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Intermediate goods imports, policy and growth. A simple theoretical model

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ABSTRACT

The adoption of state of the art techniques implemented already in more advanced countries through intermediate goods imports appears as one potential channel whereby developing countries may catch up with leader countries and grow. In order to explore this idea, this paper analyzes the behavior over time of an economy in terms of growth under alternative scenarios using the baseline model of Romer (1990). In the first regime (autarky, as represented by high distortions to the introduction of foreign designs) the economy settles down in the long run in a steady state with no per capita growth, since there is no force that can offset diminishing returns to capital. The second scenario has fewer distortions to external transactions, thus favoring the purchasing of designs of advanced capital goods and inducing a continuous flow of new varieties of durables into the economy. The arrival of these goods, in turn, generates endogenous growth in the developing country. The key feature that enables the transition from autarky to openness is an exogenous policy shock that removes some of the barriers that impeded the access of the domestic agents to technology produced elsewhere.

Key words: growth, technological diffusion, developing countries, openness.

Importaciones de bienes intermedios, política económica y crecimiento. Un modelo económico sencillo.

RESUMEN

Uno de los canales mediante los cuales los países en desarrollo pueden alcanzar a los más avanzados y crecer es la adopción de nueva tecnología mediante la importación de bienes intermedios. Este trabajo parte de esta idea y analiza el crecimiento de una economía en dos escenarios alternativos, en el marco del modelo de Romer (1990). En el primero (autarquía), existen grandes trabas a la introducción de diseños extranjeros; a largo plazo la economía se establece en un estado estacionario con crecimiento cero. El segundo es un escenario más abierto, ya que se caracteriza por distorsiones menores a la importación de tecnología extranjera, lo que a su vez favorece la entrada de bienes intermedios e induce un flujo continuo de nuevas variedades de capital en el país. La llegada de estos bienes genera crecimiento endógeno en este escenario. El rasgo que favorece la transición de la autarquía al régimen abierto es un shock exógeno de política económica que suprime algunas de las barreras que impedían el acceso de los agentes a la tecnología foránea.

Palabras clave: crecimiento, difusión tecnológica, países en desarrollo, apertura.

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1. INTRODUCTION

The literature on growth has experienced remarkable buoyancy since the mid 1980s, entailing a progressive identification, at the theoretical and empirical levels, of those factors that promote or damage growth. Although economists still have a long way to pursue in order to get a deeper picture of the causes underlying economic growth, we know much more about the determinants of growth now than we did 30 years ago[1].

One of the issues that have received more attention is the connection between openness and growth[2]. The impact of globalization on economic welfare has been – and is still - a hot point of debate in the political and economic arena.

The issue is very wide and complex. First, the notion of openness encompasses many different aspects: trade, attraction of Foreign Direct Investment (FDI), capital account liberalization, economic integration and so forth. Second, the potential reverse causality between openness and growth adds an additional difficulty to both the empirical and theoretical analysis of these concepts.

Finally, openness and growth may be related to yet another notion, technological diffusion. In effect, there is a branch of the literature on growth (Rivera Batiz and Romer, 1991; Grossman and Helpman, 1991; Lee, 1995; Barro and Sala-i-Martin, 1997) that argues that technology – another difficult variable to measure and quantify – may be generated in more advanced countries and diffused to those countries that have more difficulties to innovate (notably LDC) through trade, in particular via imports of capital goods.

This paper intends to focus in this last aspect and analyze the effect of imports of capital goods in the growth performance of the importing country. Since the intensity of these flows may be dependent upon the economic policy prevalent in the country, the role of economic policy regarding this issue is also covered here.

The structure of this paper is as follows: Section 2 motivates the issue by discussing a case study and some related literature. Section 3 presents a model intended to provide a theoretical framework to some messages of the paper. Section 4 offers some concluding remarks.

2. MOTIVATION

This paper is motivated by two basic reasons.

First, the main ideas in this paper have been suggested by the observation of the Spanish performance over the last two centuries. Spain did benefit from some technological

[1] See Temple (1999) for a thorough survey.

