Micaela Antunes* and Elias Soukiazis


DISCUSSION PAPER Nº 51
(APRIL, 2009)

(*) Financial support from FCT is gratefully acknowledged (SFRH/BD/27693/2006)

Micaela Antunes and Elias Soukiazis
Faculty of Economics, University of Coimbra, Portugal

Abstract

The neoclassical growth theory does not attribute any special importance to external demand as a constraint to growth. When an external shock occurs, it is the price system that adjusts to bring the economy back to equilibrium. The Keynesian approach emphasizes that demand forces, especially external demand through exports, are the key factors determining growth and that external demand can constrain growth. In this paper an attempt is made to introduce the balance of payments constraint hypothesis into the neoclassical growth model. To test the relevance of the balance of payments constraint hypothesis on growth a sample of 14 EU countries is selected and the empirical analysis spans from 1980 to 2004 were relevant data is available. The reason to select this specific sample is to verify whether balance of payments problems are important even for countries that implement common policies and experience a high degree of economic integration.

A panel data growth model is estimated using different proxies for human capital and foreign trade. Average years of schooling, as well as publication, patents and a combined patents/articles ratio, are used to capture different levels of human capital and 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 external competitiveness on growth.

The regression analysis shows that the inclusion of human capital and external trade and the use of interaction terms between them have significant effects on growth and most importantly that the combination of external demand with foreign trade affects growth, constituting therefore an important impediment when balance of payments problems occur. Depending on the combination of variables used the constraining factor to growth may either be foreign trade, human capital or both.

JEL code: O47, F43, C23

Keywords: growth, human capital, trade competitiveness, income-elasticities of foreign trade and balance of payments constraint

Author for correspondence: Elias Soukiazis, Faculty of Economics, University of Coimbra, Av. Dias da Silva, 165, 3004-512 Coimbra, Portugal, Tel: +351239790534, Fax: +351239790514, e-mail: elias@fe.uc.pt
1. Introduction

The role of international trade for a country’s growth performance has been widely discussed by economists, especially due to the different paths of economic growth observed for several industrialized countries from the 1950s onwards.

It is possible to distinguish two main theories explaining the international trade impact on economic growth, namely the supply-orientated approach associated to the neoclassical theory of growth and the demand-orientated approach associated to the Keynesian perspective. The former does not present a formal theory for the possible impact of the balance of payments on a country’s growth performance, but the general idea is that the accumulation of 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 the equilibrium. Contrary to this supply-orientated approach stands the Keynesian view, asserting that it is demand that guides the economic system (especially external demand) and supply simply adapts to it, within certain limits. Demand is able to generate its own supply by encouraging investment, absorbing underemployment and raising productivity growth, among others. The well known export-led growth hypothesis\(^1\) is part of this demand-orientated approach, assessing that exports are the engine of growth. The denominated new theory of endogenous growth attributing a special role to human capital tries to reduce the differences between the two main views but essentially remains a supply – orientated approach and most importantly, does not take into account that growth can be constrained by external demand.\(^2\)

The aim of this paper is to introduce factors related to external trade and external demand into the growth model and test empirically their relevance on growth. The above variables can be combined with different proxies of human capital and alternative interaction terms to check their validity on growth. In doing so we try to specify a more complete growth equation that takes explicitly into account the strength of external demand and find how the latter interacts with different levels of human capital and

\(^2\)Although Romer (1986) and Lucas (1988) point the positive effects of international trade on growth, Rodriguez and Rodrik (2000) question the sign and the significance of such impact.
foreign trade measures. These are the main aspects that distinguish this paper from previous studies. To our knowledge, growth models of the Barro’s type have not taken into consideration the balance of payments constraint hypothesis.

The 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 percentage of GDP). The income-elasticity ratio of foreign trade (capturing non-price competitiveness) is the key factor of the balance of payments constraint hypothesis derived from the well-known “Thirlwall’s law”.

Moreover, the variables related to human capital are the average years of schooling of adult population capturing basic levels of human capital qualifications, the publication rate as a measure of 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, aiming to measure the ability of transforming scientific production into innovation.

