge to the same steady-state. Divergence is a short-term phenomenon, reflecting transitory adjustments to steady-state. Trade is not considered as an impediment to growth since flexible relative prices solve trade imbalances and bring the economy back to equilibrium.

Throughout the last decades empirical evidence has not confirmed the neoclassical principle of absolute convergence. In fact, the deepening of the differences among more and less developed economies has been demonstrated in the literature. The existence of convergence is limited to more homogeneous economies (countries of the same block; regions within the same country). Economists have searched for alternatives to better understand the factors affecting economic growth and its trajectory.

Romer's work (1986) points to the failure of the neoclassical convergence hypothesis, when confronted with empirical evidence. Growth models with increasing returns to scale (coming mainly from human capital and technological progress) become an alternative to the neoclassical approach. Baumol (1986), Barro and Sala-i-Martin (1992) and Mankiw et al. (1992) assessed the existence of conditional convergence when differences on structural factors are taken into account. Since then, several

empirical studies on convergence have been performed for a variety of samples, making use of different concepts of convergence and diversified methods of analysis. Most of the theoretical growth models are based on aggregate production functions with physical capital, human capital and technology as the relevant explanatory factors of income growth (Islam, 1995; Galor, 1996; Barro and Sala-i-Martin, 2004). These models indicate that there is no tendency for a clear convergence in per capita income among economies, unless differences in structures are considered. In the real world, economies do not show the structures required by absolute convergence, except when they become alike in terms of human capital, technological progress and innovation, among others. Different economies converge to different steady-states, characterised by dissimilar economic structures, thus reflecting differences in the production functions.

Empirical studies testing the hypothesis of conditional convergence have not sufficiently explored the possibility that trade can be a conditioning factor to growth.[62] Such a flaw is more evident in studies of regional convergence within the same country.

Trade openness is generally considered to be mainly beneficial for economies, since it enables an increase in specialisation, an efficient resource allocation due to comparative advantages, and the imports of goods and ideas embodying foreign technology, related to the above-mentioned technology diffusion.

All the above arguments justify the inclusion of trade measures in the growth equations when estimated empirically. The omission of this factor can bias the results.

62 An exception is the study by Antunes and Soukiazis (2009 b), where the balance-of-payments constraint hypothesis and the degree of openness are considered as conditioning factors to explain the convergence process between the early EU countries.

3.3. THE GROWTH MODEL WITH TRADE

The growth equation more often estimated in the empirical literature is of the Barro's type, assuming that human capital is partly endogenous with increasing returns properties in the long-term that compensate the diminishing returns of physical capital. The model has been adjusted by Mankiw et al. (1992) to include human capital and by Islam (1995) to be used with panel data, controlling for differences in the production function among different economies. According to these authors, the growth equation is given by the following relation:[63]

$$\ln y\,(t_2) - \ln y\,(t_1) = \\ = \theta \ln A_0 + g\left(t_2 - e^{-\beta T} t_1\right) - \theta \ln y\,(t_1) - \theta \frac{a}{1-a} \ln(n+g+\delta) + \theta \frac{a}{1-a} \ln(s) + \theta \frac{\mu}{1-\alpha} \ln(h) + \theta \frac{\gamma}{1-a} \ln(m) + u_{i,t} \quad \textbf{(3.1)}$$

In this expression, *y* is per capita income, *n* the annual growth rate of population, *g* the growth of technology, δ the depreciation rate, *s* the savings (investment) rate, *h* human capital and *m* is trade. On the other hand, α, μ and γ are growth elasticities with respect to physical capital, human capital and trade, respectively. Finally, $\theta=(1-e^{-\beta T})$ with β the speed of convergence, *gt* is a constant (technological progress is assumed to be the same for all economies) and A_0 reflects not only the technological level but also resource endowments, the legal system and institutions, among others, and thus it may differ across economies. The term θlnA_0 is the time-invariant individual effect reflecting the economy's specific effects and $u_{i,t}$ is the error term that varies across countries and time periods. Estimating equation (3.1) by panel data techniques is the way to control for the individual effects.

In our analysis, several alternative proxies for external trade are considered. We distinguish two kinds of external trade indicators according to the trading partners involved: trade with the EU countries, labelled intra-trade and trade outside the EU area, labelled extra-trade. Given this distinction, we consider the degree of openness (ratio of external trade to GDP) and the trade balance (as percentage of GDP), in both situations – intra and extra-EU). Additionally, the *intra-*, *extra-* and *total exports* ratios, (as

63 Equation (3.1) is obtained from equation (I.9) from the Appendix I of Chapter 1, adapted to include human capital (*h*) and trade (*m*).

percentages of GDP) are used as conditioning factors to regional growth in Portugal. From the theoretical description of the model, we expect external trade variables to have a positive impact on regional growth.

Interaction terms between the external trade variables and the *Littoral* area (dummy variable) are also included, to analyse the existence of different impacts on growth depending on the location of the regions (*Littoral* versus *Interior*). Lastly, an interaction term between foreign trade and human capital is considered, to investigate the presence of technological diffusion occurring through trade openness.

The main task of the study is to verify whether human capital, external trade and sectoral labour share are relevant factors to suitably explain differences in steady-states among regions with diversified structures.

3.4. REGIONAL DISPARITIES IN PORTUGAL

3.4.1. DIFFERENCES IN REGIONAL PER CAPITA INCOME

Portugal is divided in 30 NUTS3 regions and the geographical distribution of the regions can be seen in the Appendix of this Chapter. The option for a more disaggregated territorial unit like the NUTS3 enables us to compute regional per capita GDP, an indicator to compare standards of living or levels of development between regions. **Table 3.1** displays the regional per capita income levels (at constant prices), [64] according to the NUTS3 division for the period 1996 to 2005, as well as the relative positions both at the initial and final years.

Ranking the regions in descending order according to per capita income, we observe that in 1996 the six first places belong to Grande Lisboa (19.64), Alentejo Litoral (16.40), Grande Porto (14.44), Algarve (13.32), Pinhal Litoral (13.19) and Baixo Mondego (12.40). On the other extreme with the lowest per capita incomes appear Alto-Trás-os-Montes (8.15), Douro (8.00), Beira Interior Norte (7.77), Pinhal Interior Norte (7.17), Tâmega (6.70) and Serra da Estrela (6.31).

After a decade, in 2005, the situation is the following: Grande Lisboa (25.47), Alentejo Litoral (21.98), Madeira (18.96), Algarve (16.40), Baixo Mondego (15.71) and Grande Porto (15.27) are the regions with the highest per capita income, whereas the last places belong to Cova da Beira (10.23), Douro (10.20), Minho-Lima (9.47), Serra da Estrela (9.20), Pinhal Interior Norte (9.01) and Tâmega (8.47).

Dividing the NUTS3 regions into two major groups - *Littoral* (coastal regions) and *Interior* (inland regions) - it is possible to verify that the first group contains the more developed regions, whereas the latter includes the less developed areas, either in 1996 or in 2005 (the exception is Minho-Lima, a Littoral region that is part of the bottom-group of per capita income ranking in 2005).[65] Therefore the dichotomy in

64 Monetary values have been deflated by the CPI of NUTS2 and the data was taken from the National Institute of Statistics (March 2010), after a formal request by the author.

65 The Portuguese NUTS3 regions were divided (according to their geographical location) in two groups: the Littoral area with 16 coastal regions and the Interior area with 14 inland regions. For this division, see the map and the table in the Appendix of this Chapter.

Portugal is not between North and South (as usually happens in other countries) but between West (the coastal zone) and East (the inland area).

Table 3.1. *Per capita* income of the Portuguese NUTS3 regions, 1996-2005 (constant prices, in thousands euros).

	Years											
Regions	**1996**		**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	
Minho-Lima	23rd	8.189	8.451	8.826	9.249	9.360	9.436	9.464	9.347	9.3784	27th	9.466
Cávado	20th	9.767	9.996	10.428	10.952	11.405	11.830	11.983	11.562	11.7656	18th	11.748
Ave	17th	10.524	10.873	11.346	11.939	12.068	12.083	12.134	11.838	11.5865	19th	11.391
Grande Porto	3rd	14.439	14.993	15.644	16.048	16.108	16.079	15.500	14.984	15.1429	6th	15.267
Tâmega	29th	6.700	7.191	7.631	7.971	8.272	8.456	8.562	8.298	8.2474	30th	8.465
Entre Douro e Vouga	10th	11.154	11.671	12.553	13.198	12.838	13.257	13.548	12.398	12.3842	17th	12.466
Douro	26th	7.998	7.873	8.153	8.666	9.169	9.632	9.620	9.646	9.7070	26th	10.204
Alto Trás-os-Montes	25th	8.154	7.982	8.511	8.856	9.347	9.427	9.407	9.523	10.0114	23rd	10.429
Baixo Vouga	7th	12.220	12.813	13.462	14.265	14.101	14.070	14.190	13.889	14.0218	8th	14.086
Baixo Mondego	6th	12.396	12.929	13.462	13.962	15.006	15.398	15.395	15.317	15.6411	5th	15.709
Pinhal Litoral	5th	13.186	13.926	14.520	15.672	15.486	15.751	15.631	15.446	15.5096	7th	15.248
Pinhal Interior Norte	28th	7.173	7.488	8.156	8.538	8.498	8.612	8.593	8.801	8.9546	29th	9.009
Dão-Lafões	24th	8.158	8.488	9.040	9.715	10.302	10.490	10.332	10.404	10.6666	21st	10.729
Pinhal Interior Sul	22th	8.260	8.259	8.737	8.551	8.772	8.911	8.973	9.693	9.9689	24th	10.428
Serra da Estrela	30th	6.314	6.745	7.222	7.761	7.948	8.076	8.474	8.904	9.1593	28th	9.198
Beira Interior Norte	27th	7.769	8.000	8.553	8.963	9.946	9.972	9.979	10.047	10.2402	22th	10.584
Beira Interior Sul	9th	11.193	11.328	12.021	12.132	12.766	12.645	12.628	12.583	12.7293	11st	13.310
Cova da Beira	21st	8.761	8.815	9.273	9.791	9.841	9.888	9.795	9.306	9.6742	25th	10.225
Oeste	12nd	11.047	11.472	12.144	12.695	12.764	12.818	12.681	12.820	13.0150	15th	12.718
Médio Tejo	11st	11.089	11.604	12.163	12.813	13.294	13.410	13.193	13.184	13.2762	14th	12.846
Grande Lisboa	1st	19.637	20.921	22.234	23.399	24.663	24.847	25.058	24.822	25.2668	1st	25.465
Península de Setúbal	16th	10.564	11.546	12.290	12.329	12.276	12.125	12.040	11.323	11.1834	20th	11.045
Alentejo Litoral	2nd	16.397	17.473	17.756	16.984	18.867	18.212	18.268	20.187	19.0898	2nd	21.984
Alto Alentejo	14th	10.931	11.193	11.752	12.259	12.491	12.405	12.817	13.084	13.4567	12th	13.262
Alentejo Central	18th	10.438	11.088	11.697	12.044	13.448	13.436	13.207	13.170	13.2185	13th	13.130
Baixo Alentejo	15th	10.641	10.983	10.847	11.164	11.334	11.389	11.764	11.571	12.4143	16th	12.711
Lezíria do Tejo	8th	12.190	13.566	13.773	13.731	14.007	13.809	14.163	13.945	14.1952	10th	13.582
Algarve	4th	13.323	14.021	14.647	15.338	15.916	16.227	16.277	16.177	16.0474	4th	16.404
Açores	19th	10.155	10.496	11.151	11.988	12.409	13.095	13.458	13.536	13.5963	9th	13.800
Madeira	13th	10.987	12.052	13.479	14.428	16.854	16.182	18.720	18.091	18.6977	3rd	18.964

Data source: National Institute of Statistics (2008).
Notes: Monetary values for each NUTS3 region have been deflated by annual CPI of the NUTS2 regions. Regions have been ranked according to their relative position in the first and last years.

Thus, comparing the initial and final years of the analysis, four of the regions in the six last positions of the table remain the same, although only Douro maintains its relative position (26^{th}). Additionally, only Pinhal Litoral abandons the top-six group from 1996 to 2005. The most pronounced changes are those from the islands of Madeira

and Azores, both climbing 10 positions in the ranking within the period. These remarkable changes are probably due to financial support received from the central government, without significant paybacks. Another key factor is tourism, a predominant dynamic sector promoting growth on these islands. Regarding the drops, the most evident case is that of Entre Douro e Vouga, falling from the 10th to the 17th position. In global terms, between 1996 and 2005 four regions kept their relative positions in terms of per capita income (Grande Lisboa, Alentejo Litoral, Algarve and Douro), 10 improved and 16 deteriorated their relative position.

Table 3.2. P*er capita* income of each region relative to the Portuguese weighted average, 1996-2005 (percentage).

	Years									
Regions	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Minho-Lima	65.04	63.74	63.12	63.40	61.99	62.05	61.98	62.20	61.73	61.89
Cávado	77.57	75.39	74.57	75.08	75.53	77.80	78.48	76.94	77.44	76.80
Ave	83.58	82.00	81.14	81.84	79.92	79.47	79.47	78.78	76.26	74.47
Grande Porto	114.67	113.07	111.88	110.01	106.68	105.74	101.52	99.72	99.67	99.81
Tâmega	53.21	54.23	54.58	54.64	54.78	55.61	56.07	55.22	54.28	55.34
Entre Douro e Vouga	88.59	88.02	89.77	90.47	85.02	87.18	88.73	82.51	81.51	81.49
Douro	63.52	59.38	58.30	59.40	60.72	63.34	63.01	64.19	63.89	66.71
Alto Trás-os-Montes	64.76	60.20	60.86	60.71	61.90	62.00	61.61	63.37	65.89	68.18
Baixo Vouga	97.05	96.64	96.27	97.78	93.38	92.53	92.94	92.43	92.29	92.09
Baixo Mondego	98.45	97.51	96.27	95.71	99.38	101.26	100.83	101.93	102.94	102.70
Pinhal Litoral	104.72	105.03	103.84	107.43	102.56	103.58	102.37	102.79	102.08	99.68
Pinhal Interior Norte	56.97	56.47	58.33	58.53	56.28	56.63	56.28	58.56	58.94	58.90
Dão-Lafões	64.79	64.01	64.65	66.60	68.23	68.99	67.67	69.23	70.20	70.14
Pinhal Interior Sul	65.60	62.28	62.48	58.61	58.10	58.60	58.77	64.51	65.61	68.17
Serra da Estrela	50.15	50.87	51.65	53.20	52.64	53.11	55.50	59.25	60.28	60.13
Beira Interior Norte	61.70	60.33	61.17	61.44	65.87	65.58	65.36	66.86	67.40	69.19
Beira Interior Sul	88.89	85.44	85.97	83.16	84.55	83.16	82.71	83.73	83.78	87.02
Cova da Beira	69.58	66.48	66.32	67.12	65.17	65.03	64.15	61.93	63.67	66.85
Oeste	87.74	86.52	86.85	87.03	84.53	84.30	83.05	85.31	85.66	83.15
Médio Tejo	88.07	87.52	86.99	87.83	88.04	88.19	86.41	87.73	87.38	83.98
Grande Lisboa	155.95	157.79	159.00	160.40	163.33	163.41	164.12	165.18	166.30	166.48
Península de Setúbal	83.90	87.08	87.89	84.51	81.30	79.74	78.86	75.35	73.61	72.20
Alentejo Litoral	130.23	131.78	126.98	116.42	124.95	119.77	119.65	134.34	125.64	143.72
Alto Alentejo	86.81	84.41	84.04	84.03	82.72	81.58	83.94	87.07	88.57	86.70
Alentejo Central	82.90	83.62	83.65	82.56	89.06	88.36	86.50	87.64	87.00	85.84
Baixo Alentejo	84.51	82.83	77.57	76.53	75.06	74.90	77.05	77.00	81.71	83.10
Lezíria do Tejo	96.82	102.31	98.50	94.13	92.76	90.81	92.76	92.80	93.43	88.79
Algarve	105.81	105.74	104.75	105.14	105.40	106.72	106.61	107.65	105.62	107.24
Açores	80.65	79.16	79.75	82.17	82.18	86.12	88.14	90.08	89.49	90.22
Madeira	87.26	90.90	96.40	98.90	111.62	106.42	122.61	120.39	123.06	123.97
Littoral	110.33	110.67	110.62	110.49	110.16	109.97	109.97	109.61	109.40	109.16
Interior	67.88	66.59	66.51	66.70	67.50	67.88	67.67	68.60	69.09	69.68

Data source: National Institute of Statistics (2008).
Note: Monetary values for each NUTS3 region have been deflated by annual CPI of the NUTS2 regions.

Table 3.2 offers an alternative perspective of regional disparities, where regional per capita income is compared to the weighted national average for the period 1996 to 2005.[66] We can observe that in the first year, five regions present a result higher than 100%. Grande Lisboa is on the top, having a per capita income about 56% higher than the average, followed by Alentejo Litoral (130.23), Grande Porto (114.67), Algarve (105.81) and Pinhal Litoral (104.72). In 2005, the number of regions with a living standard higher than the average ascended to 7 (with percentages rounded to units), namely: Grande Lisboa (166.48), Alentejo Litoral (143.72), Madeira (123.97), Algarve (107.24), Baixo Mondego (102.70), Grande Porto (99.81) and Pinhal Litoral (99.68). The most relevant increases occurred in Madeira, Alentejo Litoral, Grande Lisboa and Serra da Estrela.

In general terms, the figures for the *Littoral* and the *Interior* zones do not vary much during the period of analysis. However, it is worth mentioning that the performance of the *Littoral* is always about 10% higher than the average, whereas the *Interior* performs below the average (in around 30%), despite the tendency for improvement in the last years of the analysis. Having this in mind, the distinction between these two areas is important to understand regional disparities in Portugal.

3.4.2. INCOME DISPERSION

One of the most used concepts to verify if differences in per capita income narrow or widen over time is that of *σ-convergence*. The coefficient of variation is used to measure *σ-convergence* given by the standard deviation over the sample mean. When this coefficient is declining over time the dispersion of income decreases among regions and this is evidence of *σ-convergence*. Alternatively, an increase of this indicator shows that asymmetries in income expanded over time among the regions of the sample.

Table 3.3 provides the figures of the coefficient of variation for the total sample (30 regions) and the regions of the *Littoral* (16) and *Interior* (14), and **Figure 3.1** plots these results. It can be seen that for the whole sample asymmetries in per capita income increased moderately over time and the same tendency is observed in the *Littoral* area. Regarding the *Interior* zone the tendency is the opposite, showing a decline in the

66 The weighted national average is computed as:

$$\overline{GDPpc}_{Portugal,t} = \left(\sum_{i=1}^{30} GDPpc_{i,t} * pop_{i,t} \right) \Big/ \sum_{i=1}^{30} pop_{i,t}$$ with i=1, …, 30 and t=1996, …, 2005.

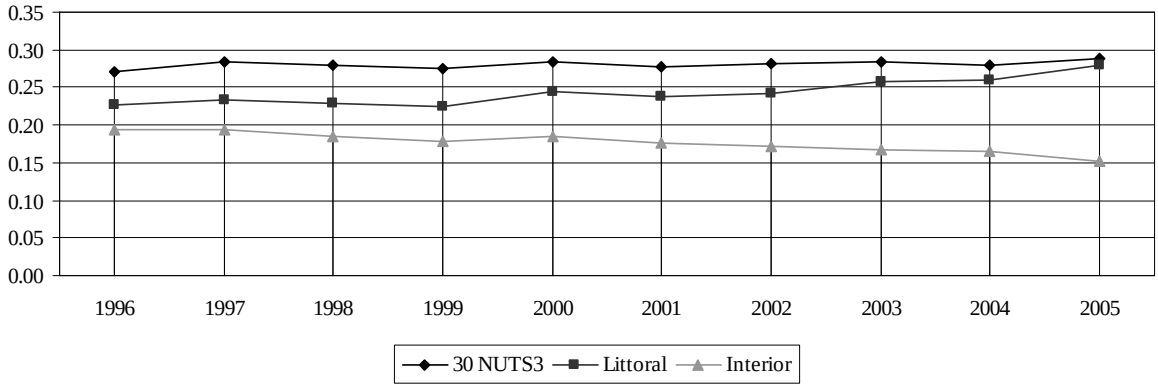
dispersion of income over time. This means that the asymmetries are higher between the more developed regions of the *Littoral* and that the less developed regions of the *Interior* become more homogeneous. In fact, there is a different performance in per capita income between these two areas and this has to be taken into account in the estimation approach. The conclusions remain roughly the same if we exclude the islands of Azores and Madeira from this analysis, the regions with the most remarkable improvements in per capita income performance.

Table 3.3. σ-convergence in per capita income among the Portuguese NUTS3 regions, the *Littoral* and the *Interior*, 1996-2005.

	Coefficient of variation					
	30 NUTS3 regions			28 NUTS3 regions (without Madeira and Azores)		
Years	**Total**	**Littoral**	**Interior**	**Total**	**Littoral**	**Interior**
1996	0.271	0.227	0.193	0.280	0.231	0.193
1997	0.283	0.233	0.193	0.293	0.239	0.193
1998	0.279	0.230	0.184	0.289	0.238	0.184
1999	0.274	0.225	0.178	0.283	0.235	0.178
2000	0.284	0.244	0.186	0.290	0.255	0.186
2001	0.277	0.237	0.177	0.285	0.251	0.177
2002	0.282	0.242	0.172	0.283	0.252	0.172
2003	0.285	0.258	0.167	0.289	0.272	0.167
2004	0.279	0.259	0.166	0.280	0.270	0.166
2005	0.288	0.280	0.153	0.290	0.294	0.153

Data source: National Institute of Statistics (2008).