[2] Extensive surveys on this issue can be found in Edwards (2002), Haveman *et al.*, (2001), and Proudman and Redding (1998).

innovations that entered slowly into the country during the end of the 19th century and the beginning of the 20th century, as telephones, trains or airplanes. But it took several decades for the country to access to leading edge phones, high speed trains or sophisticated airplanes. Thus, a crucial issue is why it took so long for Spain to catch up with other developed countries technologically. There are many potential causes: low endowments of human capital, either qualified (scientists and engineers) and unqualified (the rate of analphabetism in the country was very high), lack of a dynamic entrepreneurial class, political disorders, civil wars and corruption, and poor policy making, among others. What seems clear, despite the difficulties to identify the particular causes, is that Spain missed the great opportunities that the 19th century offered, in contrast to countries such as UK, Germany or France. In fact, Spain could be considered at the turn of the 20th century as an underdeveloped country. Now, instead, it belongs in the category of developed countries, it is among the first providers of FDI in Latin America (Bengoa, 2003) and its per capita income is expected to reach the average EU income in a few years.

Part of the explanation of the *Spanish miracle* is related to some particular episodes of liberalization. Those periods in which the country has grown more (and faster than other European countries) have been preceded by some kind of shock that has opened the country to external influences.

The first example is the Stabilization Plan of 1959. After two decades of autarky and isolation following the Spanish Civil War and the Second World War, Spanish policy makers implemented in 1959 a package of reforms, that basically covered three main aspects:

1. International trade liberalization, devaluation of the peseta and suppression of the system of multiple exchange rates.
2. A change in the orientation of monetary policy, that became more restrictive
3. Removal of regulations in some markets.

These reforms, in turn, facilitated in the following decades the imports of intermediate goods by Spanish firms, as well as the use of patents produced elsewhere, and allowed a period of rapid growth in the sixties, together with a modernization of the economy.

Although the immediate effect of the Stabilization Plan was a recession - according to Lieberman (1995), due a decrease in private investment motivated by the lack of confidence of entrepreneurs - the trend changed quickly. The rate of growth of GDP in 1960 was 1.58%, and it climbed to 12.82% in 1961,11.49% in 1962 and 10.21% in 1963. The average rate during the sixties was 8.17%, according to the same source (Table 1).

The causes behind this impressive performance have been analyzed and debated by economists and historians. Probably there is not a unique factor, but a myriad of reasons - some of them difficult to pin down by data, such as entrepreneurial spirit or human capital- underneath this growth miracle. Fuentes Quintana, for example, (1988) suggests that the “demonstration effect” of other Western Economies compelled and fostered Spaniards to improve their own per capita income.

What seems clear is that the bulk of the technology to which the Spanish firms had access to in those years was imported from abroad (Molero, 1983). As a consequence, the most dynamic sectors were those of intermediate goods, since they incorporated massively new technology, most of which was foreign (Carreras y Tafunell, 2005; Molero, 1983), and benefited from large gains in productivity. Eventually these gains were passed to the rest of the economy.

In fact, Lieberman (1995) points out to massive imports of foreign capital goods brought about by the Stabilization Plan as the principal vehicle of economic growth in the 60s. A longer historical perspective, together with more empirical analysis, is probably necessary to calibrate the importance of imports of capital goods in the Spanish process of development. At this point, nonetheless, it seems plausible to think that at least part of this performance is linked to the adoption of technology via imports, especially if we recall that, at that time, generation of new technology within Spanish firms or research centers was sparse.

The integration of Spain into the European Union in 1986 was the onset of another period of high growth and convergence. Finally, the joining of EMU by the country in January 1999, and the economic adjustment it implied, is probably part of the story behind the higher than the EU average rate of growth of Spain in the last few years.

The second motivation for this paper is a recent and very interesting line of research that intends to explain significant historical transformations, such as industrial revolutions and demographic transitions, within the background of growth models. Some of these articles stress the different rate of return of alternative technologies under various scenarios, arguing that a particular technology may not be profitable when the economy is in early stages of development, but its pay off can be worthwhile when the economy has changed sufficiently. Thus, the second technology (that in most cases generates endogenous growth) will be eventually adopted, allowing for growth in the country. Recent examples are Lucas (1998), Galor and Weil (2000), and Tamura (2002). In these papers the crucial factor favoring the transition is an increase in the rate of return of human capital.