The paper is organized by the following sections: apart from the Introduction, section 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 and the variables used in the estimation approach are explained in section 3. The empirical results obtained from the panel data regressions are analysed and discussed in the following section. The final section concludes the main findings.

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 (1992; 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 the diminishing returns of physical capital as it was assumed by 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, technical progress and innovation are found
to be some of the most important determinants of growth, among others with lower relative importance such as institutions, trade, financial markets, political stability, and so on. Economies converge to different steady-states of per capita income characterized by the above conditioning factors.

The role of human capital and technology on growth

Endogenous growth models may be grouped in two main streams: one, closer to the neoclassical perspective, giving emphasis to the accumulation of a broader concept of capital not subject to decreasing returns and the other, underlining 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 wider version of capital formed not only by physical but also by human capital is considered an input in the production function (Lucas, 1988; Mankiw et al., 1992). Human capital has, in this context, the usual meaning: it shows the ability and skills of labour force and it is measured 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 comprises models focusing 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 (in developed countries) or imitation activities (resulting from technology transfers to the less-developed countries), constituting a crucial factor in the “social capability” of countries to adopt foreign technology (Abramovitz, 1986; Benhabib and Spiegel, 2003).

Although in principle a better-educated and well-trained workforce exerts a positive effect on growth, outcomes 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, due to the consideration of the temporal dimension (Islam, 1995). In fact, the empirical evidence concerning the impact of human capital is mixed (Söderbom and Teal, 2003), which may be due to the use of poor proxies (Mankiw et al., 1992) or just reflect the need to follow in a different direction regarding human capital in the framework of the production function.
Our paper purposes four main variables to capture different levels of human capital: the average years of schooling reflecting basic levels of human capital qualifications; the publication rate as a measure of 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 aiming to measure the ability to transform scientific production into innovation. It is expected that higher levels of human capital related to scientific production and innovation differentiate more properly the steady-states of the EU countries in the growth equation.

**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 input factors - labour, a broader concept of capital and total factor productivity. Although, according to this approach, different growth rates are explained by differences in factor supplies and productivity, it is not made clear why the growth of factor supplies may vary among countries. Additionally, under 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.

Under 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 (in current account) matters for the long-term growth. According to Thirlwall, a balance of payments deficit can constrain domestic demand and retard growth. He established a simple rule that determines the rate of growth of domestic output consistent with the balance of payments equilibrium. This rule (known as “Thirwall’s law”) asserts that a country’s balance of payments equilibrium growth rate is given by the ratio of exports growth over the income-elasticity of demand for imports. Thirlwall has shown that his growth rule is equivalent to the Harrod foreign trade multiplier when it is expressed in a
dynamic form. Assuming that relative prices remain constant in the long-run, the model can be described as follows:

The rate of growth of the demand for imports is given by the following expression:

\[ m_t = \pi y_t \quad (1) \]

where \( m_t \) denotes the growth of imports, \( y_t \) is the growth of domestic income, and \( \pi \) is the income-elasticity of demand for imports. Accordingly, the demand for imports is positively related to domestic income and the magnitude of the impact is given by the income-elasticity of imports. Analogically, the demand for exports growth rate is given by:

\[ x_t = \varepsilon z_t \quad (2) \]

where \( x_t \) stands for the growth of exports, \( z_t \) is the growth of foreign income and \( \varepsilon \) is the income-elasticity of demand for exports. Therefore, the demand for a country’s exports is positively related to foreign income and the magnitude of the impact is given by the income-elasticity of exports.