Figure 3.1. Plot of σ-convergence in per capita income among the Portuguese NUTS3 regions, the *Littoral* and the *Interior*, 1996-2005.



Data source: National Institute of Statistics (2008).

3.4.3. FOREIGN TRADE INDICATORS

The evolution of foreign trade indicators is presented in **Table 3.4**, for the whole sample, the *Littoral* and the *Interior* areas and for the first and last years of the analysis.

Table 3.4. Foreign trade indicators (%), NUTS3 regions, 1996 and 2005.

	Years							
	1996	2005	1996	2005	1996	2005	1996	2005
Regions	Open-Extra		Open-Intra		Exports-Intra GDP		(Total Exports) GDP	
Minho-Lima	6.55	4.72	34.31	49.10	20.05	29.23	25.02	32.19
Cávado	7.91	4.69	54.13	49.17	39.46	31.81	42.78	34.09
Ave	19.25	16.64	71.56	68.86	50.89	45.89	59.85	54.73
Grande Porto	12.73	13.29	39.91	44.14	16.31	15.04	21.39	22.79
Tâmega	8.24	3.77	38.49	26.57	31.02	18.58	36.75	20.68
Entre Douro e Vouga	20.59	19.64	70.61	84.14	47.32	53.82	61.95	68.00
Douro	0.26	0.85	5.31	5.44	2.84	2.72	3.02	3.45
Alto Trás-os-Montes	0.76	0.41	3.32	6.91	1.03	2.90	1.43	3.23
Baixo Vouga	10.81	13.37	40.75	69.51	24.51	37.83	29.29	44.77
Baixo Mondego	3.81	5.03	22.73	22.95	15.04	15.22	17.09	18.65
Pinhal Litoral	5.58	5.80	28.00	29.43	13.00	13.64	16.96	17.06
Pinhal Interior Norte	2.77	2.18	23.44	15.29	15.79	8.83	17.69	10.52
Dão-Lafões	4.27	4.27	31.32	57.75	18.14	32.77	20.43	35.48
Pinhal Interior Sul	0.64	0.42	13.28	7.19	9.06	5.74	9.39	5.99
Serra da Estrela	0.87	1.04	8.16	5.10	3.43	2.24	3.88	2.67
Beira Interior Norte	0.77	6.22	14.65	13.82	7.15	6.45	7.42	12.38
Beira Interior Sul	3.31	1.11	11.43	9.43	5.38	5.63	8.42	6.69
Cova da Beira	7.32	4.32	36.60	20.17	22.51	13.58	27.01	17.41
Oeste	6.94	6.75	20.32	21.67	9.23	8.62	13.15	11.45
Médio Tejo	12.64	11.64	22.54	30.54	9.41	15.45	12.88	17.61
Grande Lisboa	17.18	19.95	42.46	46.27	8.27	7.75	11.96	11.35
Península de Setúbal	10.71	9.25	77.93	52.39	53.14	32.74	58.46	35.91
Alentejo Litoral	10.35	9.25	14.86	52.39	8.68	24.60	12.18	27.44
Alto Alentejo	2.43	3.88	17.52	18.66	9.41	9.19	10.53	10.07
Alentejo Central	1.81	5.28	10.41	16.98	5.54	10.27	6.98	14.96
Baixo Alentejo	0.50	1.62	2.58	13.62	0.50	13.52	0.80	15.06
Lezíria do Tejo	6.13	7.32	47.90	76.83	19.16	28.29	23.11	33.47
Algarve	0.69	0.51	3.38	3.80	1.48	1.18	1.84	1.40
28 NUTS3 Average	6.64	6.54	28.85	32.79	16.70	17.63	20.06	21.05
Littoral	9.95	9.73	40.63	47.90	23.32	24.69	28.22	29.52
Interior	3.33	3.36	17.07	17.68	10.09	10.56	11.90	12.59

Data source: National Institute of Statistics (2007).
Note: Monetary values for each NUTS3 region have been deflated by annual CPI of the NUTS2 regions.

The first variable, *Open-Extra*, refers to the degree of regional openness, considering both the exports and imports of goods with the non-EU countries. The second variable expresses the same indicator, but now reported to the trade relations within the EU. The remaining variables are *Exports-Intra/GDP*, which corresponds to

the exports ratio with the EU countries, and *Total Exports/GDP*, which is the ratio of total regional exports to the EU and non-EU countries.

From **Table 3.4**, it can be observed that the regions of the *Littoral* area (the most developed) are on average much more open than the regions of the *Interior* area (the less developed), both with respect to the non-EU and the EU countries. Additionally, the *Littoral* area is shown to be more dynamic in the exports sector both with respect to the EU countries and the rest of the world, as it can be verified by the average *Exports-Intra/GDP* and *Total-Exports/GDP* ratios.

Combining these findings with the fact that regions from the *Littoral* are richer than those from the *Interior*, a strong relation can be established between regional growth and foreign trade. This relation is shown more formally in the empirical analysis of the next section.

3.4.4. EDUCATIONAL STANDARDS

Table 3.5 illustrates regional education standards by using the rate of transition/conclusion in high school between 1996 and 2005 at the NUTS3 level.

Generally, it is shown that educational standards are improving over time but in a modest way. In 1996 the highest rate was that of Madeira and the lowest, of Oeste. In 2005, Minho-Lima displays the highest score and at the bottom of the ranking is Baixo Alentejo. It is interesting to notice that despite occupying the first position in the rate of scholar success in 2005, Minho-Lima is in the 27^{th} place on the ranking of regional per capita income (see **Table 3.1**).

The fall of educational standards in some regions can be related to specific socioeconomic characteristics of the population and qualitative factors of the educational system. Educational standards remain quite stable over time and do not vary much across regions, especially if we consider the *Littoral/Interior* division. Since differences in educational levels are not very significant among regions, the distinction *Littoral/Interior* is not important in the estimation approach with respect to this variable.

Table 3.5. Scholar success rate in high school (%), NUTS3 regions, 1996-2005.

Regions	Years									
	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Minho-Lima	72.49	68.51	67.09	66.13	63.99	62.56	64.97	69.95	72.27	73.41
Cávado	68.36	62.53	65.74	66.58	66.08	61.43	66.43	68.55	66.73	68.08
Ave	65.98	67.38	65.78	66.20	66.95	61.78	65.25	69.35	69.35	71.72
Grande Porto	68.72	66.30	68.61	66.54	63.94	58.14	62.69	67.01	69.00	71.10
Tâmega	66.56	66.87	64.93	64.43	63.51	64.12	66.47	70.64	70.03	69.34
Entre Douro e Vouga	62.49	60.06	68.03	69.49	70.76	68.46	69.86	71.88	71.36	69.36
Douro	65.01	62.19	62.79	63.29	63.27	58.39	59.69	67.76	65.94	68.96
Alto Trás-os-Montes	66.06	63.69	62.26	62.00	61.31	55.48	58.82	65.42	62.93	64.26
Baixo Vouga	61.07	61.78	63.58	63.66	64.11	60.76	60.29	66.75	64.52	67.83
Baixo Mondego	66.34	65.94	66.99	66.20	64.97	65.72	63.60	67.96	69.32	70.99
Pinhal Litoral	64.76	64.03	65.68	64.62	63.36	63.41	62.30	65.65	66.54	68.45
Pinhal Interior Norte	62.55	64.24	61.84	61.60	61.59	58.59	61.80	63.38	62.50	63.45
Dão-Lafões	64.62	60.84	64.44	64.17	63.49	65.67	65.02	66.94	67.59	68.29
Pinhal Interior Sul	70.02	62.52	60.20	63.06	64.03	64.93	61.95	70.29	72.56	68.55
Serra da Estrela	66.37	62.87	63.63	64.49	65.12	61.40	64.69	67.46	65.78	65.43
Beira Interior Norte	65.93	62.54	63.39	63.89	62.40	56.09	59.01	66.26	66.46	66.39
Beira Interior Sul	66.23	63.22	57.84	61.25	61.18	58.42	62.41	66.52	66.17	69.40
Cova da Beira	64.13	62.58	66.03	62.84	58.99	63.21	60.03	65.06	65.34	68.37
Oeste	59.15	62.08	63.37	65.24	66.55	62.69	63.45	65.48	65.07	64.18
Médio Tejo	72.45	65.32	66.46	65.48	65.04	65.32	65.15	68.76	68.00	66.07
Grande Lisboa	68.80	64.48	64.56	62.75	60.78	59.07	62.04	64.99	64.63	67.44
Península de Setúbal	65.86	62.72	61.65	61.49	61.30	57.63	60.30	64.25	62.79	66.33
Alentejo Litoral	63.42	58.15	56.86	58.27	59.36	56.34	57.56	59.37	70.75	70.12
Alto Alentejo	72.57	61.52	67.96	66.63	65.90	62.39	63.82	64.53	61.94	66.69
Alentejo Central	66.63	67.84	61.43	62.54	62.73	60.21	62.43	67.08	69.05	68.16
Baixo Alentejo	65.52	56.03	59.54	60.41	62.04	59.70	60.33	61.64	62.83	61.56
Lezíria do Tejo	67.22	68.18	63.06	65.63	67.05	60.50	59.54	64.29	65.12	66.67
Algarve	63.75	60.16	58.76	57.74	56.19	57.80	60.59	63.31	61.71	64.75
Açores	64.16	61.80	58.82	60.65	59.94	55.77	53.91	60.11	61.02	66.12
Madeira	76.36	74.52	65.50	67.82	73.56	70.11	70.05	68.12	65.01	62.32
30 NUTS3 Average	66.45	63.70	63.56	63.84	63.65	61.20	62.48	66.29	66.41	67.46
Littoral	66.18	64.29	64.01	64.31	64.31	61.38	62.68	66.06	66.57	68.05
Interior	66.76	63.02	63.05	63.29	62.90	61.00	62.26	66.55	66.22	66.78

Data source: Office of Statistics and Education Planning and National Institute of Statistics (2009).

3.4.5. EMPLOYMENT SHARE BY SECTOR OF ACTIVITY

The share of employment in each of the three main sectors of economic activity is displayed on **Table 3.6**, for each region in the years 1996 and 2005. Additionally, the absolute variation between those years is also reported.

Table 3.6. Employment share by sector (%), NUTS3 regions, 1996 and 2005.

Regions	Prim			Sec			Ter		
	1996	2005	Variation	1996	2005	Variation	1996	2005	Variation
Minho-Lima	30.09	26.57	-3.53	31.55	30.61	-0.94	38.36	42.83	4.47
Cávado	13.70	10.00	-3.71	47.01	45.11	-1.90	39.29	44.90	5.61
Ave	7.86	7.09	-0.77	64.36	59.03	-5.33	27.78	33.88	6.10
Grande Porto	2.36	2.25	-0.11	36.82	28.97	-7.85	60.82	68.78	7.96
Tâmega	19.25	15.54	-3.71	53.61	51.98	-1.63	27.14	32.48	5.34
Entre Douro e Vouga	7.66	8.04	0.38	65.11	57.44	-7.67	27.23	34.51	7.29
Douro	49.92	43.22	-6.69	14.03	13.79	-0.24	36.05	42.98	6.94
Alto Trás-os-Montes	56.54	47.41	-9.13	9.33	12.65	3.32	34.14	39.94	5.81
Baixo Vouga	19.36	15.50	-3.85	42.39	38.31	-4.08	38.25	46.18	7.93
Baixo Mondego	22.72	16.48	-6.24	22.99	19.62	-3.37	54.29	63.90	9.61
Pinhal Litoral	19.06	11.45	-7.61	41.21	41.49	0.29	39.73	47.06	7.32
Pinhal Interior Norte	34.27	29.15	-5.12	33.01	33.00	-0.01	32.72	37.86	5.14
Dão-Lafões	40.09	35.30	-4.80	25.46	24.92	-0.54	34.44	39.78	5.34
Pinhal Interior Sul	54.25	50.20	-4.05	22.24	19.64	-2.60	23.51	30.16	6.65
Serra da Estrela	41.56	26.80	-14.76	23.77	30.87	7.10	34.68	42.33	7.65
Beira Interior Norte	48.88	43.56	-5.32	16.64	16.42	-0.22	34.48	40.02	5.54
Beira Interior Sul	36.62	38.52	1.90	22.80	17.78	-5.02	40.58	43.71	3.12
Cova da Beira	30.79	32.02	1.24	33.53	26.28	-7.25	35.68	41.69	6.01
Oeste	29.80	19.63	-10.17	29.53	29.28	-0.25	40.67	51.09	10.42
Médio Tejo	23.84	16.80	-7.04	29.68	29.52	-0.16	46.48	53.68	7.20
Grande Lisboa	0.67	0.71	0.04	22.89	18.60	-4.29	76.44	80.69	4.25
Península de Setúbal	3.11	3.22	0.11	34.52	28.32	-6.20	62.37	68.46	6.09
Alentejo Litoral	14.57	16.05	1.48	26.87	21.77	-5.10	58.57	62.18	3.61
Alto Alentejo	16.03	16.95	0.91	26.73	21.89	-4.84	57.24	61.17	3.93
Alentejo Central	9.66	12.20	2.53	28.90	25.09	-3.81	61.43	62.71	1.28
Baixo Alentejo	17.47	20.97	3.50	17.92	16.37	-1.55	64.60	62.66	-1.94
Lezíria do Tejo	14.24	10.36	-3.87	34.96	31.33	-3.63	50.80	58.30	7.50
Algarve	10.89	6.87	-4.02	16.51	21.76	5.25	72.60	71.37	-1.23
Açores	16.51	13.78	-2.73	21.93	22.85	0.91	61.56	63.38	1.81
Madeira	17.10	8.38	-8.72	25.77	25.57	-0.20	57.13	66.05	8.92
30 NUTS3 Average	24.12	20.82	-3.30	31.23	28.99	-2.23	44.66	50.19	5.53
Littoral	14.01	11.02	-2.99	36.91	33.69	-3.22	49.09	55.30	6.21
Interior	34.23	30.62	-3.61	25.55	24.30	-1.25	40.23	45.08	4.86

Data source: National Institute of Statistics (2008).
Note: The primary sector (*Prim*) includes agriculture, hunting, forestry, fishing and aquaculture. The secondary sector (*Sec*) embraces industry, including energy and construction. The tertiary sector (*Ter*) refers to services.

Regarding the *Prim* variable, we assist to a relative employment reduction in the primary sector although in some regions the employment in this sector is still high in 2005 (Pinhal Interior Sul- 50.20%, Alto Trás-os-Montes – 47.41%, Beira Interior Norte – 43.56% and Douro - 43.22%). Moreover, nine regions display a positive variation between 1996 and 2005 regarding the weight of this sector on regional employment.

Additionally, in the less developed *Interior* area, employment in the primary sector is about three times higher than in the *Littoral* in 2005.

Employment in the secondary sector is also diminishing on average, with the *Littoral* area showing a higher share than the *Interior*. The declining share of employment in the secondary sector can be associated with a deindustrialisation process. Still, we assist to a positive increase of the employment share in the secondary sector, namely for: Serra da Estrela (7.10 percentage points – p.p.), Algarve (5.25 p.p.), Alto Trás-os-Montes (3.32 p.p.), Açores (0.91 p.p.) and Pinhal Litoral (0.29 p.p.).

Lastly, there is a general increase on the employment share in the services sector, with Baixo Alentejo and Algarve as the exceptions, experiencing reductions within the period (of 1.94 and 1.23 p.p., respectively). The *Littoral* displays a relatively higher share, but the pattern for the *Interior* and the 30 NUTS3 is the same, with a generalised more pronounced weight of the services sector on regional employment, which is evidence of the increasing relevance of that sector in the economy.

3.5. EMPIRICAL RESULTS

3.5.1. THE MODEL AND THE VARIABLES

In the empirical analysis we consider the growth model as was adapted by Islam (1995) and Caselli et al. (1996) to panel data. The general specification of the growth equation is of the following form:[67]

$$gGDPpc_{i,t} = b\ln(GDPpc_{i,t-1}) + c_1\ln(n_{i,t} + g + \delta) + c_2\ln(School_{i,t}) + c_3\ln(FT_{i,t}) + v_{i,t}$$

$$v_{i,t} = \alpha_i + u_{i,t} \qquad \textbf{(3.2)}$$

In this equation, α_i stands for the specific individual regional effects (Bond et al., 2001) and $u_{i,t}$ is the idiosyncratic error term. The index *i* refers to region and *t* to time. This equation relates the growth of per capita income of each region to its initial level and a set of conditioning factors, such as the population growth rate[68] (or alternatively the sectoral employment share), schooling standards, and foreign trade measures.[69] Scholar standards are given by the rate of transition/conclusion in high school (*School*) as a proxy for human capital. Several alternative indicators of foreign trade (*FT*) are used, namely: the trade balance (as percentage of GDP) related to the trade of goods with the EU countries (*TB-Intra*); the degree of openness with the countries outside the EU (*Open-Extra*); the exports ratio with the EU countries *(Exports-Intra/GDP)*; the total exports ratio with the rest of the world *((Total-Exports)/GDP)*; and finally, the growth rate of the ratio of exports to non-EU countries over GDP (*g(Exports-Extra/GDP)*).[70]

It is expected a negative correlation between the growth of per capita income and the initial level implying that poorer regions grow faster than the richer ones as the convergence hypothesis claims. On the other hand, educational standards and external trade are expected to positively affect regional growth in Portugal, although given some special conditions it may also negatively affect growth or even be irrelevant for that

67 This is a simplified form of equation (3.1), presented on section 3.3.

68 This variable includes the sum ($g+\delta$)=0.05, of the rate of technological progress and the capital depreciation rate, equal to all years and across regions.

69 The savings (investment) rate is not included in the growth equation, since there is no available data for this variable at the NUTS3 level in Portugal.

70 The trade balance is not expressed in logs since it displays some negative values.

process. Population growth may influence regional growth negatively since the available productive resources must be distributed more thinly among the working population. However, it can also have a positive effect on growth through the increase in effective demand. The final impact on regional growth will depend on which of these two effects is stronger. As an alternative to the population growth rate, we use the share of employment in the secondary sector (*Sec*) as a proxy for sectoral labour allocation.[71] An increase either on the weight of the secondary sector in terms of employment or of production is expected to lead to a faster regional growth, given the interdependence and the complementarity between many of the industrial activities and those from other sectors. On the other hand, the existence of positive externalities stemming from the innovation processes of the secondary sector is equally important, benefiting other sectors as well.

3.5.2. THE ESTIMATION METHOD

The specification of a dynamic panel data model is the most adequate approach to analyse regional growth, bearing in mind the existence of specific individual effects. *GMM* (Generalised Method of Moments) is the estimation method most commonly used in dynamic models with panel data and a lagged dependent variable. The *GMM* estimation method has already been introduced in section 1.5 and all the assumptions made and the steps taken are maintained in this section. We remind that in the regressions ran all the explanatory variables are assumed endogenous, except the interaction terms.

3.5.3. ANALYSIS OF THE REGRESSION RESULTS

Equation (3.2) is estimated by the *GMM* method and **Table 3.7** displays the obtained results. In these estimations, a balanced panel is used for the sample of 28 NUTS3 regions of the Portuguese Continent[72] for the period 1996 to 2005. The outcomes are quite promising. The first aspect to notice is that conditional convergence

71 The employment share in the secondary sector proved to be statistically more relevant in the estimations ran than the employment shares in the other two sectors. In fact, the employment share in the primary sector had a negative impact on regional growth and that of services, a positive impact with no statistical significance.

72 In order to use balanced panel data it was necessary to exclude the regions of Azores and Madeira, because data is not available for the whole period considered. On the other hand, these regions benefit from some special conditions and might bias the global results if included.

is found in all cases,[73] confirmed by the negative sign on the lagged initial income and statistical significance at the conventional probability levels.