Jones (2001) posits that the reason behind the shift from one technique to another is a change in the institutional framework, in the form of the apparition of legal protection to property rights and hence incentives to innovate. In Laitner (2000) the transformation of the productive structure of the economy is facilitated by sectoral reallocation, in turn favored by a demand shift from agricultural to manufactured products. Hansen and Prescott (2002) describe the industrial revolution as a transition from a land-intensive, Malthusian production technique to a modern technology that exhibits constant returns to scale in labor and capital[3]. Exogenous technological

[3] An interesting feature of this paper is that both technologies are available at all periods, although, depending on the degree of development of the economy, only the most profitable will be employed.

progress growing over time is the key variable that makes the second technology advantageous to adopt at a certain point of time.

All these articles stress the protagonist part played by factors that are, no doubt, relevant in explaining these phenomena (human capital, sectoral reallocation, a change in technology and in the institutional framework). Nonetheless, the role of economic policy in this kind of episodes has not been explored in detail to our knowledge. This paper, while recognizing the important role played by the aforementioned variables, intends to look more closely to the potential impact of economic policy as a facilitator or an obstacle to one of such transitions. Another difference of this paper with the above literature is that the model presented here stresses the role of an *exogenous* policy shock as the source of change from one scenario of no growth to another in which growth is possible.

A word of caution is in order here. Liberalization of foreign trade, in particular of imports, may have also some negative effects in the economy. Thus this paper does not intend to argue that liberalization of foreign trade is always and everywhere devoid of risks.

First, the apparition of imbalances related to dualism are possible. If the labor market is very rigid, it is possible that the gains obtained in the most dynamic sector do not spill over to the whole economy. Second, dependency of a country from others could lead conceivably to a underdeveloped sector of R+D. The question is if this strategy is sustainable over time for a long period; the answer is probably no, eventually the country will have to try to look for competitive advantages of their own. Unfortunately these aspects have not been traditionally covered by the mainstream growth literature[4] (Temple and Wöbmann, 2004).

3. THE MODEL

This section is intended to offer a theoretical framework of analysis that can be useful, not only to understand past episodes, but also to extract lessons and provide insights for the design of sound economic policy measures. The model discusses the performance of the economy under alternative regimes and argues that a policy shock that eases the transition from autarky to openness may allow an otherwise stagnant economy to grow at positive rates. The model is an extension of Romer (1990).

In his path-breaking paper, Romer (1986) had stressed the connection between technology and growth and showed that technology could arouse endogenously in a growth model and generate non zero, sustained growth in the steady state. The basic

[4] Dualism, however, has been analyzed in the context of the impact of FDI in host economies (Dascher, 2000).

intuition is the following: since technology is a fixed cost for the firm, the cost of a new discovery is diluted if it is divided into a larger number of units. Therefore innovations bring about non decreasing returns that can offset the decreasing returns present in physical capital. Romer (1986), however, did not describe in detail the way by which technology is generated.

This task, in turn, is accomplished in his 1990 paper. One important idea underlying the analysis in this last article is that technology is partially excludable by means of patents. These legal mechanisms warrant incentives to innovate. The main conclusion of Romer (1990) is that technology, understood as new varieties of capital goods, may generate endogenous, positive growth in the steady state.

This paper builds upon the Romer's (1990) model, with three main differences: first, and in order to match the experience of LDCs better, it allows for population growth in the first stages of development. Second, it introduces the role of policy by assuming an extra cost that must be incurred in order to obtain the patent. Third, it does not consider explicitly the R&D sector, since the interest is primarily in the imitator country. These adaptations allow us to grasp better the basic intuition of this model and the features of the transition from autarky to an open scenario.

The basic equations of Romer's (1990) model are described in Appendix 1.

3.1. Assumptions

3.1.1. Preferences

Preferences are assumed to be of the standard Ramsey (1928) type. Infinitely lived agents that maximize the present value of their intertemporal utility function [1] compose the economy.

$$u(0)=\int_0^\infty e^{-\rho t} u[c(t)] L(t) dt \quad [1]$$

$$\rho > 0$$

Where ρ is the discount rate, L(t) is the size of the family and c(t) per capita consumption.

Instantaneous utility function is assumed to be of the variety of Constant Relative Risk Aversion (CRRA) (equation 2).

$$u[c(t)]=\frac{c(t)^{1-\sigma}-1}{1-\sigma} \quad [2]$$

$$\sigma \in [0,\infty)$$

Where σ represents the relative risk aversion coefficient, and also the inverse of the intertemporal elasticity of substitution. To make the analysis tractable we assume that the utility function depends only of one consumption good, c.