The model assumes that the balance of payments is in equilibrium from the point of view of the current account. This implies that the value of exports of goods and services is equal to the value of imports expressed in a common currency and in constant prices. The equilibrium condition in balance of payments with variables expressed in growth rates is therefore given by:

\[ x_t = m_t \quad (3) \]

Substituting equations (1) and (2) into the balance of payments equilibrium condition (3) and solving for domestic income we get:

\[ y_{BP,t} = \frac{\varepsilon(z)_t}{\pi} \quad (4a) \quad \text{or} \quad y_{BP,t} = \frac{x_t}{\pi} \quad (4b)^4 \]

Equation (4a) determines the rate of growth of domestic income consistent with the balance of payments equilibrium (in current account), denoted by \( y_{BP,t} \). This relation stresses the positive impact of the growing external demand \((z_t)\) and the inverse impact of higher import penetration on the growth of domestic income. Equation (4b) is known

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3 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.
4 \( \varepsilon(z)_t \) is equivalent to \( x_t \) as it is shown in equation (2).
as “Thirlwall’s law” or the dynamic Harrod’s foreign trade multiplier. Equation (4a) can alternatively be written as:

\[
\frac{y_{BP,t}}{z_t} = \frac{\varepsilon}{\pi}
\]  

This new expression determines a country’s relative growth rate with respect to the rest of the world (or a group of other countries) 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 be growing faster than the rest of the world (\( y_{BP,t} / z_t \)) as far 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 (\( \varepsilon / \pi \)) can be used as reflecting the balance of payments constraint hypothesis. Considering the case where \( \pi > \varepsilon \) signifying that imports penetration in domestic market is higher than exports penetration in external markets, “Thirwall’s law” predicts that the country will be constrained by external demand in the long-run and will thus grow at a lower rate than the rest of the world.

In this paper, apart from the balance of payments constraint factor (\( \varepsilon / \pi \)) some other aspects related to trade will be considered in the growth equation, like the degree of openness, very relevant for the EU countries to express trade intensification and the net foreign balance to express trade competitiveness.

Indirect effects of international trade have also been found in the empirical literature, explaining 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

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5 The income-elasticity ratio with respect to exports (\( \varepsilon \)) and imports (\( \pi \)) captures the non-price characteristics of the goods produced and traded associated to quality, design, durability, confidence, innovation, marketing and distribution efficiency, known as the supply characteristics.
and technological diffusion are pointed out as additional channels to growth through trade (Grossman and Helpman, 1991, Coe et al., 1997; Vamvakidis, 1998; Yanikkaya, 2003; Di Liberto, 2005).

3. Historical evidence and the variables used in the model

Our sample consists of a set of 14 EU members\(^6\) and the time spans from 1980 to 2004. The reason to select this specific sample is to assert whether the balance of payments constraint hypothesis (through the comparison of the income-elasticity of demand for exports and imports) and the degree of openness are important determinants of growth in this set of countries, characterized by a high degree of economic integration implying free trade, free factor mobility and 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 to non-price competitiveness, thus requiring structural (and not financial) policies to be solved. Persistent trade imbalances will affect the long-run economic performance retarding growth and increasing 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 relatively to imports (\(e/\pi\))) to test its impact on growth.\(^7\)

Since our interest lays 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)\(^8\) over this period. These historical evidences are given in Table 1 and illustrated in Charts 1 and 2, respectively.

[Insert Table 1 around here]

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\(^6\) The set is constituted by Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal, Spain, Sweden and the UK.

\(^7\) A detailed description of the variables and data sources is provided in the Appendix.

\(^8\) The terms net foreign balance and net foreign trade will be used indifferently and refer to net exports of goods and services.
As Table 1 shows, the degree of openness increased substantially from 1980 to 2004 in all countries revealing trade intensification. Ranking the countries in descending order with respect to year 1980, the highest rates are those from Belgium (104.4), the Netherlands (77.7), Ireland (65.1) and Austria (57.5). Only Belgium presents a ratio higher than 100%. The top-down countries are France, Italy, Greece and Spain (all bellow 32%). In 2004 Ireland appears in the 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 now 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 are those of Italy, Austria, the UK and Belgium. The degree of openness of the EU average has doubled within the period, from 47% to 94%.