Table 3.7. *GMM* Regressions of the conditional convergence equation for the 28 NUTS3 regions of the Portuguese Continent. Balanced panel data, 1996-2005.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$lnGDPpc_{i,t-1}$	-0.2393***	-0.2539***	-0.1109*	-0.1451***	-0.1556***	-0.1790***	-0.2193***
	(-3.36)	(-3.91)	(-1.96)	(-2.93)	(-3.10)	(-4.16)	(-4.72)
$ln(n_{i,t}+g+\delta)$	0.1236	0.1334					
	(1.01)	(1.14)					
$Sec_{i,t}$			0.0099***	0.0110***	0.0110***	0.0115***	0.0055**
			(3.48)	(4.07)	(4.13)	(5.03)	(2.27)
$ln(School)_{i,t-1}$	0.1982**	0.1586**	0.1478*	0.1872**	0.1467*	0.1446**	
	(2.70)	(2.48)	(1.94)	(2.53)	(2.04)	(2.32)	
$ln(Open\text{-}Extra)_{i,t-1}*Littoral_i$	0.0350*			0.0275*			
	(2.03)			(1.89)			
$ln(Exports\text{-}Intra/GDP)_{i,t-1}*Littoral_i$		0.0603**			0.0547**		
		(2.59)			(2.52)		
$TB\text{-}Intra_{i,t-1}$			0.0065*				
			(1.88)				
$ln(Open\text{-}Intra)_{i,t}*Littoral_i$							
$ln(Total\text{-}Exports/GDP)_{i,t-1}*Littoral_i$						0.0399*	
						(1.72)	
$g(Exports\text{-}Extra/GDP)_{i,t}$							-0.0217*
							(-1.74)
$ln(School)_{i,t}*g(Exports\text{-}Extra/GDP)_{i,t}$							0.0053*
							(1.75)
$ln(School)_{i,t}$							-0.0153
							(-0.12)
Constant							0.4526
							(0.78)
Observations	224	224	224	224	224	224	252
No. regions	28	28	28	28	28	28	28
No. instruments	22	22	24	22	22	22	26
Hansen J-test	25.32	25.47	22.32	16.39	15.54	15.49	22.58
p-value	0.116	0.112	0.323	0.565	0.625	0.628	0.310
AR2 test	0.067	0.199	0.657	-0.199	-0.085	-0.115	-0.052
p-value	0.946	0.842	0.511	0.842	0.932	0.908	0.959

73 The evidence of conditional β-convergence does not contradict the lack of σ-convergence found in the analysis of the income dispersion. As Barro and Sala-i-Martin (2004) argue, β-convergence is a necessary but not a sufficient condition for σ-convergence to occur.

Notes:

Columns (1), (2), (4) and (5) - 1-step difference *GMM*, with robust standard errors and the options "collapse" and "lag (1 to 7)".
Column (3) - 1-step difference *GMM*, with robust standard errors and the options "collapse" and "lag (1 to 6)".
Column (6) - 2-step difference *GMM*, with robust standard errors and the options "collapse" and "lag (1 to 7)".
Column (7) - 2-step system *GMM*, with robust standard errors and the options "collapse" and "lag (1 to 5)".

The interaction term of each regression is exogenous (*Difference-in-Hansen test*).

Values in parenthesis are t-ratio.

* Coefficient significant at the 10% level;** Coefficient significant at the 5% level; *** Coefficient significant at the 1% level.

Hansen J-test – overidentification test of restrictions in *GMM* estimation.
AR2 test - Arellano-Bond's test to analyse the existence of second-order autocorrelation in first differences.

The second important result is that educational standards (proxy for human capital) present the expected positive and statistically significant impact on regional growth, revealing that education is a factor for regional convergence.[74] This agrees with the endogenous growth theory claiming that human capital is a factor of production with increasing returns to scale properties and substantial positive externalities in the long-term, thus contributing to faster growth.

The third relevant conclusion is that population growth has not a significant impact on regional growth although its effect is found to be positive (columns (1) and (2) of **Table 3.7**). This insignificance can be due to the slow growth of population in Portugal or even stagnancy in recent years. Alternatively, when population growth is substituted by the employment share in the secondary sector, its effect on regional growth is positive and statistically significant in all cases (columns (3) to (7) of **Table 3.7**). It is worth mentioning that it was not possible to find statistical significance when this variable was replaced by the share of employment in the tertiary sector. When the share of employment in the primary sector was used, it displayed the expected negative sign, but the remaining results were not satisfactory (namely, human capital lost statistical significance).

The fourth significant result comes from the foreign trade variables. In columns (1) and (2) it is shown that the degree of openness with the non-EU countries and the

74 The human capital variable appears in these regressions lagged one period. This is in line with the perspective that the effect of human capital on growth is not immediate.

exports ratio with the EU countries have a positive and significant impact on regional growth. However this positive effect is only statistically confirmed when these variables are multiplied by the *Littoral* dummy. This result reinforces the idea that more open and export-orientated regions grow faster and contribute to the regional growth as a whole in Portugal. This reveals the existence of some kind of positive externalities from the more competitive regions that benefit the whole economy. In fact, as we have confirmed in the previous section, the regions of the *Littoral* are much more open and much more dynamic in the exports sector in comparison to the inland regions of the *Interior*. The same conclusions are obtained from columns (4) and (5) of **Table 3.7**, where the employment share in the secondary sector is used instead of the population growth.

In column (3), trade balance with the EU countries (as a percentage of GDP) is used as a measure of foreign trade. Its positive and statistically significant effect (at the 10% level) on regional growth implies that the higher (lower) the trade surplus (deficit), the faster the growth. Therefore, higher competitiveness is an important factor for regional growth and convergence.

Column (6) shows that total exports ratio with the EU and non-EU countries of the *Littoral* area contribute positively to global regional growth. This evidence is in accord with the export-led growth hypothesis claiming that exports are the engine of growth explained by the foreign trade multiplier.

Finally, in column (7), human capital is combined with the growth of the ratio of non-EU exports to GDP. Human capital individual impact is not statistically significant but its removal from the regression would not change the results to a great extent. This interaction term aims at expressing the technological diffusion hypothesis that takes place through external trade. It can be seen that the impact of the growth of exports on regional growth is positive, as long as the rate of transition/conclusion in high school is higher than 60%[75] (this variable varies between 55.5 and 73.4%, as it is shown in **Table 3.5**). Therefore the positive impact of regional openness on growth requires higher levels of educational standards, necessary to assimilate the advanced technologies transferred through international trade. For a region to achieve faster growth rates it is necessary to be competitive in international markets and competitiveness is linked to

75 The cut-off point is obtained from:

$$\frac{\partial gGDPpc}{\partial g(Exports - Extra/GDP)} = 0 \Leftrightarrow -0.0217 + 0.0053\ln(School) = 0 \Leftrightarrow \ln(School) = 0.0217/0.0053$$

$$\Rightarrow School = \exp(0.0217/0.0053) \approx 60$$

human capital qualifications. The latter is important for adopting and understanding new technologies and developing new products able to compete in international markets.

Still regarding column (7), the impact of human capital on growth is positive, as long as the growth of the ratio of (extra-EU) exports to GDP is positive. Thus, regions that are not able to achieve positive growth rates for the international trade proxy face difficulties to obtain the desired effects of human capital on growth. This analysis gives evidence of the joint effects between human capital and foreign trade on regional growth; hence, one effect cannot be dissociated from the other.

3.6. CONCLUSION

The basic idea of this study was to show that foreign trade is important for regional growth in Portugal as it is important for the whole country, not sharing the argument that capital flows from the central government solve the problem of regional trade imbalances. For this reason the empirical analysis estimates growth equations that take into account foreign trade measures (along with human capital and sectoral employment shares) and tests their statistical relevance on regional growth and convergence.

The descriptive analysis shows that the Portuguese dichotomy between *Littoral* (16 coastal regions) and *Interior* (14 inland regions) is important to understand regional asymmetries. Regions of the *Littoral* have generally higher standards of living, are more open to trade and more competitive in international markets. Although regions of the *Littoral* area show higher educational standards, the difference comparatively to the *Interior* is not substantial. The descriptive analysis also illustrates a severe structural problem in Portugal, associated with the deindustrialisation tendency that can partly explain the low growth rates of Portugal in the last years. The employment share in the primary and secondary sectors has fallen between 1996 and 2005 and the contrary tendency has taken place in the services sector, a sign of the increasing importance of tertiary activities in the economy.

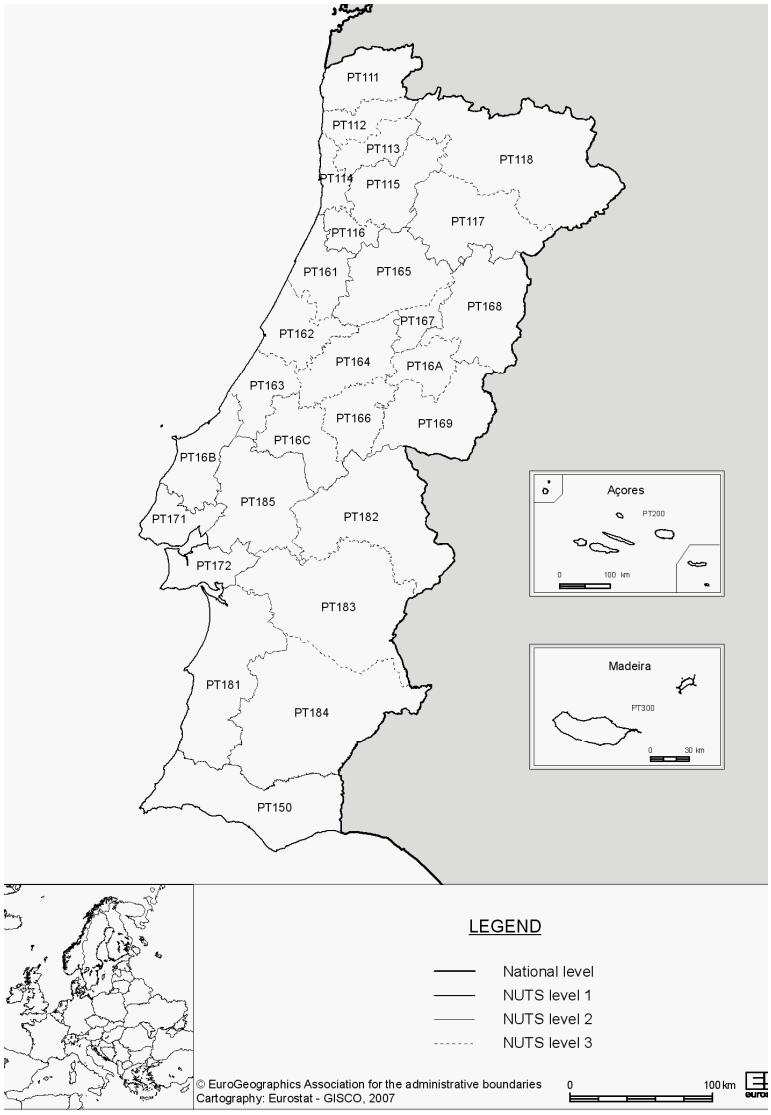
The empirical analysis based on the *GMM* regressions of the conditional convergence model provides interesting insights for the sample of the NUTS3 regions over the period 1996-2005. Conditional convergence is found and annual population growth plays an insignificant role on regional growth. The employment share in the secondary sector is shown to be more important for growth relatively to employment shares in the other two sectors, affecting regional growth positively. Another important finding is the confirmation that educational standards are important for regional growth and this is in line with the endogenous growth theory asserting that human capital is the engine of growth.

The focus of our empirical analysis is on the importance of foreign trade on regional growth and convergence. In fact our results are robust with respect to this factor. It is shown that different measures of foreign trade, such as the degree of openness with non-EU countries, the share of intra- and total exports to GDP, the trade

balance with EU Members and the growth rate of the extra-exports ratio to GDP significantly influence regional growth and contribute to the convergence process. However, trade with the EU countries is more significant than with non-EU members, as expected, since Portugal is a member of the EU. The fact that foreign trade measures gain significance only when they are combined with the *Littoral* dummy (the more competitive and more open area), reinforces the view that external trade is essential for faster regional growth. It also indicates some externality effects from the *Littoral* area that positively influence global regional growth and convergence. Finally, the significance of the interaction term between human capital and foreign trade can be taken as evidence of the technology diffusion principle. More qualified human capital is thus required to assimilate modern technologies and to turn the economies more competitive and able to participate successfully in international markets.

APPENDIX

30 Portuguese NUTS3 regions



Code	NUTS3 level
PT111	Minho-Lima (L)
PT112	Cávado (L)
PT113	Ave (L)
PT114	Grande Porto (L)
PT115	Tâmega (I)
PT116	Entre Douro e Vouga (L)
PT117	Douro (I)
PT118	Alto Trás-os-Montes (I)
PT150	Algarve (L)
PT161	Baixo Vouga (L)
PT162	Baixo Mondego (L)
PT163	Pinhal Litoral (L)
PT164	Pinhal Interior Norte (I)
PT165	Dão-Lafões (I)
PT166	Pinhal Interior Sul (I)
PT167	Serra da Estrela (I)
PT168	Beira Interior Norte (I)
PT169	Beira Interior Sul (I)
PT16A	Cova da Beira (I)
PT16B	Oeste (L)
PT16C	Médio Tejo (I)
PT171	Grande Lisboa (L)
PT172	Península de Setúbal (L)
PT181	Alentejo Litoral (L)
PT182	Alto Alentejo (I)
PT183	Alentejo Central (I)
PT184	Baixo Alentejo (I)
PT185	Lezíria do Tejo (L)
PT200	Açores (L)
PT300	Madeira (L)

Data source: Eurostat.

http://ec.europa.eu/eurostat/ramon/nuts/pngmaps/pt3.png

http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/nuts_classification

Note: (L) indicates the *Littoral* (coastal) regions and (I) the *Interior* (inland) regions.

CHAPTER 4. HOW WELL THE BALANCE-OF- PAYMENTS CONSTRAINT APPROACH EXPLAINS THE PORTUGUESE GROWTH PERFORMANCE. EMPIRICAL EVIDENCE FOR THE 1965-2008 PERIOD. *

* A preliminary version of this Chapter was presented both at the 16th Portuguese Association for Regional Development Annual Conference, in Madeira, in July 2010 and at the 50th European Regional Science Association Annual Congress, in Jönköping, Sweden, in August 2010. We are grateful to the participants for their helpful comments and suggestions.

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4.1. INTRODUCTION

In the core of the debate between the supply-constrained and the demand-led growth stands the very relevant contribution of Thirlwall, under the Post-Keynesian framework, through what has become known as "Thirlwall's Law". The growth of an economy is ultimately determined by effective demand, especially external demand, instead of being explained by the accumulation of factor inputs as the neoclassical theory assumes. The balance-of-payments equilibrium growth rate is determined by the growth of exports in relation to the income-elasticity of the demand for imports, and this is related to the Harrod foreign trade multiplier (Thirlwall, 1980) when it is expressed in a dynamic form.

The general proposition of "Thirlwall's Law" is that whenever an economy grows at a rate higher than that consistent with the balance-of-payments equilibrium, it will run into external deficits which are not sustainable in the long-run, unless capital inflows can finance the ever growing imbalances. In case a country falls into such a trap, domestic income must be adjusted downwards resulting in higher unemployment. It is income that is adjusted to bring the economy back to equilibrium and not relative prices as orthodox balance-of-payments adjustment theory assumes. Competitive devaluations are not the solution, since in the long-run they aggravate domestic inflation, lowering competitiveness and worsening even further external imbalances. Structural solutions are needed to make exports more attractive in external markets and imports less sensitive to changes in domestic income.

The importance of the balance-of-payments constraint hypothesis has been tested in Chapter 2, estimating a growth model for a set of EU countries. The aim of this study is to analyse whether "Thirlwall's Law" accurately predicts the actual GDP growth of Portugal over the 1965-2008 period. More specifically, the study is carried out not only for the whole period but also for shorter overlapping periods, to which the McCombie test (McCombie, 1989) is applied to assess the validity of the Law.

The whole period is also divided in the pre- and post-accession periods to the EU to compare the country's performance in terms of the growth of domestic income, imports and exports. Additionally, it is possible to compare the income-elasticity of demand for imports from both periods.

The outline of this Chapter is the following: in section 4.2 we reconsider the model developed by Thirlwall to predict a country's actual growth. In section 4.3 we explain the variables and the data used over the time period considered. Unit root tests are also performed to justify the specification of the import and export demand functions. The import and export demand functions are estimated in section 4.4, to provide the income-elasticities of demand for imports and exports necessary to test "Thirlwall's Law". In section 4.5 we compute the growth rates consistent with balance-of-payments equilibrium, and compare them to the actual growth rates for 15-year overlapping periods using either a constant or a varying income-elasticity of demand for imports over time. The final section concludes on the accuracy of "Thirlwall's Law" as a way of predicting actual growth in Portugal.

4.2. "THIRLWALL'S LAW" RECONSIDERED

In this section we focus on the original version of "Thirlwall's Law" (Thirlwall, 1979) assuming both that the trade balance[76] is initially in equilibrium and that there are no relative price effects, at least in the long-run. Thirlwall and Hussain (1982) also consider a model starting from disequilibrium on the current account, implying the existence of capital inflows.[77] We will not adopt this extended version in the present study because, although capital inflows can be important in the short-run for adjusting external imbalances, in the long-run their impact on growth is dubious. As Blecker (2009) argues, increasing inflows can at most be a temporary way of relaxing the balance-of-payments constraint, but they do not allow a country to grow at the export-led cumulative growth rate in the long-run. What matters in the long-term analysis of growth is the growth of exports. In Thirlwall's original model, exports and the income-elasticity of imports play a key role in determining long-run growth because faster growth of exports allows faster growth of the imports needed to pay for the import content of other components of demand.

The model can be described in three equations, in growth rates:[78]

$$m_t = \pi y_t + \psi\left(pd_t - pf_t - e_t\right) \qquad \text{Import growth function} \qquad \textbf{(4.1)}$$

$$x_t = \varepsilon z_t + \eta\left(pd_t - pf_t - e_t\right) \qquad \text{Export growth function} \qquad \textbf{(4.2)}$$

76 Although "Thirlwall's Law" refers to balance-of-payments equilibrium on current account, in the empirical literature what is usually used is trade balance of goods and services because this item shows the real competitiveness of the economy.

77 There is an interesting theoretical analysis on this topic by Barbosa-Filho (2002), who considers the balanced trade, the unbalanced trade and the sustainable debt versions of the balance-of-payments constrained growth models, analysing the implications for trade, growth and real exchange rates. In line with Moreno-Brid (1998-99), the author shows that in the case of small open economies which usually have income-elastic imports (imports elasticity higher than one), Thirlwall's original model (1979) is more likely to be the valid one.

78 The original model with variables in levels (upper case letters) is the following:

$$M_t = aY_t^{\pi}\left(\frac{PD}{E * PF}\right)_t^{\psi}$$

$$X_t = bZ_t^{\varepsilon}\left(\frac{PD}{E * PF}\right)_t^{\eta}$$

$$PD_t * X_t = PF_t * E_t * M_t$$

$$pd_t + x_t = pf_t + e_t + m_t \qquad \text{Trade balance equation starting from equilibrium} \qquad \textbf{(4.3)}$$

where m_t, x_t, y_t and z_t (lower case letters) are the rates of growth of real imports, exports, domestic and foreign income, respectively.[79] As for the remaining variables, pd_t and pf_t are the rates of growth of domestic and import prices and e_t is the rate of change of the nominal exchange rate. π and ε are the income-elasticities of demand for imports and exports, both expected to be positive and ψ and η are the price-elasticities of demand for imports and exports (ψ>0 and η<0).

Substituting equations (4.1) and (4.2) into (4.3) and solving for y_t, we obtain the economy's rate of growth consistent with the balance-of-payments equilibrium $y_{BP,t}$, given by:

$$y_{BP,t} = \frac{(1+\eta-\psi)(pd_t - pf_t - e_t) + \varepsilon(z_t)}{\pi} \qquad \textbf{(4.4)}$$

Assuming that relative prices remain unchanged in the long-run, that is,($pd_t - pf_t - e_t = 0$), the expression simplifies to:

$$y_{BP,t} = \frac{\varepsilon(z_t)}{\pi} \qquad \textbf{(4.5a)} \qquad \text{or} \qquad y_{BP,t} = \frac{x_t}{\pi} \qquad \textbf{(4.5b)}[80]$$

Generally speaking, the rate of growth of a country is approximately given by the ratio of export growth relative to the income-elasticity of demand for imports (4.5b).[81] It is income growth that adjusts to preserve equilibrium and not relative prices. If a country wishes to control external deficits (coming from $y>y_{BP}$) it must decrease the constraint on the balance-of-payments, either through an increase in export growth (x) or a decrease in the income-elasticity of the demand for imports (π), or a combination of both.

Alternatively, equation (4.5a) can be rewritten as:

79 For a description of the variables and data sources, see the Appendix of this Chapter.

80 Equation (4.5b) is obtained from the restriction $pd_t - pf_t - e_t = 0$ imposed on equation (4.2).

81 For details on this explanation, see Thirlwall (1982).

$$\frac{y_{BP,t}}{z_t} = \frac{\varepsilon}{\pi} \qquad \textbf{(4.5c)}^{82}$$

This expression tells us that relative income growth between the domestic country and the rest of the world is given by the ratio of the income-elasticity of the demand for exports to the income-elasticity of demand for imports of the domestic economy. In other words, a country can grow faster than the rest of the world ($y_{BP}>z$) without creating balance-of-payments problems only if its income-elasticity with respect to exports is higher than that of its imports ($\varepsilon>\pi$). This interpretation is interesting and related to the concept of convergence or catching-up, where "competitiveness" is the key factor for such tendency to occur.

In terms of policy, the country has to improve the supply characteristics of the goods and services produced and turn the economy more "competitive" in international markets. These supply characteristics are related to quality, design, product differentiation, innovation, post-sale services, etc, which determine non-price competitiveness.

The hypothesis of constant relative prices has been criticised in the literature (e.g. McGregor and Swales (1985; 1991) Alonso and Garcimartín (1998-99); López and Cruz (2000)). By adopting this specification in the present study we do not assume that relative prices do not mater in international trade performance; only that it is of minor significance in the long-run. In most empirical studies in this field relative prices have been shown to be statistically insignificant and even when they are significant the price-elasticities with respect to imports and exports are very low in magnitude when compared to the income-elasticities, showing that imports and exports are less sensitive to price changes than to income changes. Blecker (2009) argues that it is safe to conclude that the longer the time period considered the more likely it is that relative prices remain constant. In our study, when relative prices are regressed on a time trend there is no significant trend during the period of analysis showing that the hypothesis of constant relative prices in the long-run is reasonable.