Notice that this set up, while simple, does not rule out the (quite feasible) possibility of preferences changing over the transition, in particular when the country is opened up to foreign trade and ideas. For example, if agents were to become more concerned about welfare considerations as the standard of life rises, as it is the case in developed countries, this could be captured by a change (increase) in the parameter σ, or by transforming slightly the utility function, that would become u(c,g), g being some sort of welfare services provide by the state[5]. However, and in order to keep the analysis tractable, in this paper preferences will be supposed to remain the same over time.

Population growth is a piecewise function of the living standard (as in Kremer, 1993, and Hansen and Prescott, 2002). The living standard, in turn, is captured by the wage. The aim of the paper is not to explain a demographic transition; this last issue, while no doubt interesting, exceeds its scope. Hence, and to keep the analysis tractable, we shall posit a very simple pattern of population growth[6]. Since child raising is intensive in time, (especially in mothers' time), a relationship can be established between the number of desired offspring and the opportunity cost of time, as captured by the wage[7]. When wages are low the opportunity cost of bringing up a child is relatively smaller and fertility is high. When wages rise, especially for women, the opportunity cost of dropping from a job temporarily increases and fertility diminishes. It can be the case that the number of births equals the number of deaths and hence the rate of growth of population approaches zero[8]. A simple way to capture this idea is to establish a wage threshold or a reservation wage, w*, that determines the agents' willingness to raise children. This is a simplifying assumption but matches reality quite well[9]. Denoting by γ_L the rate of growth of population, population growth is thus defined as follows:

$$\gamma_L = n \quad for\ w < w^*$$
$$\gamma_L = 0 \quad for \quad w \geq w^*$$

To assume a constant rate of growth for population is a rather common modeling strategy in these kind of analysis. I leave for further research the complete endogeneization of the population growth.

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[5] See Sanchez-Robles (2002).

[6] More complex formulations would imply the explicit discussion of the time allocation between work and other activities, introducing another choice variable and a great deal of difficulty in the analysis. However, I do not dismiss the idea of pursuing this strategy in future research.

[7] This kind of analysis can be traced back to Becker and Barro (1988), Barro and Becker (1989), Becker, Murphy and Tamura (1990), and Galor and Weil (1993).

[8] As a matter of fact, population in Spain has been constant in the last two decades. Similar behaviors can be observed in other developed countries.

[9] Alternatively, we could assume that fertility is a decreasing function of the degree of development of the country, as measured by income. If the country is developed then women will have more access to the job market and fertility will be reduced.

Agents can lend and borrow in the financial markets at the interest rate prevailing in the economy, r. From now on we shall drop the subscript t in order to alleviate notation.

3.1.2.The production side

The economy produces two broad kinds of goods: final and intermediate. The final good, Y, is produced with the combination of labor and capital. Y is sold in competitive markets at a normalized price of 1 and can be used for direct consumption or invested.

Following Romer (1990), we can think of the capital stock as made up by the sum of the elements of a bounded sequence $\{x_i\}$, where each element of the sequence is a specific variety of intermediate goods or durable. Durables do not depreciate to make the analysis tractable[10]. The evolution of capital over time is thus given by equation 3.

$$\dot{K} = Y - c \quad [3]$$

Where a dot over a variable represents its derivative with respect to time.

The intermediate goods x_i enter in an additively separable fashion (they are neither perfect complements nor perfect substitutes among each other) into the aggregate production function (equation 4)

$$Y = AL^{1-\beta} \sum_{i=1}^{M} x_i^{\beta} \quad [4]$$

$$0 < \beta < 1$$

$$i = 1,2,3 \ldots M$$

Where i indexes the different types of durables in the economy, L is labor, β is the elasticity of input with respect to the durable and A captures the level of efficiency in the country in aspects not related to technology *stricto sensu*.

A is constant over time by assumption, since otherwise the model would not converge to a balanced growth path but could display explosive dynamics. It is true that, strictly speaking, changes in policy could conceivable have influence in this parameter, that would also become endogenous. In fact, this idea – the modeling of economic policy through changes in A - opens a new avenue for future research, but it is beyond the scope of this paper. Here it will be assumed that all relevant changes in policy are transmitted to the economy via a variation in the distortion τ.