With respect to net foreign balance, only four countries registered a surplus in 1980 – the UK, Demark, Spain and Italy. In contrast, in 2004 eight countries registered a positive net trade – Ireland, Sweden, Finland, the Netherlands, Denmark, Germany, Belgium and Austria. On the other hand, Italy and France report negative but close to zero net trade. It can also be seen that Greece, Italy, Portugal, Spain and the UK deteriorated their trade performance in the period considered. This is an interesting result showing that the southern countries of the EU, as being less competitive, did not benefit much from the free single market, compensated instead, as it is known, by large transfers in the form of structural funds. As for the UK, the explanation also lays on competitiveness and structural problems regarding the balance of payments performance\(^9\). As a whole, the EU average passes from a deficit in 1980 to a surplus of 2% in 2004. Thus, during the interval between 1980 and 2004 some relevant changes have occurred both in the openness degree and the trade balance in the core of the EU countries that have to be taken into consideration in the growth process.

In Chart 3 it is possible to analyse how the income-elasticity ratio with respect to exports and imports \((\varepsilon/\pi)\) performs over the five-year intervals, from 1976 to 2004.

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\(^9\) For a detailed analysis of the balance of payments problems in the UK, see Thirlwall and Gibson (1992).
As it can be observed, Ireland is the only country where the ratio is always higher than one, showing that exports penetration is higher in foreign markets than imports penetration in domestic market. Another interpretation 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”, this country has the advantage to grow relatively faster without incurring balance of payments problems. The experience of the remaining countries is mixed, with the income-elasticity ratio varying across countries and over the time-intervals considered. In general, the higher the income-elasticity ratio of foreign trade the higher the country’s growth rate is expected to be, with a privileged value higher than one showing that a country has the ability to grow faster relatively to other trade partners.

Moreover, as Chart 3 shows, there are five records of negative income-elasticity ratios, contradicting the conventional trade theory. Those cases may be explained by various special circumstances that took place in some countries during certain periods: Finland (1991-1995) due to the collapse of the former USSR being its principal trade partner; Germany (1991-1995) because of the costs of the unification process; Greece (1981-1985) due to adaptation problems in the first years of its adhesion to the former EEC and its low competitiveness; Italy (2001-2004) due to recent lack of growth and political instability; and Portugal (1981-1985) because of the sever problem of external debt payment and the restrictive measures imposed by the IMF in that period. All these states of affairs affected seriously external competitiveness, creating balance of payments problems that reflected in the growth performance of these countries.

These preliminary findings on foreign trade performance justify our interest in measuring the impact of these variables on economic growth. For this purpose, a general specification of the “Barro regression” will be considered. 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 $s$, different levels of human capital $HC$, and some measures related to foreign trade $FT$. 
Four different proxies are used to account for different levels of human capital: average years of education of the population aged 25-64 \((educ)\)^{10} aiming to capture the basic level of education (Arnold et al., 2007); the articles ratio \((art)\) defined as the number of papers published per country’s million inhabitants aged 25 or over, as a proxy for scientific production; the patents ratio \((pat)\) defined as the number of patents per country’s million inhabitants aged 25 or over, aiming to capture higher levels of human capital associated to research and development activities; and a combined ratio \((pat/art)\) revealing a country’s ability to transform scientific research into innovation (Soukiazis and Cravo, 2008). Our growth equation considers as foreign trade variables the degree of openness \((op)\) and the net foreign balance \((nfb)\)^{11} to account for the impact of international trade on growth. The income-elasticity ratio with respect to exports and imports \((\varepsilon/\pi)\) is also included in the regression to highlight the balance of payments constraint hypothesis.

Taking into consideration the discussion presented in the previous section about the role of human capital and foreign trade on growth we expect them to have a positive impact. The annual population growth rate is expected to have a negative impact on economic growth (although a positive but not statistically significant effect is also plausible), since the available capital must be spread more thinly over the working age population. Physical capital is considered to positively influence the rate of growth of output, due to its impact on the steady-state level of output per capita and hence on the growth of output - the neoclassical view - or to spillover effects and economies of scale - the endogenous growth approach (Economidou et al., 2006).