"Thirlwall's Law", as has been defined in equation (4.5b), will be tested empirically for the Portuguese economy over the period 1965-2008 in the following sections.

82 This equation was also used in Chapter 2.

4.3. VARIABLES AND DATA ANALYSIS

The period of analysis takes 44 annual observations which we consider to be long enough to accommodate the assumptions of the model. Our aim is to examine whether the balance-of-payments constrained growth approach is adequate to explain the performance of the Portuguese economy over this period. Despite the controversy involving the type of variables to be used – levels or rates of growth - we opt for the latter to avoid the existence of spurious relations, since in principle variables in growth rates are stationary. Thus, the option for dynamic import and export demand functions is suitable and in line with other studies, as in Bairam (1993).

4.3.1. IMPORT AND EXPORT GROWTH PERFORMANCE

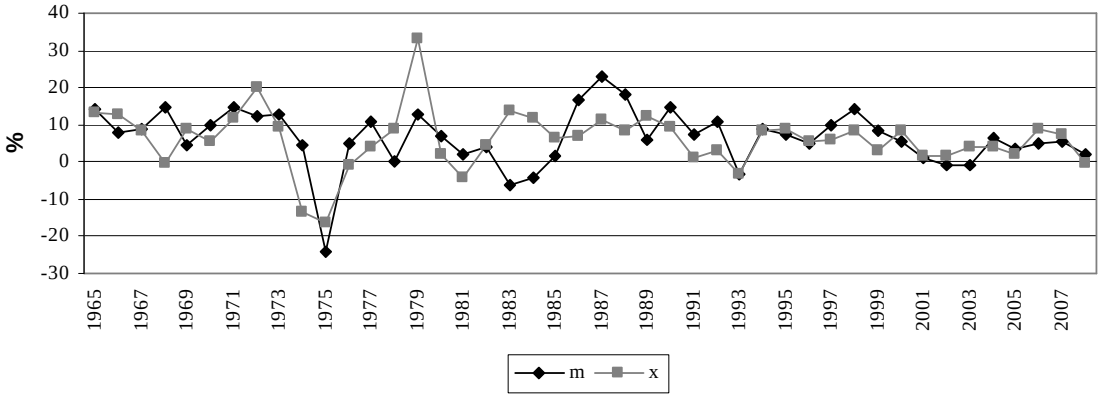
The first step is to analyse the temporal evolution of the variables to detect whether some regular tendencies exist for the whole period, as well as for the periods of the pre- and post-accession to the EU. Combining the information from **Table 4.1** (the two first rows) and **Figure 4.1**, we observe that the average annual growth rate of imports (6.53%) is slightly higher than that of exports (6.05%) over the whole period. From 1993 onwards the gap between the growth of imports and exports is more stable which coincides with the post-Maastricht period and the effort made towards nominal convergence and a fixed exchange rate regime. Dividing the whole sample in the pre- and post-accession periods, it is observed that imports grew faster in the post-accession period (7.60% against 5.37%) and exports grew slower in the same period (5.51% against 6.65%). Another interesting result is that export growth (6.65%) was higher than import growth (5.37%) in the pre-accession period but this tendency was reversed in the post-accession period, with 5.51% for exports and 7.60% for imports. Therefore, Portugal has been loosing competitiveness in the post-accession period competing in a free market and moving towards a fixed exchange rate system.

Table 4.1. Descriptive statistics of variables.

Variable	Period	Obs	Mean	Std. Deviation	Min	Max
(1) *m* % Imports	1965-2008	44	6.53	7.78	-24.2	23.1
	1965-1985	21	5.37	9.03	-24.2	14.6
	1986-2008	23	7.60	6.46	-3.3	23.1
(2) *x* % Exports	1965-2008	44	6.05	7.82	-16.4	33.0
	1965-1985	21	6.65	10.66	-16.4	33.0
	1986-2008	23	5.51	3.95	-3.3	12.2
(3) *y* % Domestic income	1965-2008	44	3.58	3.24	-4.3	11.2
	1965-1985	21	4.39	3.85	-4.3	11.2
	1986-2008	23	2.84	2.41	-2.0	7.5
(4) *z* % Foreign income	1965-2008	44	3.19	1.52	0.1	6.3
	1965-1985	21	3.70	1.83	0.1	6.3
	1986-2008	23	2.72	0.99	0.8	4.6
(5) *c* % Consumption	1965-2008	44	3.38	3.20	-2.9	13.0
	1965-1985	21	3.66	4.18	-2.9	13.0
	1986-2008	23	3.12	2.00	-0.1	6.9
(6) *i* % Investment	1965-2008	44	3.78	7.87	-17.4	18.0
	1965-1985	21	3.21	9.28	-17.4	17.9
	1986-2008	23	4.29	6.49	-7.4	18.0
(7) *rpm* % Relative price of imports	1965-2008	44	1.14	7.76	-24.9	27.3
	1965-1985	21	-1.55	7.95	-24.9	8.7
	1986-2008	23	3.60	6.85	-5.5	27.3
(8) *rpx* % Relative price of exports	1965-2008	44	0.10	3.99	-12.9	11.3
	1965-1985	21	-1.04	4.74	-12.9	6.1
	1986-2008	23	1.14	2.88	-3.2	11.3
(9) *ca* Current account	1965-2008	44	-4.18	5.03	-13.5	5.5
	1965-1985	21	-2.73	5.59	-13.5	5.5
	1986-2008	23	-5.51	4.14	-11.9	2.1

Data sources: European Commission (2002; 2009) and OECD (1997; 2006b; 2009).
Notes:
Variables (1) to (8) are annual growth rates.
Variable (9) is current account as a percentage of GDP at market prices.

Figure 4.1. Annual growth rate of imports (*m*) and exports (*x*), 1965-2008.

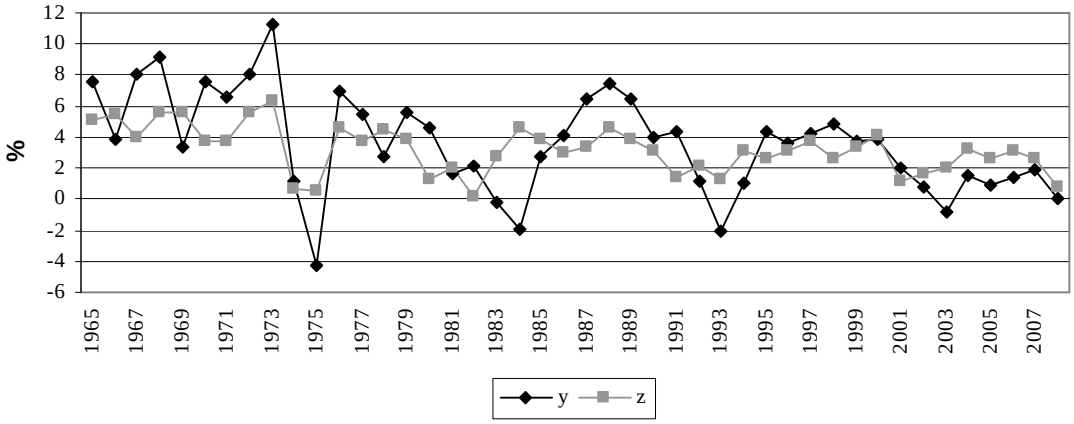


Data source: European Commission (2002; 2009).

4.3.2. RELATIVE INCOME GROWTH PERFORMANCE

From the analysis of **Table 4.1** (rows 3 and 4) and mostly from **Figure 4.2**, it is shown that both the growth of domestic income (y) and the growth of foreign income (z)[83] follow a downward trend throughout the whole period. Still, for the whole period the average annual growth rate of domestic income (3.58%) surpasses that of external income (3.19%) showing evidence of moderate convergence. However, for many years (1966, 1969, 1975, 1978, 1981, 1983-1985, 1992-1994, 2000 and finally from 2002 onwards), Portugal was growing at a slower rate than the OECD countries. It is important to note that Portugal grew at a higher rate in the pre-accession period (4.39%) than in the post-accession period (2.84%) and that the difference between the growth of the Portuguese economy and that of the OECD countries was higher in the former (0.69 percentage points - p.p.) than in the latter (0.12 p.p.). Therefore, not only Portugal grew more rapidly in the pre-accession period but also faster relatively to the OECD countries. In general, the data show that Portugal grew on average at a slightly higher rate than that of the rest of the world and for that to be feasible, according to equation (4.5c), the income-elasticity of the demand for exports (ε) must be higher than that of imports (π).

Figure 4.2. Annual growth rate of domestic (y) and foreign income (z), 1965-2008.



Data source: European Commission (2002; 2009) and OECD (1997; 2006b; 2009).

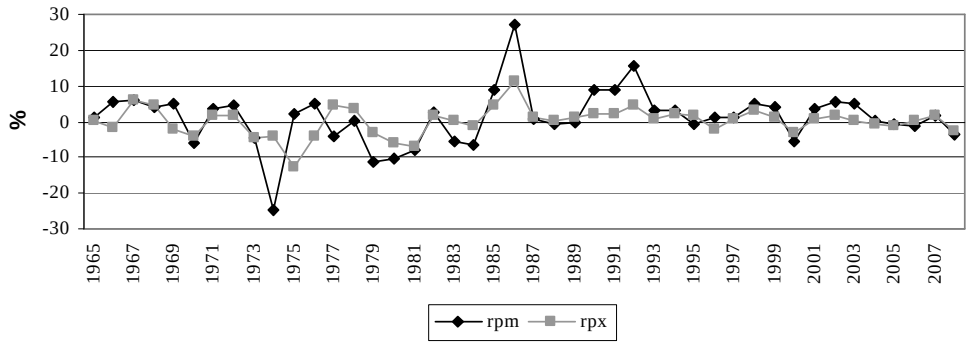
83 Foreign income is approximated by the growth rate of the OECD countries. This is a reasonable proxy, since more than 80% of Portuguese imports and exports are associated with these countries. For details on the computation of z, see the Appendix of this Chapter.

4.3.3. RELATIVE PRICES OF IMPORTS AND EXPORTS

Turning to the analysis of relative prices in **Figure 4.3** (and **Table 4.1**, rows 7 and 8), the average annual growth rate of relative price of imports (*rpm*), defined as the difference between the growth of domestic and import prices, reaches a minimum in 1974 (gain in price competitiveness) and the highest value in 1986 (loss of price competitiveness). As for the relative price of exports (*rpx*), defined as the growth of export less import prices, the behaviour is similar. For both proxies, the 1965-1985 negative average implies a favourable position in terms of price competitiveness, since domestic (for *rpm*) and exports prices (for *rpx*) are not growing as fast as imports prices, and this is the pre-accession period. That pattern is reversed during 1986-2008 (the post-accession period), with import prices growing at a slower rate than domestic and export prices. This tendency is, of course, explained by the removal of import tariffs and exchange rate stability, not allowing competitive devaluations. Combining these results with the export and import behaviour of **Figure 4.1**, we conclude that Portugal lost competitiveness after joining the EU in 1986, and this is associated with a lower growth performance in the same period relatively to the pre-accession period.

An interesting aspect to notice is a long-run movement of relative prices of imports and exports towards zero, most notorious in the post-accession period. This can be taken as evidence that relative prices remain constant in the long-run ($pd_t - pf_t - e_t = 0$) thus justifying the use of equations (4.5a) or (4.5b) for predicting Portuguese actual growth.

Figure 4.3. Annual growth rate of relative price of imports (*rpm*) and exports (*rpx*), 1965-2008.



Data source: Author's computation based on European Commission (2002; 2009).

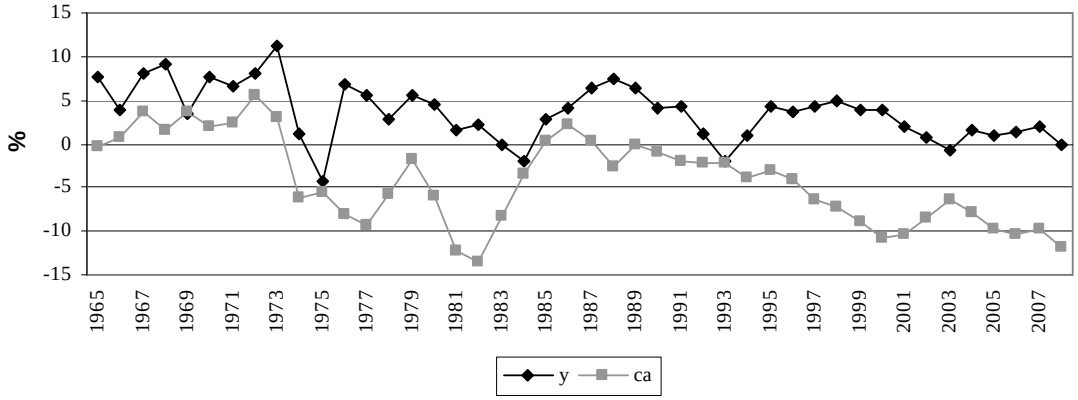
4.3.4. CONSUMPTION AND INVESTMENT GROWTH BEHAVIOUR

Private consumption (*c*) and investment (*i*) growth rates will be used as instruments for domestic growth in the *2SLS* estimation of the import function. This is the reason why these two variables appear in **Table 4.1** (rows 5 and 6) and they exhibit different growth behaviour. Consumption growth performance is more or less stable, although in the post-accession period a small fall occurred (3.12% against 3.66%). By contrast, investment has been growing faster after Portugal joined the EU (4.29% against 3.21%). Therefore, the slower growth rate of the Portuguese economy in the post-accession period is probably mostly due to the poorer performance of exports and loss of competitiveness of the economy as we observed before.

4.3.5. CURRENT ACCOUNT PERFORMANCE

The last row of **Table 4.1** reports the current account average (as a percentage of GDP) for the whole period and the two sub-periods before and after Portugal joined the EU. The current account average is always negative, but the striking evidence is that the average external deficit is twice as high in the post-accession than in the pre-accession period (-5.51% against -2.73%). If we consider that the current account includes some current transfers from the EU, it means that these financial inflows were not sufficient to reduce the deficit. This result is consistent with the poorer performance of exports and the relatively higher increase in imports in the post-accession period as we have seen before. The accumulation of higher external deficits could explain the slower growth performance of the Portuguese economy in the latter period and this is consistent with the balance-of-payments constraint hypothesis which will be tested in the following sections. Through the analysis of **Figure 4.4** it is possible to observe that, generally, both domestic income growth (*y*) and the current account (*ca*) evolve in the same direction.

Figure 4.4. Evolution of actual growth rate (*y*) and the current account on % of GDP (*ca*), 1965-2008.



Data source: European Commission (2002; 2009).

4.3.6. UNIT ROOT TESTS

In time series analysis it is prudent to ensure that the series used are stationary, to avoid the existence of spurious relations. Thus, we use Augmented Dickey-Fuller tests (*ADF*) to check for unit root based on three alternative specifications: with no constant and no trend; with constant and no trend; with constant and trend. The choice of the lag length that ensures the absence of serial autocorrelation follows Adkins and Hill (2008). We start with four lags, testing the statistical significance of the last lagged coefficient and eliminating it in case of statistical insignificance. The process ends when the last lag is significant at least at a 10% level. Additionally, a Breusch-Godfrey LM test is performed after the *ADF* regressions to check the existence of serial autocorrelation in the residuals. The idea is to choose the most parsimonious *ADF* model with no error autocorrelation.

Alternatively, the Phillips-Perron (*PP*) test is also used to check if the conclusions from the *ADF* tests are robust, using Newey-West standard errors to account for serial correlation. *ADF* tests are criticised for failing whenever a structural break occurs in the period under analysis, for not considering the change in the mean that it implies (McCombie, 1997).

The unit root tests are displayed in **Table 4.2**. In the same table we also include those variables that will be used as extra instruments in the estimation of the import demand function: the growth of real private consumption (*c*) and the growth of real investment (*i*). As can be observed, all variables are integrated of order 0, *I(0)*, implying

that we always reject the null hypothesis of the existence of a unit root. Therefore, all variables we consider in the estimation approach are stationary when expressed in growth rates ensuring that no spurious relations are involved when the import and export functions are estimated.

Table 4.2. Unit root tests, 1965-2008.

	Z(t)		1% critical value	
Variable	**ADF**	**PP**	**ADF**	**PP**
m	-3.959***	-4.750***	-3.648	-3.628
x	-5.388***	-4.468***	-3.634	-3.628
y	-4.517***	-4.602***	-4.242	-4.214
z	-5.116***	-4.634***	-4.224	-4.214
c	-3.876***	-3.887***	-3.628	-3.628
i	-5.416***	-3.421***	-3.634	-2.631
rpm	-4.781***	-4.694***	-2.631	-2.631
rpx	-5.016***	-4.213***	-2.633	-2.631

Notes:

ADF - Augmented Dickey-Fuller test for unit root

Regression without constant and trend for *rpm* and *rpx*.

Regression with constant and with no trend for *m*, *x*, *c* and *i*.

Regression with constant and trend for *y* and *z*.

0 lags for *c* and *rpm*, 1 lag for *x*, *z*, *i* and *rpx*, 3 lags for *m* and *y*.

PP - Phillips-Perron test for unit root

Regression without constant and trend for *i*, *rpm* and *rpx*.

Regression with constant and with no trend for *m*, *x* and *c*.

Regression with constant and trend for *y* and *z*.

3 Newey-West lags.

*** Coefficient significant at the 1% significance level.

Critical values are provided by Stata.

4.4. ESTIMATION OF THE IMPORT AND EXPORT DEMAND FUNCTIONS

As a starting point, in **Table 4.3** we present a simple correlation matrix containing only the significant correlations (at the 5% significance level) between the variables to consider in the estimation approach. This preliminary analysis may help us finding the most relevant explanatory variables both in the exports and imports demand functions. Moreover, it also enables us to check the variables more closely linked to the (endogenous) domestic growth, to justify the choice of instruments.

Table 4.3. Correlation matrix, 1965-2008.

	m	*x*	*y*	*z*	*c*	*i*	*rpm*	*rpx*	*ca*
m	1.0000								
x	0.4823	1.0000							
y	0.7657	0.4333	1.0000						
z	0.4451	0.5671	0.6568	1.0000					
c	0.5574		0.6153		1.0000				
i	0.6998	0.3488	0.6282	0.3613	0.3686	1.0000			
rpm							1.0000		
rpx	0.4833	0.3204					0.6138	1.0000	
ca	0.3995	0.3776	0.5367	0.5832	0.4328	0.3091	0.2991		1.0000

Notes:

The significance of the correlation coefficient is given by the following *t-test*: $t = r\sqrt{\frac{n-2}{1-r^2}}$, where *n* is the number of observations and *r* the correlation coefficient. The null hypothesis is that the correlation between a pair of variables is null in the population.
The correlations displayed are statistically significant at the 5% significance level.

The first aspect to notice is that the growth of imports (*m*) is linearly and positively correlated with the growth of domestic output (*y*), and export growth (*x*) is positively correlated with the external output growth (*z*) as expected. The expected positive correlation between import growth (*m*) and relative price of import growth (*rpm*) is only statistically confirmed when lagged values are used for the latter. As for export growth (*x*), it is positively correlated either with the relative price of export growth (*rpx*) or its lagged value (rpx_{t-1}). However this correlation is modest, 0.32, and has a wrong sign. Regarding the growth of domestic output (*y*), it is positively related to private consumption (*c*), investment (*i*), export (*x*) and external output growth (*z*), as expected. It is important to highlight here that the correlation between domestic growth and the current account is positive (0.54) implying that higher current account deficits

are associated with lower growth rates, or what it turns to be the same thing, higher current account surpluses are associated with higher growth rates of domestic output. This finding is consistent with the balance-of-payments constrained growth hypothesis, although in the correlation analysis we do not refer to causality between variables.

For estimation purposes the import demand function is specified as follows:

$$m_t = a + \pi\,(y_t) + \psi\,(rpm_{t-1}) + \omega_t \qquad \textbf{(4.6)}$$

It is expected that the growth of imports is positively related to the growth of domestic income and the lagged value of the growth of the relative price of imports (defined as the difference between the growth of domestic and import prices). We use lagged instead of current prices essentially because the latter displayed no statistical significance. In theoretical terms, it may be justified by the fact that relative price changes do not have an immediate impact on import growth, given that international transactions are based on contracts with fixed terms in the short-run.

Analogously, the export demand function is defined as:

$$x_t = \beta + \varepsilon\,(z_t) + \eta\,(rpx_{t-1}) + \nu_t \qquad \textbf{(4.7)}$$

It is expected that a higher growth of foreign income (OECD countries) stimulates the growth of exports and that the lagged relative price of exports (defined as the difference between the growth of export and import prices) has a negative impact on export growth.

The first step is to estimate separately each equation by *OLS* and these results are shown on **Table 4.4**.

The outcomes for the export function reveal a positive and statistically significant income-elasticity of demand for exports, but the price-elasticity has a (wrong) positive sign.[84] An interesting aspect to highlight is that the income-elasticity of the demand for exports (2.57) is higher than that of imports (1.56) and this justifies our earlier finding from the previous section that Portugal grew on average at a faster rate than the OECD countries over the whole period, reflecting some kind of convergence or catching-up tendency.