The inclusion of the income-elasticity ratio in the growth regression is an attempt to insert the export-led growth hypothesis of the demand-orientated approach into the endogenous growth model. It is expected that this ratio shows a positive effect on growth, since the increase in the ratio due to a higher income-elasticity of the demand for exports \((\varepsilon)\) relatively to the income-elasticity of the demand for imports \((\pi)\) puts an economy in a more favourable position in terms of competitiveness regarding the rest of the world. Finally, interaction terms are also included in the growth regression.^{12}

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10 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.

11 Net foreign balance \((nfb)\) is not expressed in logarithms because of negative values for some observations.

12 The exogeneity of interaction terms was tested through Difference-in-Hansen tests.
Several hypotheses were alternatively tested, namely, the interaction between foreign trade and human capital variables or between the income-elasticity ratio and the foreign trade measures or the human capital proxies (no reasonable results emerged, though, from the last attempt). If the \((\varepsilon/\pi)\) ratio appears as an important factor in the growth equation for the set of the EU countries (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 panel data regressions explained in the following section.

4. Empirical evidence from growth regressions

The dynamic panel data specification is the most suitable approach for analysing growth dynamics taking into account country-specific effects. The estimation method most commonly applied to dynamic equations with panel data and a lagged dependent variable is GMM (Generalised Method of Moments), using 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 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 includes not only lagged levels but also lagged differences as instruments, this time in the levels equation (Arellano and Bover, 1995; Blundell and Bond, 1998).

In the present study, proper outcomes are found either using difference or system GMM, with the former method appearing more times in the tables. The reason may be that given that we are in the presence of a short panel, the use of lagged levels as instruments enables the maximization of the sample size. Moreover, estimators using instruments in levels have much smaller variances and are thus recommended (Baltagi, 2005).

The reported results are the most efficient ones accomplished and those that succeeded in the diagnostic tests of over-identification and absence of second order serial correlation of error terms in differenced form. In the meantime we report the number of instruments used in all estimations. Whenever it was necessary, lags length was reduced and the instruments were collapsed, thus reducing the size of the instruments matrix.
small samples the collapse option is extremely useful because it prevents the number of instruments from exceeding the number of units (countries) and the consequent bias that emerges from there (Roodman, 2006).

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 the following:

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

with \( v_{i,t} = \alpha_i + u_{i,t} \)

(6)

where \( \alpha_i \) refers to country-specific effects, like 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 (\( i=1, \ldots, 14 \)) and \( t \) to time (\( t=1985, \ldots, 2004 \)). Yearly time spans are considered too short for studying growth, since short-term disturbances may appear large in short-term intervals (Islam, 1995). Thus, we opted for five-year time-intervals, benefiting from the fact that error terms are less correlated than in a yearly basis.

The dependent variable is the annual growth rate of per capita income in five-year intervals. The growth regressions can be adapted to consider each of the four human capital proxies separately, combined alternatively with the international trade variables. Under this procedure, the most plausible outcomes are presented in Table 2. The proxies for human capital (\( HC \)) used are the average years of schooling of 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 openness degree (\( op \)), the net foreign balance (\( nfb \)) and the income-elasticity ratio with respect to exports and imports (\( \varepsilon/\pi \)) that reflects (non-price) competitiveness and illustrates the strength of demand on growth.

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13 The regressions were run in Stata.
14 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 Economou et al. (2006).
15 A four-year interval is considered in 2001-2004, due to lack of data.
16 No reasonable results emerged from its inclusion in the regression.
As a preliminary note, we want to clarify that the lagged per capita income ($y_{i,t-5}$), the annual growth rate of population ($n_{i,t}$)\textsuperscript{17} and the investment ratio ($s_{i,t}$) are common to all growth regressions ran. As for the remaining variables, we tested their relevance assuming alternative combinations between the human capital and foreign trade proxies.

[Insert Table 2 around here]

In column 1 of Table 2, the combination of the patents/articles ratio (capturing the ability to transform scientific work into innovation) with the openness degree 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 expected. Our results thus show that higher trade intensification and higher innovation capability are beneficial for inducing higher economic growth in the EU countries. With respect to the innovation proxy, our results confirm the idea that higher levels of human capital are more appropriate to differentiate the steady-states of countries with higher levels of development. On the other hand, the coefficient of the lagged per capita income is negative confirming the hypothesis of conditional convergence and the impact of the investment ratio on growth equations is positive as expected, both statistically significant at the 1% level.

Moreover, no other human capital proxy performed better when it was combined with the openness variable, in terms of statistical significance. On the other hand, 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). In addition, it was not possible to combine the net foreign balance with any of the four human capital proxies in the growth regression (in the four versions of the GMM method), but in every case, when human capital was excluded the results improved and the remaining coefficients presented their expected signs and statistical significance.\textsuperscript{18}

Column 2, apart from the convergence factor, the investment ratio and the annual growth rate of population, includes in the growth regression the average years of

\textsuperscript{17} To the annual population growth rate $n_{i,t}$ we added $(g+\delta)=0.05$, with $g$ the rate of technological progress and $\delta$ the rate of capital (human and physical) depreciation, equal across countries and through time. For more details on this issue, see Islam(1995).

\textsuperscript{18} These results are not reported here but are available by the authors upon request.
education \((educ)\) as the human capital proxy, together with the openness degree \((op)\) and an exogenous interaction term between the last two. The impact of human capital on growth is positive as long as the openness degree is higher than 31.8%.\(^{19}\) Countries that lay behind this cut-off point must take precautions regarding economic growth: France (1980), Greece (1980; 1985), Italy (1980) and Spain (1980; 1985). Conversely, the impact of openness is also positive only if the average years of education remains superior to 6.6 (and that does not happen only once, for Spain, in 1980). 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 is transferred through trade which can only be absorbed and developed by higher levels of education.

The knowledge/technology diffusion hypothesis is reinforced in column 3, where higher levels of human capital efficiency expressed by the patents/articles ratio and the openness degree are considered. Both factors have a positive impact on growth as expected and are statistically significant (the patents/article ratio only at 10%). Reasonable results are also obtained from the interaction between the income-elasticity ratio \((\epsilon/\pi)\) and the openness factor. This specification intends to investigate whether the impact of foreign trade on growth depends on the economy’s relative position regarding (non-price) competitiveness towards the rest of the world and \textit{vice-versa}. Our evidence suggests that the impact of the income-elasticity ratio on growth is expected to be positive whenever the trade intensity ratio is higher than 38%, which does not happen for 15 times, over our sample: France (1980, 1985, 1990), Germany (1980), Greece (1980, 1985, 1990), Italy (1980, 1985), Portugal (1980), Spain (1980, 1985, 1990) and the UK (1980, 1985). In fact, trade intensification and economic competitiveness are important determinants for growth.

\textbf{Table 3} reports alternative panel regressions using exogenous interaction terms whose results become reasonable after removing the variables with coefficients displaying no statistical significance.

\[\text{[Insert Table 3 around here]}\]

\(^{19}\) The cut-off point is given by: \(\exp (0.5272/0.1524) = \exp (3.459) = 31.8.\)
The two first columns of Table 3 display the outcomes from the combination of the patents ratio with the openness degree and the corresponding interaction term. As foreign trade does not appear individually significant it is removed from the growth regression and the results improve. Once more, the interaction between trade intensification and higher levels of human capital associated to innovation appear to be relevant for growth. The general conclusions are similar, whether two-step system (column 1) or one-step difference GMM (column 2) is run. In the former, the impact of innovation activities on growth is expected to be positive as long as the openness degree 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 affects significantly the pattern of growth.

Columns 3 and 4 of Table 3 show that when trade (through openness) is linked to even higher levels of human capital given by the patents/articles ratio, the results are more reasonable. The difference between the two regressions lays in the estimation method (two-step system in column 3 and two-step difference in column 4). In both cases the impact of openness on growth is always positive, because the condition over the patents/articles ratio is always attained. Following this, the impact of foreign trade on growth of the EU countries during the period considered is always the desired, since human capital does not constitute a limitation for 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 3 report significant evidence from the link between trade (through openness) and non-price competitiveness given by the ratio of the income-elasticity of exports and imports. It is shown that the impact of the income-elasticity ratio on growth is positive whenever the openness degree remains higher than 56% (column 5) or 51% (column 6). This is also an interesting result suggesting the importance of competitiveness on growth when trade intensification occurs. Since the income-elasticity ratio captures the non-price competitiveness and it is a crucial parameter to the export-led growth and the balance of payments constraint hypotheses, our results highlight the relevance of these factors on growth.