84 The (unexpected) positive impact of relative prices on exports was also found by Bairam (1988), for Portugal, during 1970-1985. However, the magnitude of the impact is very low when compared to that of income. Also, MacDonald (2001) argues that "(…) the sign of the effect of exchange rate movements on trade is ambiguous."

Table 4.4. Estimation results from the export and import demand functions.

	OLS		SUR		2SLS
Variable	**Exports**	**Imports**	**Exports**	**Imports**	**Imports**
z_t	2.5736***		2.7690***		
	(3.81)		(4.37)		
rpx_{t-1}	0.4730*		0.4263*		
	(1.86)		(1.79)		
y_t		1.5590***		1.5280***	2.1483***
		(7.04)		(7.35)	(7.22)
rpm_{t-1}		0.3639***		0.3670***	0.2881***
		(3.99)		(4.30)	(2.84)
Constant	-2.2876	0.4612	-2.8944	0.5653	-1.4985
	(-0.98)	(0.46)	(-1.32)	(0.59)	(-1.22)
Obervations	43	43	43		43
R-squared	0.36	0.70			0.79
F (2,40)	11.42	45.98			44.12
	(0.0001)	(0.0000)			(0.0000)
BP test of error independence across equations			$\chi_1^2 = 3.890$		(0.0486)
Pagan-Hall heteroscedasticity test			$\chi_4^2 = 6.5$		(0.1648)
Cumby-Huizinga autocorrelation test			$\chi_1^2 = 0.0611$		(0.8048)
Anderson canon. corr. LM statistic			$\chi_3^2 = 28.076$		(0.0000)
Cragg-Donald Wald F- statistic #			$F(3,38) = 23.83$		(0.0000)
Endogeneity test			$\chi_1^2 = 14.305$		(0.0002)
Sargan statistic			$\chi_2^2 = 0.908$		(0.6351)

Notes:

Numbers in parenthesis are t-ratio (for estimated coefficients) and p-values (for tests).

* Coefficient significant at the 10% level;** Coefficient significant at the 5% level; *** Coefficient significant at the 1% level.

A statistic higher than 10 indicates no weak instruments and consequently, no biases in the coefficients.

Our focus is on the import demand function and we observe that both the income-elasticity and price-elasticity of the demand for imports display their expected signs and are statistically significant at the 1% level. However, they may be biased and inconsistent due to the endogeneity of the growth of domestic income. Two reasons can explain this endogeneity, with adverse tendencies: a higher domestic growth may induce more imports and if imports rely on raw materials, machinery and investment equipment, then growth will be induced further. The second reason is from the balance-of-payments perspective: a faster increase in imports relatively to exports will deteriorate the trade balance position affecting negatively the growth of domestic

income. Thus, an instrumental variables approach is required to make the results more consistent. We use as instruments for the growth of domestic income (y), the growth of private consumption (c), the growth of investment (i) and the growth of exports (x). The suitability of these instruments will be tested in the *2SLS* estimation approach.

Before turning to the instrumental variables estimation, we jointly run the export and import demand functions by the *SUR* (Seemingly Unrelated Regression) estimation technique (see **Table 4.4**). In case the error terms across equations are contemporaneously correlated, there are gains in efficiency from using this method in comparison to *OLS* (AlDakhil, 1998; Baum, 2006). The drawback is that in *SUR* all regressors are exogenous (contradicting our assumption of y being endogenous). The results from the *SUR* estimation do not differ substantially from those of *OLS* and according to the Breusch-Pagan (*BP*) test of cross error independence we reject the null hypothesis of error independence between equations at the 5% significance level but only marginally (at the 1% significance level the null is not rejected). Thus, no significant efficiency gains arise from using full information estimation techniques applied to system equations.

Since our aim is to obtain estimates for the income-elasticity of demand for imports ($\hat{\pi}$) in order to determine the balance-of-payments equilibrium growth rate relying on the assumption that domestic income growth (y) is endogenous, we estimate the import demand function using the *2SLS* method, [85] as in Bairam (1988), Atesoglu (1993; 1995) and Léon-Ledesma (1999).

The estimates of income and price-elasticities display the expected signs and are statistically significant. The income-elasticity of demand for imports (2.15) is higher than in the *OLS* (1.56) and *SUR* (1.53) methods. Comparing the ratio of the elasticities ($\varepsilon_{OLS}/\pi_{2SLS}$=1.20) with the relative income ratio (y/z =1.12) the approximation is closer than with the *OLS* (ε/π=1.65) and *SUR* (ε/π=1.81) methods, giving evidence in favour of "Thirlwall's Law" as expressed in equation (4.5c).

The Pagan-Hall heteroscedasticity test indicates the existence of homoscedasticity and thus there is no need for robust standard errors. Additionally, the

85 For more information on instrumental variables estimation, see Baum et al. (2003).

Cumby-Huizinga test[86] shows the absence of first-order error autocorrelation. The diagnostic tests from the *2SLS* regression are satisfactory. The rank condition for identification is checked through the Anderson canonical correlation LM statistic and shows that the excluded instruments are correlated with the endogenous regressor and the equation is thus identified. Furthermore, the Cragg-Donald Wald F-statistic indicates that the instruments are not weak. The endogeneity test for (*y*) reveals that this variable cannot be treated as exogenous in the import demand function. Finally, the Sargan statistic leads us to accept the validity of the instruments set.

We also check the exogeneity of the (included and excluded) instruments, as well as the redundancy of the excluded instruments. We conclude that the instruments are exogenous and non-redundant (i_t is redundant at the 1% significance level, but not at the 5% level), as it can be observed in **Table 4.5**.

Table 4.5. Tests of exogeneity and redundancy of the instruments.

Instruments	Exogeneity test	p-value	Redundancy test	p-value
x_t	$\chi^2_1 = 0.040$	(0.8425)	$\chi^2_1 = 12.086$	(0.0005)
c_t	$\chi^2_1 = 0.882$	(0.3476)	$\chi^2_1 = 18.891$	(0.0000)
i_t	$\chi^2_1 = 0.749$	(0.3867)	$\chi^2_1 = 6.345$	(0.0118)
rpm_{t-1}	$\chi^2_1 = 0.490$	(0.4839)		

Notes:
Exogeneity test – H_0: the orthogonality condition is valid, i.e., the instrument is exogenous.
Redundancy test – H_0: the instrument is redundant.

86 The Cumby-Huizinga test is a generalisation of the Breusch-Godfrey procedure to analyse the independence of the regression errors. It becomes especially useful in contexts of endogenous regressors, existence of overlapping data and conditional heteroscedasticity of the regression error term (Baum et al., 2007).

4.5. BALANCE-OF-PAYMENTS EQUILIBRIUM GROWTH RATE

4.5.1. OVERALL, PRE- AND POST-ACCESSION PERIODS

After the estimation of the imports demand function, it is possible to compute the growth rate consistent with the balance-of-payments equilibrium to compare it with the actual growth rate of the economy over the period 1965-2008. The expression (4.5b) is the preferred one to compute the balance-of-payments constrained growth rate (Bairam, 1997), due to the instability of the income-elasticity of demand for exports over time. The results can be observed in **Table 4.6**.

Table 4.6. Evidence of "Thirlwall's Law".

	y	x	π	$y_{BP}=x/\pi$	$(y_{BP}-y)$	ca
1965-2008	3.58	6.05	2.15	2.82	-0.76	-4.18
1965-1985	4.39	6.65	2.22	2.99	-1.40	-2.73
1986-2008	2.84	5.51	2.66	2.07	-0.77	-5.51

Notes:
y, *x* and *ca* were taken from **Table 4.1**.
$\pi_{1965\text{-}2008}$ was taken from the *2SLS* estimation in **Table 4.4**.
$\pi_{1965\text{-}1985}$ and $\pi_{1986\text{-}2008}$ come from the *2SLS* regressions for the corresponding sub-periods.

The average annual growth rate of domestic income for the whole period is 3.58%, which is higher than the average growth rate consistent with the balance-of-payments equilibrium (2.82%), meaning that during the period 1965-2008 Portugal was growing beyond its capacity, accumulating balance-of-payments deficits. In fact, the average current account deficit (as percentage of GDP at market prices), *ca*, is -4.18% for the whole period.

Considering once more the pre- and post-accession periods to the EU there are some interesting remarks to make. In the post-accession period, Portugal not only grew at a lower rate both in terms of income and exports (as we mentioned earlier) but additionally, the income-elasticity of imports was higher in this period (2.66) relatively to the pre-accession period (2.22). As a consequence, the growth rate consistent with balance-of-payments equilibrium was lower in this period (2.07) relatively to the pre-accession period (2.99). Therefore, the increase in the income-elasticity of demand for imports after Portugal joined the EU was not counterbalanced by the growth of exports,

to allow a higher growth of domestic income. On the other hand, the increase in imports and the poorer performance of export growth jointly explain the higher external imbalances in the post-accession period measured by the current account deficit as a percentage of GDP (-5.51) which more than doubled relatively to the pre-accession period (-2.73).[87]

Table 4.6 also shows how close is the balance-of-payments equilibrium growth rate (y_{BP}) to the actual growth rate (y) in Portugal. Comparing the difference between the two (y_{BP}-y) we observe that it is always negative, revealing that Portugal grew at a higher rate than that consistent with the balance-of-payments equilibrium and this is in line with the current account deficits accumulated over time. The approximation between the two growth rates is closer for the whole period (0.76 p.p. unexplained) and the post-accession period (0.77 p.p. unexplained), but wider in the pre-accession period (1.40 p.p. unexplained). Overall, "Thirlwall's Law" is a useful instrument for predicting the growth performance in Portugal.

4.5.2. OVERLAPPING PERIODS WITH CONSTANT INCOME-ELASTICITY OF IMPORTS

One criticism of "Thirlwall's Law" relates to the computation of a single growth rate for the whole period (Atesoglu, 1993). Therefore, we analyse the same Law considering 30 overlapping periods with a 15-year time span. Firstly, we test the validity of the Law by assuming that the income-elasticity of demand for imports is the same for all periods, in line with Léon-Ledesma (1999). The results are reported in **Table 4.7**, where we also display averages of the current account/GDP ratio (*ca*), the annual growth rates of domestic income (y) and exports (x); the annual growth rate of income consistent with the balance-of-payments equilibrium given by $y_{BP} = \frac{x}{\hat{\pi}}$, as well as the corresponding differences relative to the actual growth rates (y_{BP}-y). Following McCombie (1989) we also report $\pi^* = \frac{x}{y}$, that is, the income-elasticity of demand for imports assuming equilibrium in the balance-of-payments (or trade balance). If the

87 It is important to note that current transfers from the EU (included in *ca*) did not contribute substantially to reduce this deficit, signifying that the current account deficit could be even higher without taking into account these transfers.

average π^* for the set of overlapping periods is not significantly different from $\hat{\pi}$, neither is *y* from y_{BP}, confirming therefore the validity of "Thirlwall's Law".

Table 4.7. Actual and balance-of-payments equilibrium growth rates, 15-year overlapping periods.

Period	*ca*	*y*	*x*	y_{BP}	$(y_{BP}-y)$	π^*
1965-1979	-0.96	5.55	7.01	3.26	-2.28	1.26
1966-1980	-1.33	5.35	6.26	2.91	-2.43	1.17
1967-1981	-2.19	5.19	5.11	2.38	-2.81	0.98
1968-1982	-3.34	4.79	4.87	2.27	-2.52	1.02
1969-1983	-3.99	4.17	5.81	2.71	-1.46	1.40
1970-1984	-4.46	3.81	6.01	2.80	-1.02	1.58
1971-1985	-4.56	3.49	6.09	2.84	-0.66	1.74
1972-1986	-4.59	3.33	5.75	2.68	-0.65	1.73
1973-1987	-4.93	3.22	5.15	2.40	-0.82	1.60
1974-1988	-5.31	2.97	5.09	2.37	-0.61	1.71
1975-1989	-4.90	3.33	6.79	3.16	-0.17	2.04
1976-1990	-4.60	3.88	8.51	3.96	0.08	2.19
1977-1991	-4.20	3.71	8.65	4.02	0.31	2.33
1978-1992	-3.73	3.42	8.59	4.00	0.58	2.51
1979-1993	-3.49	3.10	7.76	3.61	0.51	2.50
1980-1994	-3.63	2.79	6.12	2.85	0.06	2.19
1981-1995	-3.43	2.77	6.56	3.05	0.28	2.37
1982-1996	-2.89	2.91	7.23	3.37	0.46	2.49
1983-1997	-2.41	3.05	7.33	3.41	0.36	2.40
1984-1998	-2.35	3.39	6.99	3.25	-0.13	2.06
1985-1999	-2.71	3.77	6.41	2.99	-0.78	1.70
1986-2000	-3.45	3.84	6.53	3.04	-0.80	1.70
1987-2001	-4.29	3.70	6.19	2.88	-0.82	1.67
1988-2002	-4.87	3.33	5.55	2.58	-0.74	1.67
1989-2003	-5.13	2.77	5.26	2.45	-0.32	1.90
1990-2004	-5.64	2.45	4.71	2.19	-0.25	1.93
1991-2005	-6.23	2.24	4.21	1.96	-0.28	1.88
1992-2006	-6.79	2.04	4.71	2.19	0.15	2.31
1993-2007	-7.28	2.09	5.00	2.33	0.23	2.39
1994-2008	-7.93	2.23	5.19	2.41	0.19	2.33
Average						1.89

Data source: Author's computation using data from European Commission (2002; 2009) for *ca*, *y* and *x*.
Notes:

ca – Current account as % of GDP at market prices
y – Annual growth rate of real GDP
x – Annual growth rate of real exports

y_{BP} - balance-of-payments equilibrium growth rate, given by $y_{BP} = \frac{x}{\hat{\pi}}$

$\pi^* = \frac{x}{y}$ - income-elasticity of demand for imports assuming trade balance in equilibrium

The difference between y_{BP} and *y* is negative in most of the periods, meaning that the growth rate of the economy was in excess of the rate compatible with the

balance-of-payments equilibrium, which in the long-run cannot be sustainable. In eleven out of the thirty overlapping periods, from 1976 to 1997 and later from 1992 to 2008, the difference is positive, which would theoretically imply that Portugal was growing less than it was capable of from the point of view of the balance-of-payments equilibrium and was therefore reducing external imbalances. From the second column of **Table 4.7** the reduction in current account deficits is confirmed for the former but not for the latter overlapping periods. This result suggests that for y_{BP} to predict more accurately the actual growth rate in Portugal some adjustments have to be made.

Following McCombie (1989), the average π^* for the 30 overlapping periods is 1.89. When we estimate the import function for the whole period and test whether $\pi = \pi^*$ using the t-test, we conclude that they are statistically equal implying that the condition $y_{BP} = y$ is valid. Therefore, "Thirlwall's Law" is a good predictor of the actual Portuguese growth rate for the period 1965-2008.

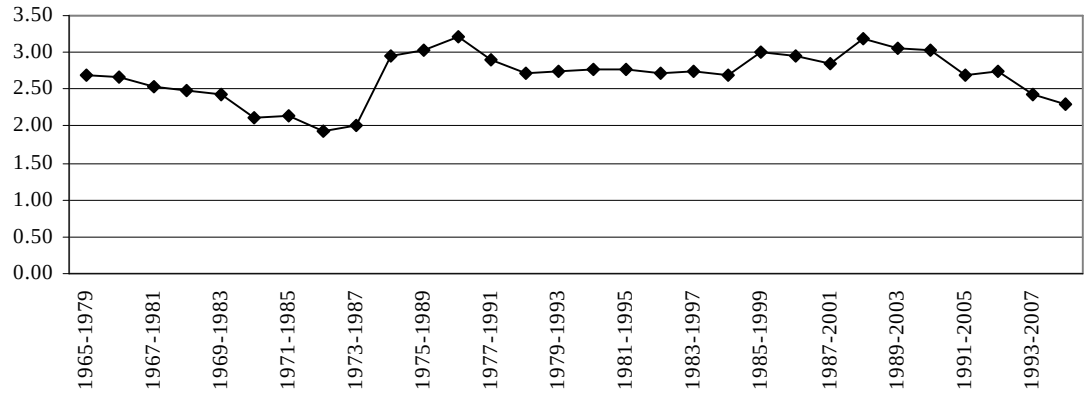
4.5.3. OVERLAPPING PERIODS WITH INCOME-ELASTICITY OF IMPORTS CHANGING OVER TIME

We compute the income-elasticity of demand for imports by estimating the import demand function for each of the 15-year overlapping periods. [88] The specification of the equation is the same as for the whole period, i.e., the growth of imports is related to the growth of domestic income and the growth of lagged relative price of imports and the estimation method is again *2SLS*, assuming that domestic income is endogenous. Apart from the first two overlapping periods, the outcomes indicate that the equations are identified. Still, we present the results even for these two problematic estimations, to be consistent with the whole period 1965-2008, defined in the beginning of the analysis.

In **Table 4.8** we show the income-elasticity of demand for imports obtained from the *2SLS* regression for each overlapping period and from **Figure 4.5** we are able to detect its overall tendency.

88 Léon-Ledesma (1999) used the income-elasticity of the demand for imports obtained from the whole period of analysis to predict actual income growth in Spain across various overlapping periods.

Figure 4.5. Evolution of the estimated income-elasticity of demand for imports in the overlapping periods.



Data source: Author's computation.

As may be inferred from the chart, there is a general favourable downward tendency up to 1986. After the accession to the EU, there is a sharp increase in the income-elasticity of imports that is maintained approximately till 1990. In fact, the EU membership made the Portuguese economy more vulnerable to imports due to the free circulation of goods and services and the abolition of any kind of tariffs on imports. In the following periods, the elasticity drops and keeps more or less stable around that limit until 2004. In the last periods the income-elasticity of the demand for imports declines moderately, but its value remains higher than 2 implying an increase in import growth twice the increase in domestic income growth.

Also in **Table 4.8**, we replicate the income-elasticity of the demand for imports compatible with the equilibrium in the balance-of-payments (π^*), for an easier comparison of the results. The McCombie test is performed for each of the overlapping periods and the absolute value of the *t-test* is shown.

Comparing the estimated income-elasticity of demand for imports $\hat{\pi}$, derived from the *2SLS* regressions, with π^*, the hypothesis that y_{BP} is a good predictor of y (that is $\hat{\pi} = \pi^*$) is never rejected at the 5% significance level (the Law is rejected three times only, at the 10% significance level, in the periods: 1974-1988, 1985-1999 and 1987-2001). Thus, by implementing the McCombie test our evidence shows that "Thirlwall's Law" is accurate for predicting actual growth in Portugal, for most of the period considered. McCombie and Thirlwall (1994) argue that y has not to be precisely equal to $y_{BP}(=x/\pi)$, but close enough to be interesting and to suggest that there is a common force operating constraining growth. A number of reasons can be given as to why there

may be (usually small) divergence between y and y_{BP}, including supply constraints, biased estimates of π, capital flows and terms of trade effects.

Table 4.8. Balance-of-payments equilibrium growth rates with income-elasticity of imports varying over the 15-year overlapping periods.

Period	π (1)	π^*	Abs. value of the t-test (2)	$y_{BP}=x/\pi$	$(y_{BP}-y)$
1965-1979	2.70	1.26	1.31	2.60	-2.95
1966-1980	2.67	1.17	1.35	2.34	-3.01
1967-1981	2.53	0.98	1.55	2.02	-3.17
1968-1982	2.49	1.02	1.50	1.96	-2.84
1969-1983	2.43	1.40	1.64	2.39	-1.78
1970-1984	2.10	1.58	1.02	2.85	-0.96
1971-1985	2.13	1.74	0.74	2.86	-0.63
1972-1986	1.93	1.73	0.33	2.98	-0.34
1973-1987	2.01	1.60	0.67	2.57	-0.65
1974-1988	2.96	1.71	1.80*	1.72	-1.25
1975-1989	3.04	2.04	1.37	2.24	-1.09
1976-1990	3.22	2.19	1.10	2.64	-1.24
1977-1991	2.89	2.33	0.89	2.99	-0.72
1978-1992	2.73	2.51	0.35	3.15	-0.27
1979-1993	2.74	2.50	0.48	2.84	-0.26
1980-1994	2.77	2.19	1.08	2.21	-0.59
1981-1995	2.76	2.37	0.70	2.38	-0.40
1982-1996	2.72	2.49	0.42	2.65	-0.25
1983-1997	2.74	2.40	0.60	2.68	-0.37
1984-1998	2.68	2.06	1.11	2.61	-0.78
1985-1999	2.99	1.70	1.81*	2.14	-1.62
1986-2000	2.96	1.70	1.71	2.21	-1.63
1987-2001	2.85	1.67	1.78*	2.17	-1.53
1988-2002	3.18	1.67	1.67	1.75	-1.58
1989-2003	3.05	1.90	1.25	1.73	-1.05
1990-2004	3.03	1.93	1.38	1.56	-0.89
1991-2005	2.68	1.88	1.20	1.57	-0.67
1992-2006	2.75	2.31	0.68	1.72	-0.32
1993-2007	2.44	2.39	0.10	2.05	-0.05
1994-2008	2.30	2.33	0.06	2.26	0.03

Notes:

(1) The estimated coefficient from the *2SLS* regression is always statistically significant.

The Anderson canonical correlation LM statistic indicates that the equation is underidentified, for the two first sub-periods.

(2) The null hypothesis is that $\hat{\pi} = \pi^*$, for each overlapping period.
$\hat{\pi} = \pi^*$ always, for a 5% significance level.
* denotes that $\hat{\pi} \neq \pi^*$, for a 10% significance level.

In fact our results show that the actual growth rate is always higher than that compatible with the balance-of-payments equilibrium (except for the last overlapping

period), indicating the existence of external deficits. This evidence is now much more in conformity with the negative averages of the current account (as a percentage of GDP) found for each overlapping period, as reported in **Table 4.7**.

The approach based on the overlapping periods' estimation of the income-elasticity of the demand for imports is apparently more appropriate to analyse "Thirlwall's Law", instead of considering a single π estimated for the whole period and then using it to compute the balance-of-payments equilibrium growth rate either for the whole period or for each of the overlapping stages. With the approach from **Table 4.8**, the McCombie test enables us to analyse the performance of "Thirlwall's Law" period by period. The general conclusion is that the Law accurately predicts actual growth for the Portuguese economy, giving support to the balance-of-payments constraint hypothesis.

4.6. CONCLUSION

The present study analyses whether the demand-orientated approach based on the balance-of-payments constraint hypothesis is suitable for explaining Portuguese growth in the 1965-2008 period. The model developed by Thirlwall to compute the balance-of-payments equilibrium growth rate is adopted, assuming constant relative prices in the long-run (a plausible hypothesis) and initial equilibrium on trade balance. The import and export demand functions are estimated to obtain the income-elasticities with respect to imports and exports, which are crucial parameters for computing "Thirlwall's Law".

A preliminary data analysis shows that Portugal grew on average at a higher rate than the OECD countries in the whole period, 1965-2008, and this is consistent with the empirical finding that the income-elasticity of the demand for exports is higher than that of imports, as "Thirlwall's Law" implies. This corroborates the hypothesis that a country can grow faster than the rest of the world only when its income-elasticity of demand for exports exceeds that of imports, as long as capital inflows can compensate external imbalances. It is also observed that Portugal grew faster in the pre- than in the post-accession period to the EU, and this is consistent with higher current account deficits accumulated in the latter as a result of both faster import growth and lower export growth.

The crucial parameter of the income-elasticity of demand for imports is obtained by estimating the import demand function by *2SLS*, with domestic income growth being endogenous. Knowing that parameter, the balance-of-payments equilibrium growth rates are computed for a series of 15-year overlapping periods and are compared with the actual growth rates. The approximation of the two rates is quite close, validating "Thirlwall's Law" as a good way of predicting actual growth of the Portuguese economy. The McCombie test reinforces this conclusion. Generally it is found that Portugal grew slightly higher than the rate compatible with the balance-of-payments equilibrium, and this is consistent with the accumulation of current account deficits over the period considered.

In addition, the income-elasticity of the demand for imports is estimated individually for each overlapping period and a sharp increase is observed of its value after Portugal joined the EU. Assuming that the income-elasticity of demand for imports

is changing over time, the confirmation of “Thirlwall’s Law” becomes more satisfactory. When the McCombie test is performed, it shows that actual growth in Portugal can be accurately predicted by the balance-of-payments equilibrium growth approach in almost all the overlapping periods.

The overall analysis shows that external demand constraints are crucial for explaining the growth performance of the Portuguese economy, especially in the post-accession period. For the country to achieve sustainable growth rates exports must increase and import sensitivity to domestic income changes must be reduced, turning the economy more competitive both in domestic and foreign markets and this is compatible with the increase in the balance-of-payments equilibrium growth rate.

At the micro level, policies are needed to improve the non-price characteristics of the goods and services associated with quality, design, innovation, product differentiation, marketing and efficient distribution. These non-price characteristics are captured by income-elasticities. Thus, if an improvement in one of these features is related to an increase in the income-elasticity of demand for exports (which in turn reflects non-price competitiveness), those policies will be contributing to turn the economy more competitive.

APPENDIX

Description of the variables and data sources

- *m* – Annual growth rate of real imports.

Imports of goods and services at 1995 (2000) prices (national currency; annual percentage change).

- *x* – Annual growth rate of real exports.

Exports of goods and services at 1995 (2000) prices (national currency; annual percentage change).

- *y* – Annual growth rate of real GDP.

GDP at 1995 (2000) market prices (national currency; annual percentage change).

- *c* – Annual growth rate of real private consumption.

Private final consumption expenditure at 1995 (2000) prices (national currency; annual percentage change).

- *i* – Annual growth rate of real investment.

Gross fixed capital formation at 1995 (2000) prices (national currency; annual percentage change).

- *px* – Annual growth rate of export prices.

Price deflator exports of goods and services (national currency; annual percentage change).

- *pm* – Annual growth rate of import prices.

Price deflator imports of goods and services (national currency; annual percentage change).

- *py* – Annual growth rate of domestic prices.

Price deflator GDP at market prices (national currency; annual percentage change).

- *rpm* – Annual growth rate of the relative price of imports (*py-pm*).

- *rpx* – Annual growth rate of the relative price of exports (*px-pm*).

- *ca* –Balance on current transactions with the rest of the world (% of GDP at market prices).

Data on *m*, *x*, *y*, *c*, *i*, *px*, *pm*, *py* and *ca* were taken from European Commission (2002; 2009). Constant figures are at 1995 prices (for 1965-1980) and 2000 prices (for 1981-2008), depending on the Statistical Annex from which they were obtained (2002 and 2009, respectively).

- *z* – Annual growth rate of real foreign income (OECD countries).

1965–1970: GDP at the price levels and exchange rates of 1990 (billions of US dollars) – OECD (1997).

1971–1994: GDP at the price levels and exchange rates of 2000 (billions of US dollars) – OECD (2006 b).

1995-2008: Real GDP (% change from previous year) – OECD (2009).

CHAPTER 5. GROWTH PERFORMANCE IN PORTUGAL SINCE THE 1960's: A SIMULTANEOUS EQUATION APPROACH WITH CUMULATIVE CAUSATION CHARACTERISTICS.

5.1. INTRODUCTION

The Keynesian demand-orientated approach admits, contrary to the neoclassical supply-led growth theory, that demand, especially exogenous demand (through exports) is the main driving force of growth. When external imbalances occur (mainly due to current account deficits), it is income that adjusts to preserve the balance-of-payments equilibrium. In this approach, growth is not constrained by the supply of factor inputs and productive factors are endogenous to the growth process, transferred to locations where demand is stronger and not to where relative prices are more favourable, as the neoclassical theory assumes.

The demand-orientated approach to growth takes into account the existence of heterogeneity across economies and specific structures, where free trade and free factor mobility can lead to uneven economic development. Consequently, the tendency for convergence of the neoclassical analysis, due to the lower stock of capital in poorer economies and diminishing returns to scale of the productive factors, does not occur automatically.

The existence of increasing returns to scale especially in the non-primary sector will induce a cumulative causation growth process with circular tendencies towards sustainable growth. Once an economy gains a competitive growth advantage (through exports) it will preserve it and may even extend it further making difficult for others to compete on the same activities.

The core of the cumulative causation growth process is the "Verdoorn's Law", assuming that productivity growth is endogenous, depending on the growth of output (mainly of industrial output). This relation captures the increasing returns properties (both static and dynamic) found in the industrial sector and turns the growth process virtuous with cumulative causation characteristics.

The cumulative causation model represented by a multi-equation system will be tested for the Portuguese economy to verify whether this approach is relevant to explain the growth performance of this country in the last decades. A complete growth model with structural interrelated equations will be estimated simultaneously by *3SLS*, expressing the main features of the cumulative growth process with circular characteristics. Special attention will be given to the productivity gap between Portugal

and the leader (the *USA*), aiming to capture the possibility for catching-up tendencies in technology and innovation activities.

The outline of the study is the following: in section 5.2, some theoretical considerations related to the cumulative causation principle are reviewed. In section 5.3 historical trends of the main variables used in the model are explained. In section 5.4 the structural multi-equation model is presented and the virtuous circle of cumulative growth is described. Section 5.5 reports the estimation results and discusses the relevance of the cumulative causation model to explain the Portuguese economic performance. The final section concludes.

5.2. THE CUMULATIVE CAUSATION PRINCIPLE

The process of cumulative causation growth was used by Myrdal (1957) to explain international differences in the level of development between countries. Labour migrates from poor to rich countries seeking for better remuneration and better employment opportunities, enhancing demand and growth in the destination country. Capital migrates to developed countries where risk is lower, tax incentives are generous, skilled labour is available and profit perspectives are higher. Trade is unfavourable to the developing countries, producing mainly primary commodities with inelastic demand and low value added. Trade is more advantageous to the developed countries, specialising in increasing returns to scale activities with high income-elasticity of demand, and high value added. Efficiency-wages[89] have the tendency to fall more rapidly in faster-growing countries as a result of gains in productivity. Therefore, developed countries gain a cumulative competitive advantage, especially in manufacturing commodities. Spread effects - with favourable repercussions on backward countries - are weaker at the international level than within nations, resulting in persistent and sometimes even widened international differences on growth.

Kaldor (1957; 1966) developed his growth theory using many of Myrdal's ideas and criticised the neoclassical approach of exogenous growth, considering it unrealistic and unable to explain differences in growth rates between countries or regions. In contrast to the neoclassical doctrine of constant returns to scale of the reproducible factors, Kaldor attributed to industry and manufacturing the exclusive role of generating increasing returns to scale through the workings of the "Verdoorn's Law". Once an economy obtains a growth advantage (mainly in exports) it will tend to sustain it at the expense of other economies, because faster output growth leads to faster productivity growth through the Verdoorn's effect. Higher productivity in turn reduces efficiency-wages and consequently prices, turning the economy more competitive expanding the growth process in a circular and cumulative way.[90] At the heart of the cumulative growth process stands the hypothesis of increasing returns to scale associated with the "Verdoorn's Law", reflecting some kind of technological progress and turning the

89 Efficiency- wage is defined as the ratio of money wage to productivity.

90 The Kaldorian view is part of the Keynesian approach to growth and it emphasises the role of prices on growth, in short- to mediu-run contexts (Blecker, 2009).

growth process self-sustained. The increasing returns are not only static, related to the scale of production, but also dynamic, coming from learning-by-doing, induced investment, embodied technical progress, external economies, among other factors. For Kaldor (1970; 1981) the competitive industry is responsible for the polarisation phenomenon and the poles of economic activities are on the industrial sector. On the other hand, exports that are mainly produced in the industrial or manufacturing sectors are the most potent element of exogenous demand, with higher multiplier effects on national income.

The cumulative process develops in a virtuous cycle favouring the economy with the initial competitive advantage and making it difficult for other economies to establish the same activities. This is the essence of the theory of cumulative causation growth, that explains the phenomenon of divergence between the centre and the periphery or between industrial and agricultural economies, and hence between developed and developing economies. Developing or less developed economies have not the ability to explore activities with increasing returns to scale properties and to generate a cumulative process of expanding growth. Trade openness will benefit economies that have the ability to explore activities with substantial economies of scale and produce competitive commodities. The message which can be drawn from Kaldor's model of cumulative causation is that faster growth can be obtained by making the economy more competitive and/or altering the industrial structure in a way to produce goods with higher income-elasticity of demand and obtaining higher gains of productivity reflected in the Verdoorn's relation.

Some studies attempted to test empirically the validity of the cumulative growth model, among them, Amable (1993), Atesoglu (1994), Pini (1996), Targetti and Foti (1997), De Benedictis (1998), and more recently Fingleton (2000), Greunz (2001), Castellacci (2002) and Léon-Ledesma (2002).[91] Most of them are cross-country or cross-region studies, using diverse sets of equations to describe the cumulative growth process and different proxies to express the technology gap. A summary of these studies including a technology gap is given in **Table 5.1**, which is self-explained.

91 For a comparative survey on the Post-Keynesian perspectives of the export-led cumulative causation growth and the balance-of-payments constraint approach, see Blecker (2009).

Table 5.1. Comparative studies of cumulative causation models.

Study	Growth approach	Exogenous variables	Sample	Period	Estimation method	Technology gap approximated by
Amable (1993)	Interactions between equipment investment share, innovative activity, education and productivity growth	-technology gap (follower) -% of concerned age group engaging in primary education -% of real government expenditure	59 countries	1960-85	*FIML*	(real GDP per worker level in country *i* relatively to the USA's)
Targetti and Foti (1997)	Interactions between output growth, productivity and exports	-world productivity -world demand -technology gap -investment-output ratio	25 countries	1950-88	iterative *3SLS*	ln (GDP per worker level in USA relatively to the country *i*'s)
Fingleton (2000)	Interactions between productivity, investment share, R&D activity, education and aggregate output growth	-technology gap -weighted average of the level of technology in neighbouring countries -primary education	60 countries	1960-85	*FIML*	1-(productivity level in country *i* relatively to the USA's)
Greunz (2001)	Interactions between output growth, the proportion of industrial and service employment, and the innovative activity	-technology gap (follower) -physical infrastructures -level of qualification of the working-age population -real R&D expenditures	153 European regions	1989-96	*FIML*	(real GDPpc level in region *i* relatively to the 3 best performing regions)
Castellacci (2002)	Interactions between output growth, exports growth, domestic prices, average productivity, knowledge stock (leader and follower), technology gap and innovative activity	-technology gap -world demand -money wages -level of education of the working population -investment-output ratio	26 OECD countries	1991-99	k-means clustering algorithm	ln (ratio of R&D on GDP in the leader relatively to the follower's)
Léon-Ledesma (2002)	Interactions between output growth, exports, domestic prices, productivity and innovation	-technology gap -growth of foreign prices -world income growth -investment-output ratio -growth of money wages -rate of growth of the cumulative sum of real output -level of education of the working population	17 OECD countries	1965-94	iterative *3SLS*	1-(productivity level in country *i* relatively to the USA's)

Data source: Author's elaboration, using the cited references.

Our study differs from the previous ones in two main aspects: it uses time series data[92] to explain growth performance of a unique country, Portugal; the structural model and some variables are different from those of the previous studies as we will explain in the next sections.

92 The circular and cumulative growth models mentioned in **Table 5.1** are cross-section studies to explain short to medium-run growth. We use a time-series analysis of 42 annual observations to explain a relatively long-run growth performance of the Portuguese economy.

5.3. HISTORICAL TRENDS OF THE MAIN VARIABLES

In line with the previous considerations, we adopt a demand-driven approach of circular and cumulative causation, in order to verify whether such a perspective is adequate to explain the Portuguese growth performance throughout the last decades. The first step is to define the variables that enter the model and analyse their evolution over time. [93]

Table 5.2 displays some descriptive statistics of the variables to be used in the structural model, namely the mean, the standard deviation, the minimum and the maximum values. Combining this information with that from the figures of the evolution of variables over time, we are able to observe important tendencies throughout the last decades.

The two first rows of **Table 5.2** and **Figure 5.1** show that for most of the years Portuguese growth (y) exceeded that of the OECD countries (z).[94] The exception has been during the period 1983-1985 where Portuguese growth was lower than the OECD average explained by the restrictions imposed by the IMF to solve the external debt crisis. More recently, from 2002 onwards, the country has been experiencing a slowdown in growth, more evident than in the OECD countries, and this period coincides with the participation of Portugal in the EMU. The decline of growth in the latter period can be due to the loss of competitiveness in external markets. Unlike Portugal, the OECD growth average does not display negative values in any occasion. Both growth rates declined throughout the period but for Portugal the decrease has been more pronounced: Portugal's growth dropped from 7.6% in 1965 to 1.4% in 2006, while in the OECD countries the fall was from 5.1% in 1965 to 3.1% in 2006.

93 For the description of the variables, see the Appendix I of this Chapter.

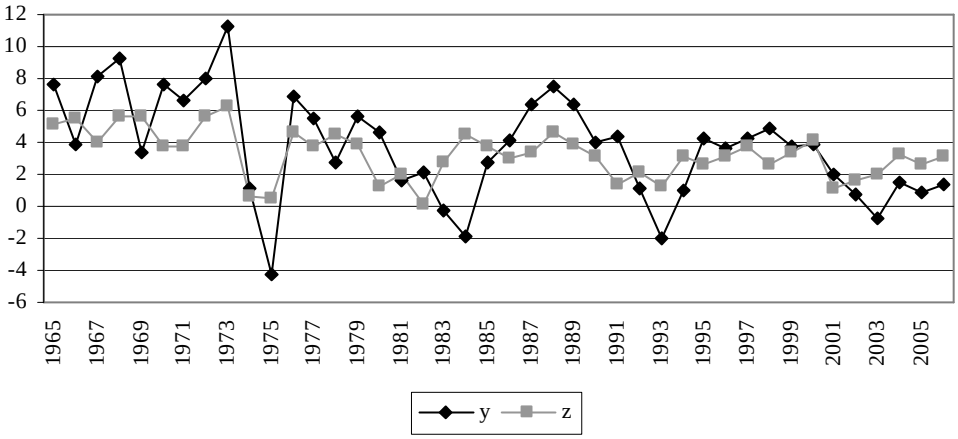
94 Although the OECD sample includes Portugal, the rate of OECD income growth with Portugal is not substantially different from the one excluding it. Therefore, foreign income is approximated by the growth rate of the OECD countries. This is a reasonable proxy, since more than 80% of Portuguese imports and exports are associated with these countries. For details on the computation of z, see the Appendix I of this Chapter.

Table 5.2. Descriptive statistics of variables, 1965-2006 (42 observations).

Variable	Mean	Std. Deviation	Min	Max
(1) *y* % Domestic income	3.70	3.26	-4.3	11.2
(2) *z*% Foreign income	3.26	1.51	0.1	6.3
(3) *x* % Exports	6.18	7.94	-16.4	33
(4) p % Domestic prices	10.37	7.78	1.4	26.5
(5) *pm* % Import prices	9.13	12.11	-6.8	43.8
(6) w % Nominal compensation per employee	14.13	8.72	2.1	35.1
(7) wr % Real compensation per employee	3.46	4.71	-2.9	18.6
(8) prod % Productivity	3.39	3.02	-3.2	11.7
(9) gap Productivity gap	56.31	5.99	49.1	71.3
(10) *(I/O)* Investment-output ratio	30.70	4.40	19.1	38.7
(11) *open* Degree of openness	42.12	13.12	25.7	69.1

Data sources: European Commission (2002; 2009); Heston et al. (2009) and OECD (2006 b; 2009).
Notes: Variables (1) to (8) are annual growth rates. Variables (9) to (11) are ratios.

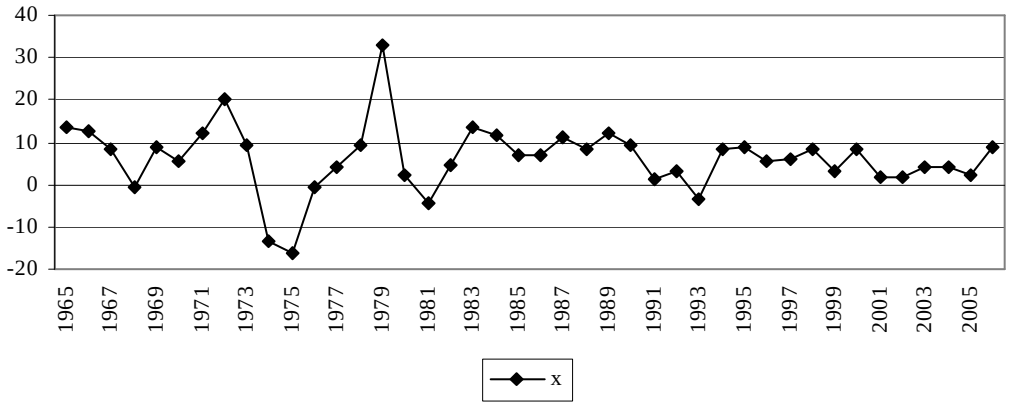
Figure 5.1. Annual growth rate of domestic (*y*) and foreign income (*z*), 1965-2006.



Data source: European Commission (2002; 2009) and OECD (2006b; 2009).

From the third row of **Table 5.1** and the **Figure 5.2**, it can be seen that exports grew on average around 6% per annum for the whole period fluctuating within a wide range, although it becomes narrower after 1986, the year that Portugal joined the EU. Export growth presented a peak of 33% in 1979 and the lowest record in 1975, of about -16.4%, following the year of the change of the political regime. Considering the whole period, the annual growth rate fell from 13.5% in the beginning of the period to 8.7% in 2006. The growth of exports is substantially lower after Portugal joined the EU revealing difficulties in competing in free external markets.

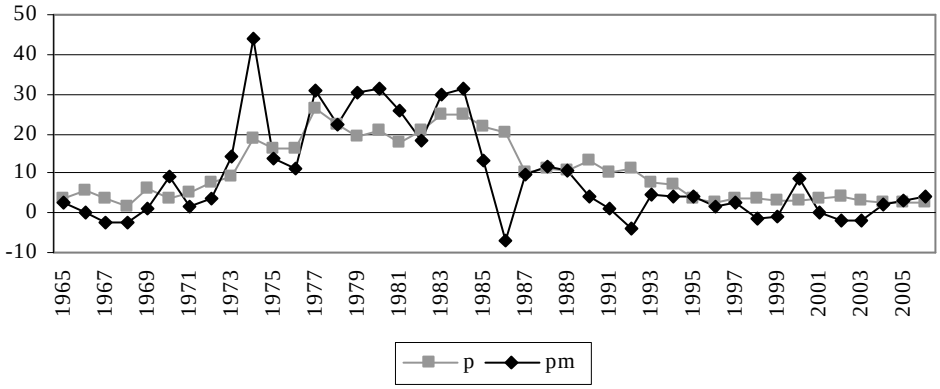
Figure 5.2. Annual growth rate of exports (*x*), 1965-2006.