Generally, the panel 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 kind of connection between human capital qualifications and trade performance. Another issue arising from the regression analysis is that balance of payments problems reflected in low competitiveness may be harmful for growth and the impact depends on the degree of openness.

5. Final conclusions

We have argued in this paper that the neoclassical approach to growth does not attribute a special role to foreign trade, and most importantly, that the supply-orientated view (including both the neoclassical and endogenous growth approaches) does not consider that foreign trade imbalances can 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 the 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 growth and the foreign trade imbalances as a serious impediment to growth.

In this paper an attempt is made to reconcile these two views by introducing into the growth model factors related to foreign trade - and explicitly the balance of payments constraint hypothesis – to test their relevance. A more complete model of growth is estimated by using different proxies of human capital and foreign trade to differentiate more properly the EU countries. Interaction terms have also been used to detect important links between human capital and foreign trade, and also between (non-price) competitiveness and trade intensification.

The empirical analysis estimates growth equations by using a panel data approach for a set of the early European Union members, over the period 1980-2004. Our empirical results are encouraging, showing that human capital (especially higher levels) and foreign trade (mostly through openness) or the interactions between them are important determinants to growth. Important links are detected 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. The constraining element to growth may either be foreign trade, human capital, or both. Conditional convergence is found between the EU countries, being reinforced when human capital, foreign trade and (non-price) competitiveness are controlled for in the growth model.
Appendix

Description of the variables and data sources

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

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

- $educ_{i,t}$ is 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 authors 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 authors, subtracting from 100 the consumption, investment and government shares of RGDPL - percentage in 2000 constant prices.
• $n_i g + \delta$, the annual average growth rate of population, was computed by the authors from the population figures, to which was added 0.05 for the rate of technical progress plus capital depreciation as usually is assumed in growth empirical studies.

• $(\varepsilon/\pi)_{i,t}$ is the income-elasticity ratio of demand for exports and imports. The elasticity was computed by the authors from the definition, using the first difference of the logarithm of the variable of interest to compute the corresponding annual growth rate. The annual average 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)
Table 1. Openness degree and net foreign balance for the EU countries, 1980 and 2004

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
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<tr>
<td>Austria</td>
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<td>-2.964</td>
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<tr>
<td>Belgium</td>
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<td>173.987</td>
<td>-1.403</td>
<td>4.204</td>
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<tr>
<td>Denmark</td>
<td>48.588</td>
<td>94.516</td>
<td>1.804</td>
<td>4.686</td>
</tr>
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<td>Finland</td>
<td>42.668</td>
<td>77.906</td>
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<td>9.126</td>
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<td>France</td>
<td>31.622</td>
<td>57.467</td>
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<td>Germany</td>
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<td>-2.277</td>
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<td>Greece</td>
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<td>54.260</td>
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<td>-10.060</td>
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<td>176.668</td>
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<td>18.047</td>
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<td>54.526</td>
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</tr>
<tr>
<td>Netherlands</td>
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<td>146.847</td>
<td>-1.101</td>
<td>6.757</td>
</tr>
<tr>
<td>Portugal</td>
<td>35.612</td>
<td>79.891</td>
<td>-3.081</td>
<td>-9.959</td>
</tr>
<tr>
<td>Spain</td>
<td>21.463</td>
<td>65.119</td>
<td>1.751</td>
<td>-6.578</td>
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<td>Sweden</td>
<td>44.977</td>
<td>88.911</td>
<td>-2.647</td>
<td>10.391</td>
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<td>UK</td>
<td>34.819</td>
<td>59.906</td>
<td>2.499</td>
<td>-4.630</td>
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<td>EU Average</td>
<td>46.888</td>
<td>93.537</td>
<td>-1.265</td>
<td>2.088</td>
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</tbody>
</table>

Note on Table 1 and Charts 1 and 2: Source of the data is Heston et al. (2006). For description of variables, see Appendix A.