Data source: European Commission (2002; 2009).

As **Table 5.1** shows, domestic prices (*p*) grew on average faster than import prices (*pm*) (10.37% against 9.13%). **Figure 5.3** shows that the growth of domestic prices was always non-negative and reached its maximum in 1977, prior to the second oil crisis that aggravated prices worldwide. After Portugal joined the EU the growth of domestic prices is generally faster than that of import prices and this is probably due to the removal of import duties. During the whole period and especially in the post-accession period Portugal behaves poorly as far as price competitiveness in international markets is concerned. As we will explain bellow, this is because money wages grow faster than labour productivity turning the economy less competitive.

Figure 5.3. Annual growth rate of domestic (*p*) and import prices (*pm*), 1965-2006.

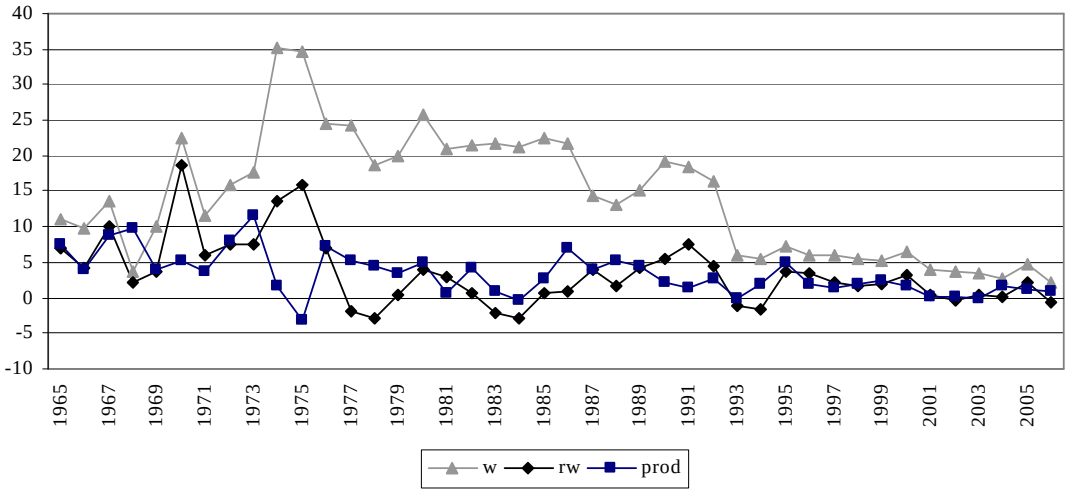


Data source: European Commission (2002; 2009).

Comparing the growth of the nominal compensation per employee (*w*)[95] with the growth of labour productivity (*prod*) in **Figure 5.4**, we are able to infer about the growth of efficiency wages. The first aspect to notice is that only in 1968 the growth of productivity was faster than that of nominal wages. In the remaining years, the growth of nominal wages exceeded that of productivity and this is pointed out as a persistent problem for Portugal, affecting its competitiveness both domestically and abroad. Over the whole period nominal wages grew on average 14.13% per annum, much more than the average growth of productivity of 3.39% (see **Table 5.1**). A striking aspect is that the growth of productivity is declining over time, going from 7.4% in the beginning of the period to 0.9% in 2006. Although nominal wages growth has declined over time (because of lower inflation rates) the gap between the latter and productivity growth remains substantial over time, influencing negatively the economy's competitiveness. When we consider the growth of real compensation per employee (*rw*) in the analysis, the picture is slightly different. Although the average growth of real wages (3.46%) is slightly faster than the average growth of productivity (3.39%), the difference between the two has consistently been diminishing over time.

95 Nominal compensation per employee will be referred to as nominal wages in the text, for simplicity.

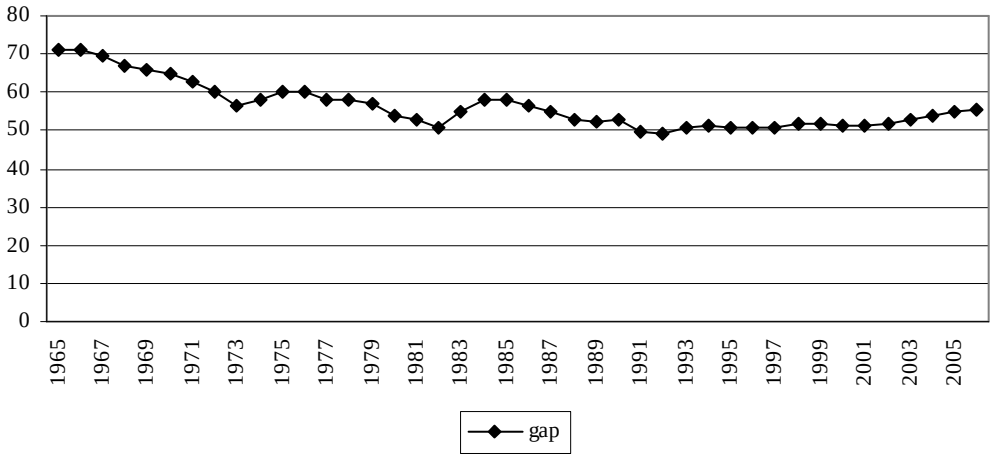
Figure 5.4. Annual growth rate of nominal (*w*) and real compensation per employee (*wr*) and of productivity (*prod*), 1965-2006.



Data source: European Commission (2002; 2009).

The technology gap (*gap*) is defined as one minus the ratio of the Portuguese productivity level relatively to the USA's, considering that the latter is the leading country in productivity gains due to higher innovation and technology advances. When the *gap* is declining towards zero it means that Portugal is catching-up with the leader over time, making progresses in productivity. From **Table 5.1** it can be observed that the Portuguese productivity level, on average, corresponds to only 56% of the USA's but **Figure 5.5** shows that some improvement has taken place over time. In fact, the gap in productivity is declining throughout the period (from 70.92 in 1965 to 55.42% in 2006), giving some evidence of convergence relatively to the leader. However, the catching-up tendency stabilised around 1992 (the lowest record) and after that the gap in productivity has been rising slowly.

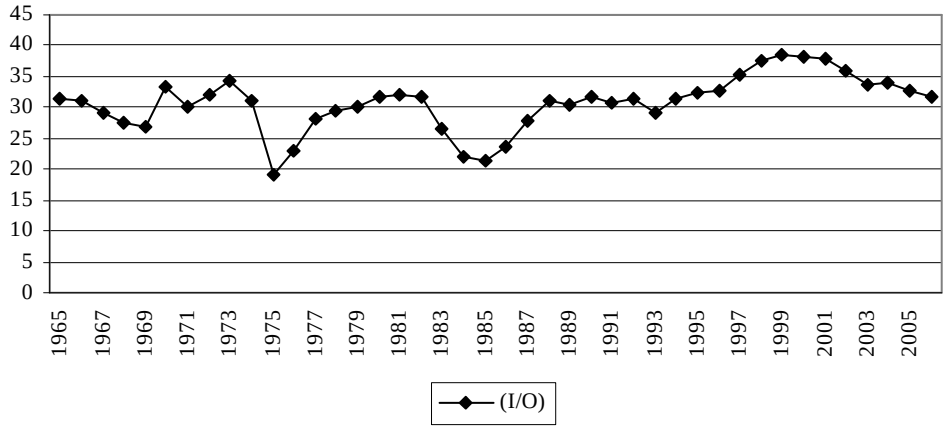
Figure 5.5. Productivity gap relative to the USA (g*ap*), 1965-2006.



Data source: Author's computation using data from Heston et al. (2009).

The investment-output ratio (*I/O*) is used in our model as a proxy for physical capital accumulation and its average for the whole period is 30.7% (see **Table 5.1**). **Figure 5.6** shows that the lower records are around 1975 and 1985, respectively, which can be explained by the change of the political regime in the former and by the austerity programs imposed by the IMF in the latter period. A strong increase in investment is observed after Portugal joined the EU and continues up to 1999. After that a downward tendency occurs, which can partly explain the low growth performance of Portugal in the last decade.

Figure 5.6. Investment-output ratio (*I/O*), 1965-2006.

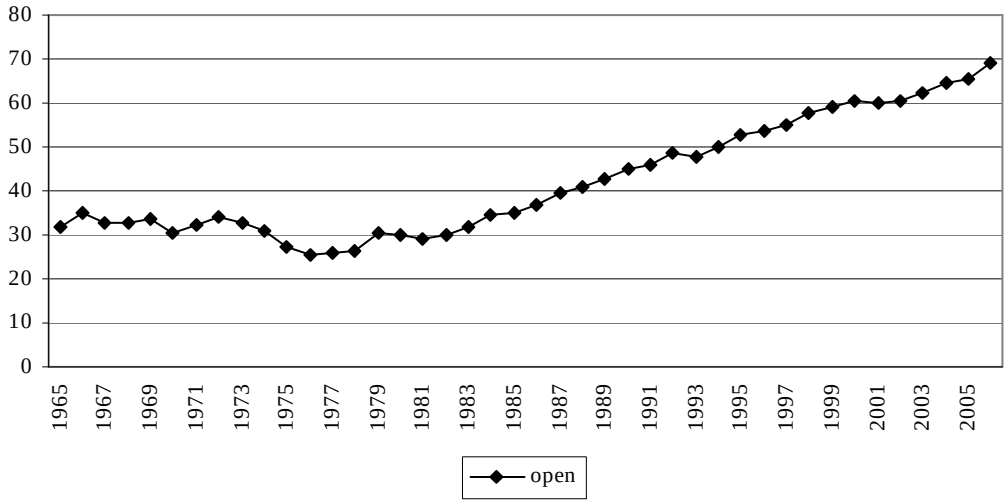


Data source: Heston et al. (2009).

The degree of openness (*open*) is given by the ratio of external trade over GDP and **Figure 5.7** clearly demonstrates that till the beginning of the 1980's the Portuguese

economy remained relatively closed, with this indicator fluctuating around 30%. Since 1983, the economy develops strong trade relations with the rest of the world and especially with the European countries, reaching a degree of openness of nearly 70% in 2006. Trade openness and the degree of liberalisation are important factors to explain growth, given the impact they may have on capital accumulation, through the transfer of knowledge and technology. Additionally, trade openness offers new exports' opportunities and the possibility to explore economies of scale due to market size.

Figure 5.7. Degree of openness (*open*), 1965-2006.



Data source: Heston et al. (2009).

In the following section we present the structural model to estimate and for that, we take into consideration the variables described above, as well as the interaction between them, to ascertain whether they are able to generate a cumulative causation growth process in the Portuguese economy, in the period from 1965 to 2006.

5.4. THE STRUCTURAL MODEL

The model that we suggest is derived from the cumulative causation growth theory and the technology gap hypothesis and is formed by the following equations:[96]

$$y_t = a_1 + a_2 x_t + a_3 y_{t-1} \quad \text{(export-led growth)} \quad \textbf{(5.1)}$$

$$x_t = b_1 + b_2 z_t + b_3 p_t + b_4 pm_t \quad \text{(growth of exports)} \quad \textbf{(5.2)}$$

$$p_t = c_1 + c_2 w_t + c_3 prod_t \quad \text{(growth of domestic prices)} \quad \textbf{(5.3)}$$

$$prod_t = d_1 + d_2 y_t + d_3 gap_{t-1} + d_4 (I/O)_{t-1} \quad \text{(growth of productivity)} \quad \textbf{(5.4)}$$

$$(I/O)_t = e_1 + e_2 y_t + e_3 open_t + e_4 (I/O)_{t-1} \quad \text{(investment-output ratio)} \quad \textbf{(5.5)}$$

Equation (5.1) reflects the idea that export growth (*x*) is the most potent element of demand inducing faster domestic growth (*y*), the well known export-led growth hypothesis (Dixon and Thirlwall, 1975). Exports are the autonomous component of demand with the highest multiplier effects on growth (the Hicksian super-multiplier) and enable the growth of induced investment and consumption. Additionally, the lagged domestic income growth is introduced, being consistent with the partial adjustment mechanism. All parameters are expected to be positive in this equation.

Equation (5.2) defines the main determinants of export growth. The explanatory variables are standard: the growth of external demand (*z*), approximated by the growth of the OECD countries; the growth of domestic prices (*p*) and that of import prices (*pm*), capturing the non-price and price competitiveness of exports, respectively. It is expected that the growth of external demand influences the growth of the country's exports positively. The growth of domestic prices is expected to affect export growth negatively, whereas the growth of import prices - reflecting the price competitiveness of foreign competitors - is expected to have a positive impact on the Portuguese export growth.

96 All variables in the system are expressed in growth rates, except *gap*, *(I/O)* and *open*, which are ratios.

The formation of domestic prices is explained by equation (5.3).[97] The formation of domestic prices is explained by an identity given by 1 plus the mark-up on unit labour costs, and in our model we assume a constant mark-up. Hence, the growth of domestic prices is explained by the growth of money wages (nominal compensation per employee) and the growth of domestic productivity. Defining in this way the determinants of domestic prices we are consistent with the view that to be competitive in external markets the growth of money wages must not exceed the growth of labour productivity and this is in line with Kaldor's idea of efficiency-wages. Therefore, it is expected that money wages influence positively the growth of domestic prices (wage cost driven inflation) and that gains in productivity contribute to reduce domestic prices.

Equation (5.4) is an augmented version of "Verdoorn's Law", which relates labour productivity growth (*prod*) to the domestic output growth (*y*). The Verdoorn's coefficient is assumed to capture the increasing returns properties associated with technical progress, innovation and R&D activities.[98] In this equation we add the investment-output ratio (*I/O*), like Léon-Ledesma (2002),[99] essentially because growth in productivity also depends on the capacity of the economy to invest in physical capital, like machinery, equipments and infrastructure networks. Depending on the kind of investment, the ratio may reflect the embodied technical progress. The productivity gap variable (*gap*) aims at capturing any possibility for convergence or catching-up, given that it is an opportunity for the lagging country to adopt better technologies (Amable, 1993). Therefore, productivity in Portugal is expected to grow faster since it is a laggard country relatively to the *USA*. We intend to verify whether the relative backwardness in terms of technology (captured by labour productivity)[100] is relevant to explain the productivity growth through the caching-up effect. We expect all coefficients in this equation to be positive.

It was Abramovitz (1986) that first introduced the idea of technological gap[101] between the more and the less developed economies, which in turn is not *per se* a sufficient condition for the latter to catch-up with the former in terms of income per

97 Export prices are a proxy for domestic prices. We alternatively used the growth rate of price deflator GDP as a proxy for domestic prices, but no reasonable results were obtained.

98 For more details see Kaldor (1975).

99 But contrary to Léon-Ledesma (2002), we consider the investment-output ratio as endogenous.

100 Castellacci (2002) used the relative ratio of R&D expenditures on GDP as a proxy for technological gap (see **Table 5.1**).

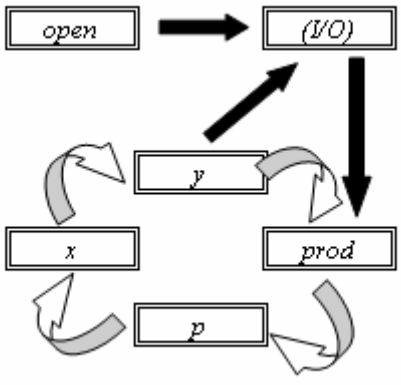
101 For a broader discussion about the technology gap literature, see for instance, Castellacci (2002).

head or per worker. For that to be feasible the "social capability" of the economy, related to institutional, educational and social characteristics, has to be taken into account. It is the existence of these two pre-conditions – technological gap and "social capability" – that determines the possibility for an economy to catch-up. The potentiality to catch-up depends on conditions related to the diffusion of knowledge, the rate of structural changes, capital accumulation and the expansion of demand.

The last equation (5.5) explains the capital accumulation process approximated by the investment-output ratio (*I/O*) and it is assumed to be endogenous, since it is a by-product of production and not a cause for it (Kaldor, 1975). The investment-output ratio is primarily explained by the growth of output (*y*), and this is consistent with the accelerator theory. The degree of openness (*open*) is used as an additional factor to explain physical capital accumulation aiming to capture the technology diffusion mechanism and new investment opportunities through trade. Higher trade is important for the diffusion process facilitating the free movement of knowledge and technology with positive effects on investment. Since investment adjusts partially to its equilibrium level the lagged investment ratio is used to measure the adjustment process, being consistent with the partial adjustment mechanism.[102]

The basic idea of the model is that exports are the engine of growth inducing a virtuous process of domestic growth with cumulative characteristics. **Figure 5.8** depicts the functioning of the circular and cumulative mechanism and elucidates the causal relationships between the variables.

Figure 5.8. The circular and cumulative mechanism



Data source: Author's elaboration.

102 In a preliminary work we included the patents ratio (proxy for innovation) as an explanatory factor of the investment-output ratio, but no satisfactory results were accomplished.

If for any reason the growth of exports (*x*) increases, it will affect positively the growth of domestic output (*y*) - through equation (5.1) - which in turn will increase productivity (*prod*) - the Verdoorn's effect through equation (5.4) - turning domestic prices more favourable - through equation (5.3) - and exports more competitive in international markets - equation (5.2). Exports will increase further inducing faster growth of domestic output, and the whole process restarts operating in a cumulative way with expanding tendencies. The increase in productivity is responsible for the cumulative tendencies of the process leading to a sustainable expansion of domestic output through higher exports. Productivity growth can also increase by higher accumulation of physical capital *(I/O)* embodying technical progress – equation (5.4). Our model allows the accumulation of physical capital to be affected by more intensive trade (*open*), probably through the technology diffusion mechanism - equation (5.5). Growth of domestic output, exports, domestic prices and productivity, and also capital accumulation are endogenous to the system and they have to be determined simultaneously.

5.5. EMPIRICAL RESULTS

The method used for estimating the five relations of the system simultaneously is *3SLS (Three-Stage Least Squares)* as it is more efficient to capture the interrelation between equations and the causal and feedback effects between the variables.[103] **Table 5.3** provides the estimation results where simultaneity is dealt with by using instrumental variables. Domestic output growth, export growth, domestic prices growth, productivity growth and the investment-output ratio are assumed to be endogenous, and all the other variables of the system are exogenous, serving as instruments.

The obtained results show that this system of structural equations is adequate for explaining the economic performance of Portugal over the 1965-2006 period. The goodness of fit is reasonable and the joint significance of all coefficients is highly confirmed, in general terms. Further attempts to improve the results of the export equation (5.2) by introducing some extra explanatory variables, such as the patents ratio (proxy for innovation), the investment-output ratio (proxy for capital accumulation) whether current or lagged or the enrolment ratio in secondary education (proxy for human capital) were not successful in finding a better fit and statistical significance for these factors. [104]

The first equation of the system expressing the export-led growth hypothesis is robust, showing a strong relation between output growth and export growth. A lagged dependent variable was introduced, to be consistent with the partial adjustment mechanism. The short-run impact with respect to exports is 0.361 and the long-run, 0.515,[105] revealing the potentiality of exports as the engine of growth. The speed of adjustment of the actual growth difference towards the desired growth is quite fast, implying that 70% of this difference is realised within a year.

103 For more details on the *3SLS* method, see for instance, AlDakhil (1998) and Wooldridge (2002).

104 Additionally, estimations of the system were run with modified variables, smoothed by the Hodrick-Prescott filter, and alternatively by the moving-average. Also, estimations with stationary variables were carried out. The idea was to avoid short-run cyclical influences and biases of the estimates. However, no reasonable outcomes were obtained and the idea of working with modified data was abandoned.

105 The long-run impact is given by: 0.361/(1-0.299)=0.515.

Table 5.3. The *3SLS* estimation of the cumulative growth model, 1965-2006.

	Coefficient	Std Error	t-stat	p-value	R^2	F-stat	p-value
Export-led growth			(Dependent variable: y_t)				
x_t	0.361	0.083	4.35	0.000***	0.119	13.30	0.000
y_{t-1}	0.299	0.110	2.71	0.007***			
constant	0.325	0.788	0.41	0.681			
Growth of exports			(Dependent variable: x_t)				
z_t	3.034	0.650	4.67	0.000***	0.2953	8.14	0.000
p_t	0.035	0.211	0.17	0.869			
pm_t	-0.087	0.122	-0.71	0.476			
Constant	-3.268	2.854	-1.14	0.254			
Growth of domestic prices			(Dependent variable: p_t)				
w_t	0.735	0.073	10.11	0.000***	0.6543	51.52	0.000
$prod_t$	-0.128	0.294	-0.44	0.664			
Constant	0.427	1.501	0.28	0.776			
Growth of productivity			(Dependent variable: $prod_t$)				
y_t	0.695	0.119	5.85	0.000***	0.8164	44.99	0.000
gap_{t-1}	0.098	0.043	2.26	0.025**			
$(I/O)_{t-1}$	-0.058	0.046	-1.26	0.210			
Constant	-2.955	2.827	-1.05	0.297			
Investment-output ratio			(Dependent variable: $(I/O)_t$)				
y_t	0.490	0.146	3.35	0.001***	0.7814	46.44	0.000
$open_t$	0.105	0.031	3.37	0.001***			
$(I/O)_{t-1}$	0.689	0.090	7.63	0.000***			
Constant	3.354	2.579	1.30	0.195			

Notes:

Endogenous variables: y_t, x_t, p_t, $prod_t$, $(I/O)_t$.
Exogenous variables: y_{t-1}, z_t, pm_t, w_t, gap_{t-1}, $(I/O)_{t-1}$, $open_t$.

* Coefficient significant at the 10% level;** Coefficient significant at the 5% level; *** Coefficient significant at the 1% level.

The export equation also gives interesting insights. The impact of foreign demand on exports growth is high, showing that a 1 percentage point (p.p.) increase in external demand (approximated by the growth of OECD countries) implies a 3.03 p.p. increase in the Portuguese exports (everything else constant). Portuguese exports are quite elastic with respect to external demand, having the advantage of growing faster in periods of world expansion. That advantage will only become effective if the county is able to increase exports non-price competitiveness, associated with supply

characteristics like quality, design, product differentiation, high embodied technology and efficient promotion. The high income-elasticity with respect to exports can be a drawback for Portugal in case world demand is declining.

In the same equation it is shown that exports are not sensitive with respect to price changes. The impact of domestic prices growth on the demand for exports is positive, an unexpected result,[106] but it is statistically insignificant. Similarly, the impact of foreign prices (approximated by the growth of import prices) is negative, contrary to what would be expected, but once again, it is not statistically significant.[107] Moreover, not only the impact of prices on exports is insignificant, but the size of the impact is very small (close to zero) in comparison to that of external demand.

This is important evidence revealing that what matters in international trade is non-price competitiveness captured by the income-elasticity of the demand for exports which in turn is determined by the supply characteristics mentioned earlier.

The third equation explains the growth of domestic prices mainly by two factors: the growth of money wages (approximated by the growth of nominal compensation per employee) and the growth of labour productivity. In this way we are in line with Kaldor's idea of efficiency-wages as the relevant element for the formation of domestic prices, in order to turn the economy more competitive. Our results reveal some interesting insights with respect to these variables. It is shown that money wages have a positive and statistically significant impact on domestic prices implying that 1 p.p. increase in the former is responsible for a 0.7 p.p. increase in the latter.

This evidence is in accord with the wage-cost push inflation hypothesis. On the other hand, the growth of productivity has its expected negative impact on the growth of domestic prices but it is not statistically significant. This is a disappointing result signifying that gains in productivity are not transmitted to prices to turn the economy more competitive. As we have seen in **Figure 5.4**, productivity growth is declining towards zero over time and money wages grow faster than productivity. Therefore, efficiency-wages growth is high and this does not help to improve price

106 The (unexpected) positive impact of relative prices on exports was also found by Bairam (1988) for Portugal, during 1970-1985. Antunes and Soukiazis (2009 a) also found a positive impact of relative prices on exports, for Portugal during 1965-2008. However, the magnitude of the impact is very low when compared to that of income.

107 We opted to separate the impacts of domestic and import prices growth in equation (5.2) instead of using relative prices growth (the difference between the two variables). The reason is that we assume domestic price growth as endogenous and import prices growth as exogenous. Thus, the consideration of relative prices would make this distinction difficult.

competitiveness. We detect here a structural problem of the Portuguese economy that can be responsible for the interruption of the cumulative causation process of growth, thus not allowing the economy to grow faster.

The fourth equation of the system explains the growth of domestic productivity based on "Verdoorn's Law". According to this Law, the growth of productivity is explained by the growth of output and this relation captures the static and dynamic increasing returns to scale related to technical progress, innovation and R&D activities. Our results from **Table 5.3** show that the growth of output is substantial for explaining productivity growth implying that every 1 p.p. increase in the former is responsible for a 0.7 p.p. increase in the latter. On the other hand, the potentiality for a catching-up effect in productivity levels is confirmed by the positive impact of the productivity gap (lagged one period) on productivity growth. In fact, the distance between the follower (Portugal) and the leader (the USA) in terms of productivity levels is an opportunity for the backward country to imitate and disseminate the advanced foreign technologies. This is in line with Abramovitz's idea of "social capability" in order to catch-up with the leader. The investment-output ratio aiming to capture capital accumulation is also introduced in the productivity equation but its impact is not statistically significant and carries a wrong negative sign. Léon-Ledesma (2002) argues that it is not uncommon to find a negative and/or a statistically insignificant impact of investment-output ratio and that may be explained by the existent correlation between the domestic output growth and the investment-output ratio.

The last equation explains capital accumulation. Similarly to the output growth regression - equation (5.1) -, the investment-output ratio follows a partial adjustment mechanism but this time with a relatively slow speed of adjustment. About 31.1% of the difference between the actual investment ratio and its desired level is realised within the same period. The investment-output ratio is highly explained by internal and external demand conditions given by the growth of domestic output and the degree of openness, respectively. The short-run impact with respect to domestic output growth is 0.49 and in the long-run is even higher – 1.56 – and this is consistent with the accelerator principle. The strength of domestic demand is essential for inducing higher investment. The short-run effect with respect to the degree of openness is 0.105 and the long-run, 0.34, revealing that the internationalisation of the economy is responsible for enhancing higher investment accumulation.

We also regressed each of the equations individually, by *2SLS*, with all the exogenous variables used as instruments, like previously. The intention was to carry out some diagnostic tests to justify the robustness of our results. The outcomes are reported in **Table 5.4** in the Appendix II.

In general terms, the estimated parameters and their significance do not change when compared to the results from **Table 5.3**. However, there are two exceptions: in the export equation the signs of domestic prices *p* and import prices *pm* are now correct, although they still remain statistically insignificant; the investment-output ratio (*I/O*) still has a negative impact on productivity growth but now it is statistically significant at the 5% level.

We performed four diagnostic tests. The first is the Sargan statistic, a test of over-identifying restrictions to check the validity of the instruments used in the regressions and that hypothesis is confirmed in all cases. The second is the Pagan-Hall heteroscedasticity test, showing that only in the third equation the hypothesis of homoscedasticity is rejected at the 5% significance level but not at the 1% level. The third test is the Cumby-Huizinga test for autocorrelation. The null hypothesis is that errors are not first-order autocorrelated and this is confirmed in all cases (in equation (5.3) at the 1% significance level but not at the 5% level). The last one is a normality test, conceptually similar to the Jarque-Bera skewness and kurtosis test. The null hypothesis is that residuals from a given regression are normally distributed, and this hypothesis is not rejected in all equations (at the 5% significance level for equations (5.1) and (5.5) and at the 1% level for equation (5.2)).

Given these outcomes and combining the information from **Tables 5.3** and **5.4**, we can assert that our structural model is robust. However, the cumulative causation growth process cannot be confirmed completely since the linkages which turn this process sustainable may be broken in three main points: (i) the investment-output ratio aiming to capture capital accumulation does not significantly affect productivity growth; (ii) the impact of productivity on domestic prices is not relevant, thus preventing the economy from becoming more competitive; (iii) the role of prices on exports is not significant as well, and consequently it does not act as an additional factor for increasing exports competitiveness.

Therefore, we detected some structural setbacks on the Portuguese economy and two of the failing links are related to productivity growth. The lack of a significant impact of *(I/O)* on productivity growth prevents the country from achieving faster

growth rates, enabled by trade openness and technology diffusion that affect capital accumulation. This can also help to explain the declining productivity growth over time observed in **Figure 5.3.** Taking into account that money wages grow faster relatively to labour productivity, domestic prices absorb increasing wage costs, preventing the economy from being competitive in terms of prices. The drawback here is explained by the failure in transmitting productivity gains to domestic prices competitiveness.

5.6. CONCLUSION

This study aims to explain the growth process of the Portuguese economy since the 1960's by estimating a multi-equation structural model. The basic idea of the model focuses on the cumulative causation principle of the demand-orientated approach, where exports are a crucial element for the growth process.

The structural equations of the model are jointly estimated by *3SLS* to capture the causal and feedback effects of the endogenous variables of the system. The results confirm the validity of the cumulative causation principle as a useful instrument for describing the Portuguese reality from 1965 to 2006.

Our evidence suggests that the export-led growth equation follows a partial adjustment mechanism with a fast speed of adjustment, with exports having a significant impact on the growth of domestic output, which is consistent with the foreign trade multiplier of the Hicksian type.

The most important determinant of exports is the expansion of external demand. This is a competitive advantage for Portugal signifying that exports can grow faster than the growth of external demand and, therefore, attaining faster growth rates of domestic output through the foreign trade multiplier. However, this high dependence on external demand can be harmful to the Portuguese economy in case of an international recession.

The growth of money wages is the major factor contributing to the increase of domestic prices in Portugal and productivity growth gains do not affect domestic prices to turn the economy more competitive. In fact, this evidence has been pointed out as the main structural problem of the Portuguese economy explaining the moderate growth performance especially in the last decade.

Productivity growth is highly explained by the growth of domestic output, and this relation captures substantial returns to scale according to "Verdoorn's Law". The positive effect of the productivity gap on the growth of domestic productivity can be taken as evidence of catching-up or "social capability" implying some kind of knowledge and technology diffusion, as had been stressed by Abramovitz.

The investment-output ratio also follows a partial adjustment process with a slow speed of adjustment. The growth of domestic output has the major impact on capital accumulation and this is in line with the accelerator principle. The degree of internationalisation of the economy (through openness) is also important for capital

accumulation. Competing in international markets implies higher investment in physical capital, which embodies new technology.

The aim of estimating the model was to show that the relations involved are responsible for generating a cumulative causation growth with self-expanding tendencies. In our study it is shown that the cumulative causation process can be broken in some points that prevent the economy from growing faster. The main failure is found in the productivity equation, explained by the irrelevance of capital accumulation to enhance faster productivity growth. Another concern is about the formation of domestic prices, where productivity is shown to be inappropriate to improve price competitiveness. A third failure is on the export growth, where prices do not matter to improve exports competitiveness. Therefore, there are essential links in the cumulative process that fail to generate higher growth in Portugal. In terms of economic policy, measures are needed to remove these obstacles that prevent the economy from growing faster and most of all policies are required to increase labour productivity.

APPENDIX I

Description of the variables and data sources

- *y* – annual growth rate of real GDP - GDP at 1995 (2000) market prices (national currency; annual percentage change).

- *x* – annual growth rate of real exports - Exports of goods and services at 1995 (2000) prices (national currency; annual percentage change).

- *pm* – annual growth rate of import prices - Price deflator imports of goods and services (national currency; annual percentage change).

- *p* – annual growth rate of price deflator GDP at market prices (national currency; annual percentage change).

- *prod* – annual growth rate of labour productivity – GDP at 1995 (2000) market prices per person employed (annual percentage change).

- *w* – nominal compensation per employee - total economy (national currency; annual percentage change).

- *wr* – real compensation per employee; GDP deflator - total economy (national currency; annual percentage change).

Data on *y, x, pm, p, prod, w* and *wr* were taken from European Commission (2002; 2009). Constant values are at 1995 prices (for 1965-1980) and 2000 prices (for 1981-2006), depending on the Statistical Annex from which they were obtained (2002 and 2009, respectively).

- *gap* – technological gap, given by one minus the ratio between the level of labour productivity in Portugal over that of the USA. Labour productivity is given by real GDP Laspeyres2 per worker (2005 constant prices).

- *(I/O)* – investment-output ratio, given by the investment share of real GDP (2005 constant prices).

- *open* – degree of openness, given by the ratio of the real external trade (exports plus imports) over real GDP (2005 constant prices).

Data on labour productivity (to compute *gap*), *(I/O)* and *open* were taken from Heston et al. (2009).

- *z* - annual growth rate of real foreign income (OECD countries).

1965–1994: GDP at the price levels and exchange rates of 2000 (billions of US dollars) – OECD (2006 b).

1995-2006: Real GDP (% change from previous year) – OECD (2009).

APPENDIX II

Table 5.4. The *2SLS* estimation of each equation of the cumulative growth model, 1965-2006.

	Coefficient	Std. Error	t-stat	p-value	Sargan statistic	Heteroscedasticity test	AR(1) test	Normality test
Export-led growth								
x_t	0.298	0.093	3.22	0.003***	χ^2_5=7.832	χ^2_7=9.492	χ^2_1=0.0716	χ^2_2=5.30
y_{t-1}	0.400	0.138	2.89	0.006***	p-value=0.1657	p-value=0.2193	p-value=0.7890	p-value=0.0707
Constant	0.326	0.863	0.38	0.708				
Growth of exports								
z_t	2.947	0.817	3.61	0.001***	χ^2_4=3.118	χ^2_7=9.175	χ^2_1=1.8090	χ^2_2=9.20
p_t	-0.132	0.310	-0.42	0.674	p-value=0.5382	p-value=0.2403	p-value=0.1786	p-value=0.0101
pm_t	0.090	0.175	0.52	0.609				
Constant	-2.880	3.794	-0.76	0.452				
Growth of domestic prices								
w_t	0.726	0.111	6.55	0.000***	χ^2_5= 2.364	χ^2_7=15.850	χ^2_1=4.4853	χ^2_2=3.16
$prod_t$	-0.295	0.229	-1.29	0.204	p-value=0.7969	p-value=0.0265	p-value=0.0342	p-value=0.2064
Constant	1.110	1.051	1.06	0.297				
Growth of productivity								
y_t	0.716	0.130	5.48	0.000***	χ^2_4=2.431	χ^2_7=8.860	χ^2_1=0.1697	χ^2_2=1.96
gap_{t-1}	0.070	0.049	1.43	0.160	p-value=0.6571	p-value=0.2629	p-value=0.6804	p-value=0.3753
$(I/O)_{t-1}$	-0.108	0.051	-2.12	0.041**				
Constant	0.091	3.179	0.03	0.977				
Investment-output ratio								
y_t	0.463	0.166	2.79	0.008***	χ^2_4=6.858	χ^2_7=10.304	χ^2_1=1.4897	χ^2_2=5.92
$open_t$	0.106	0.033	3.18	0.003***	p-value=0.1436	p-value=0.1720	p-value=0.2223	p-value=0.0517
$(I/O)_{t-1}$	0.649	0.112	5.78	0.000***				
Constant	4.651	2.871	1.62	0.113				

Notes:

Equations (5.2) and (5.5) were estimated with the *bw(auto)* option. Therefore, the automatic bandwith selection procedure of Newey and West is chosen, with the default Bartlett kernel. The estimates are efficient for homoscedasticity and the statistics are robust to autocorrelation.

Equation (5.3) was estimated with the *bw(auto)* and *robust* options, thus requesting HAC standard errors that are robust to both arbitrary heteroscedasticity and arbitrary autocorrelation. In this case, we have robust standard errors and the Hansen-J statistic instead of the Sargan statistic.

* Coefficient significant at the 10% level;** Coefficient significant at the 5% level; *** Coefficient significant at the 1% level.

FINAL CONCLUSIONS

The main scope of this study was to show how relevant are foreign trade and human capital for the process of economic growth and, most importantly, to find the links between them and economic growth. For this reason we carried out an empirical analysis focusing firstly on the growth process across countries and later, on Portugal. Foreign trade and its interaction with human capital had not been considered in a systematic way in the empirical literature before, especially at the regional level. The balance-of-payments constraint hypothesis had been ignored in the neoclassical growth literature and an attempt was made in this study to introduce this factor into the neoclassical growth approach, bringing together supply and demand forces, at the empirical level. The export-led growth theory was used specifically to explain the growth performance of the Portuguese economy as a whole. A cumulative causation growth model was also considered to detect important linkages between the main forces that explain the growth process in Portugal. These are the main contributions of this study to the growth literature.

In the first Chapter a more general analysis involving different sets of countries (World, high-, middle- and low-income countries, Europe, OECD and EMU countries) was adopted, for the period 1980-2000. The main aim was to ascertain whether human capital and external trade were relevant factors for explaining growth. For that, four proxies were considered for human capital: the average years of schooling of adult population, the publication rate, the patents rate and the patents/articles ratio to control for scientific production and innovation capacity. Also, two different proxies were used for foreign trade, the degree of openness and the net foreign balance as a percentage of GDP, to determine the impact of foreign trade on a country's domestic growth and perceive whether these factors influenced the growth process among countries. Additionally, interaction terms between the degree of openness and human capital were considered, to check the existence of technology diffusion among countries.

The general conclusion of the Chapter was that both human capital and foreign trade were relevant factors for growth, but the appropriate proxies to use differed according to the set of countries considered. Moreover, the interaction terms used between openness and human capital proved to be relevant for explaining growth in the sample of countries of Europe and OECD, giving evidence of the existence of technology diffusion among these sets of advanced countries characterised by a higher degree of integration.

In Chapter 2 we focused on the growth of the EU countries. With this sample we were able to extend the analysis till 2004 and most importantly, to include the income-elasticity ratio of foreign trade in the growth equation. This was an attempt to verify how reasonable it was to include demand forces associated with competitiveness into the standard supply-orientated neoclassical growth model.

The regression analysis showed that the inclusion of human capital and external trade and the use of interaction terms between them had a significant impact on growth. Most importantly, it was shown that the combination of external demand (through the income-elasticity ratio of foreign trade) with openness affects growth, constituting therefore an important impediment when balance-of-payments problems occur. Depending on the combination of the variables used, the constraining factor to growth may either come from foreign trade, human capital or both.

Chapter 3 proceeded with a regional growth analysis at the NUTS3 level, for Portugal over the period 1996-2005. To our knowledge regional studies had not considered systematically the importance of foreign trade on regional growth, and this was the contribution of our study. Bearing in mind the data limitations at the regional level, we were able to show that factors associated with external trade, human capital and the share of sectoral employment were relevant to explain regional growth and convergence in Portugal. Our evidence also showed that the dichotomy between the *Littoral* and the *Interior* areas was important for explaining growth, revealing different potentialities. The regions of the *Littoral* are richer, more open and more dynamic in the exports sector, contributing substantially to the economic growth of the whole country.

In Chapter 4, we presented an alternative approach based on the balance-of-payments constraint hypothesis to explain growth performance in Portugal for the 1965-2008 period. “Thirlwall’s Law”, given by the ratio of exports growth over the income-elasticity of demand for imports was used to predict actual growth in Portugal. Despite the limiting assumptions that relative prices were constant in the long-term and capital flows were absent from the analysis, it was shown that “Thirlwall’s Law” accurately predicted actual growth in Portugal for the whole period, the pre-accession and post-accession periods and also across various overlapping periods. To implement “Thirlwall’s Law”, the income-elasticity of the demand for imports was obtained from the estimation of the imports demand function assuming that domestic income growth was endogenous. This elasticity was obtained not only for the whole period but also for

the various overlapping periods and the McCombie test was performed, validating the Law in almost every case.

Our results revealed that Portugal grew slightly higher than the OECD countries in the entire period and this was consistent with our findings that the income-elasticity of the demand for exports exceeded that of imports. Portugal also grew slightly faster than the rate consistent with the balance-of-payments equilibrium, accumulating external deficits over time. Dividing the sample in the pre- and post-accession periods to the EU, it was shown that Portugal grew at a slower rate in the latter, and this was consistent with a lower export growth and a higher income-elasticity with respect to imports in this period. To overcome this problem, policies are needed to improve the supply characteristics of exports related to non-price competitiveness (captured by the income-elasticities of foreign trade) and reduce the imports sensitivity with respect to domestic income changes.

Chapter 5 employed a simultaneous equation system with cumulative causation characteristics. The intention was to detect the interrelated growth forces that generated a growth process with expanding virtuous tendencies, for the Portuguese economy during the 1965-2006 period. The model was formed by five equations, referring to domestic income growth, export growth, domestic prices growth, productivity growth and the investment-output ratio. The intention was to analyse this circular and cumulative mechanism which included a productivity gap to measure Portugal's backwardness relatively to the leader (the USA). The estimation of the model by *3SLS* revealed the existence of some drawbacks of the Portuguese economy that prevent it from growing faster over the analysed period. First of all, capital accumulation does not influence significantly productivity growth. In the second place, productivity growth is declining over time and exerts no significant impact on the formation of domestic prices. Prices are mainly determined by the growth of nominal wages and gains in productivity are not transmitted to domestic prices in a way to turn the economy more competitive. Finally, prices do not contribute substantially to improve exports competitiveness. Portuguese exports are highly dependent on external demand conditions and when external demand is declining it seriously affects Portuguese growth. Thus, exports performance is mainly determined by foreign demand and this relation is captured by the income-elasticities of the demand for exports.

The general conclusion of the study is that foreign trade and its interaction with human capital are important factors for explaining economic growth not only at the

country level but also at the regional level. Growth can be constrained by human capital qualifications and foreign trade performance. Therefore, policies should be developed to turn the economies more competitive in the internal and external markets, together with policies to improve human capital qualifications and to promote innovative activities.

Although our intention was to give some answers regarding the growth process, namely in what concerns the impact of foreign trade, its interaction with human capital and the relevance of the balance-of-payments constraint hypothesis, some important issues are still uncovered. The inclusion of capital flows and a more disaggregated analysis with respect to foreign trade is needed, to identify the sectors with higher income-elasticities of demand in international markets. Another issue that can also be addressed is the introduction of internal constraints into the growth model, related to public deficit and public debt. This topic presents great relevance recently, especially for the EMU countries. These are reasonable lines of investigation for further research in the future.

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