Chart 1. Openness degree for the EU countries, 1980 and 2004
Chart 2. Net foreign balance for the EU countries, 1980 and 2004

Net foreign balance

Chart 3. Income-elasticity ratio ($\varepsilon/\pi$) over five- (four-) year intervals, from 1976 to 2004

Income-elasticity ratio
Table 2. Panel data growth regressions for the EU countries (14), 1980-2004

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
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</thead>
<tbody>
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<td>(\ln(y_{i,t}))</td>
<td>-0.1423***</td>
<td>-0.1638***</td>
<td>-0.1412***</td>
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<td></td>
<td>(-5.29)</td>
<td>(-4.99)</td>
<td>(-4.76)</td>
</tr>
<tr>
<td>(\ln(n_{i,t}+g+\delta))</td>
<td>0.1071</td>
<td>0.1087</td>
<td>-0.0452</td>
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<td></td>
<td>(1.36)</td>
<td>(0.91)</td>
<td>(-0.41)</td>
</tr>
<tr>
<td>(\ln(s_{i,t}))</td>
<td>0.0865***</td>
<td>0.1118***</td>
<td>0.0944***</td>
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<tr>
<td></td>
<td>(4.44)</td>
<td>(3.59)</td>
<td>(5.85)</td>
</tr>
<tr>
<td>(\ln(pat/art_{i,t}))</td>
<td>0.0426***</td>
<td>0.0341*</td>
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<tr>
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<td>(3.25)</td>
<td>(2.14)</td>
<td></td>
</tr>
<tr>
<td>(\ln(op_{i,t}))</td>
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<td>0.0596***</td>
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<tr>
<td></td>
<td>(4.64)</td>
<td>(-2.16)</td>
<td>(3.03)</td>
</tr>
<tr>
<td>(\ln(educ_{i,t}))</td>
<td>-0.5272**</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>(-2.52)</td>
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<td>(\ln(op_{i,t})*\ln(educ_{i,t}))</td>
<td>0.1524**</td>
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<tr>
<td></td>
<td>(2.76)</td>
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<td></td>
</tr>
<tr>
<td>(\epsilon_{i,t}/\pi_{i,t})</td>
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<td>(-1.98)</td>
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<tr>
<td>(\ln(op_{i,t})*(\epsilon_{i,t}/\pi_{i,t}))</td>
<td>0.0225**</td>
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<td></td>
<td>(2.18)</td>
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Observations 56 56 56
Number of countries 14 14 14
Number of instruments 10 11 13

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)".
The interaction term is exogenous.

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 is the Arellano and Bond test for 2nd order serial autocorrelation in first differences.
### Table 3. Panel data growth regressions for the EU countries (14), 1980-2004. Additional results.

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1)</th>
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<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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<tbody>
<tr>
<td>$\ln(y_{i,t})$</td>
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<td>$-0.1353^{***}$</td>
<td>$-0.0889^{***}$</td>
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<td>($-5.78$)</td>
<td>($-3.16$)</td>
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<td>$\ln(n_{i,t}+g+\delta)$</td>
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<td>($-1.88$)</td>
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<tr>
<td>$\ln(s_{i,t})$</td>
<td>0.1104***</td>
<td>0.1229***</td>
<td>0.0952***</td>
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<td>(3.64)</td>
<td>(3.66)</td>
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<tr>
<td>$\ln(pat_{i,t})$</td>
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<td>0.0149**</td>
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<td>(9.24)</td>
<td>(3.64)</td>
<td>(3.66)</td>
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<td>Hansen J-test</td>
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<td>AR2</td>
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<td>0.126</td>
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<tr>
<td>p-value</td>
<td>0.393</td>
<td>0.598</td>
<td>0.212</td>
<td>0.900</td>
<td>0.111</td>
<td>0.314</td>
</tr>
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</table>

**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 1.
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