The upper bound of the summation, M, reflects the number of varieties of intermediate goods available in the country. From the economic viewpoint, therefore, this limit is a

[10] This assumption is not inappropriate if we think of x as the flow of services associated to the use of that good.

measure of the degree of technological progress in the country[11]. Intuitively, Country A has a higher level of technology than B because A can employ steel, glass, cement and computers in the production of plants, whereas B can only use steel, glass and cement.

The economy is endowed with an initial amount of capital stock[12]. It is equivalent to assume that some designs have already been used and the correspondent intermediate goods have been produced, or that the durables have entered into the country in the form of capital goods.

Each intermediate good is produced in a monopolistic competition setting (as in Romer, 1990) by the owner of the correspondent design. The inputs in the production of the durable are the design and foregone output. One unit of output can be converted into one unit of durable at no cost.

Generally speaking, countries that are not at the technological frontier have in most cases an underdeveloped R+D sector and hence it is cheaper for them to imitate than to innovate. Hence it is plausible to assume that the monopolist purchases the design for the production of the i^{th} intermediate good from the technological leader at a fixed cost $\mu + \tau$, along the lines of Barro and Sala-i-Martin (1997).

We can think of different kinds of relationship between the follower and the leader country (or set of countries). A general and intuitive benchmark is to assume that the follower can imitate a certain number of intermediate goods that have already been produced in the leader country, thus profiting by means of a catch up mechanism from *the state of the art* technology. The set of durables available in the follower country will be a subset of the durables that have been already invented elsewhere by the leader or leader countries. Denoting by Λ the number of varieties of intermediate goods available at the technological frontier, then

$$M \leq \Lambda$$

A straightforward extension of this intuition is to assume that technological progress in the country of study, M, is proportional to technological progress in the leader country, Λ. More formally,

$$M = \varepsilon \Lambda$$

$$\varepsilon > 0$$

[11] Technological progress is captured in this model by an increase in the *variety* of goods available. Alternatively, it could be understood as an increase in the *quality* of the durables, along the lines of Aghion and Howitt (1992) and Grossman and Helpman (1991). Basic predictions of the model would remain unchanged.

[12] This assumption is necessary in order for the economy to be able to start operating, and it parallels the assumption $K_o > 0$ in a standard Ramsey setting. Anyhow, it is not unreasonable, as it is exemplified by the case of Spain. Spain did have trains, planes and ships at the beginning of 20[th] century. For the first half of the 20[th] century the number of intermediate goods available did not change dramatically. A radical change of the varieties available could be observed, however, after 1959.

If ε is less than one, then the imitator always lags behind the leader(s). Other possibilities should not be totally ruled out, though[13]. To come closer to the experience of LDCs, I shall just assume that ε is less than one and thus convergence is at most partial, ruling out overtaking phenomena.

Since the designs have been invented abroad, there is a component in the cost of the design, τ, related to the regime prevailing in the economy as regards the economic relations with other countries. In particular, we shall assume that if the economy is less (more) open the design will be more (less) expensive. If there are barriers to international flows, it will be more costly for the firms in the country to access the owner of the design and set the deal. We could also think of τ as a distortion in the currency market, or as a cost associated to the bureaucratic procedures needed to purchase the design. Alternatively, it might capture the effort necessary for an entrepreneur to travel abroad in order to set a deal for the use of a patent. As we see, this general setting can be adapted to different institutional environments.

3.2. Discussion of the model

As usual, the steady state will be defined as the long run dynamic equilibrium of the economy. More specifically, the steady state will be defined as a dynamic equilibrium such that: a) sequences of prices and quantities ensure that firms maximize profits, b) households maximize utility, and c) variables grow at constant rates.

a) In equilibrium the i^{th} incumbent firm chooses the optimal price and quantity of the durable such that maximizes profits (see Appendix 2,3). Since equilibrium price and quantity are the same for all varieties of intermediate goods, we can drop the subindex i without loose of generality.

Now, firms that are deciding whether to bring in or not a new intermediate good, will compare costs and profits associated to the introduction of that good. They will introduce the $M+1^{th}$ good if and only if they can break even the initial outlay. In other words, their decision rule is linked to equation 5 below:

$$V_{M+1} = \mu + \tau \quad [5]$$

Where V_{M+1} is the present discounted value of the amount of profits associated to the introduction of the M+1 variety of good. If the left-hand side of equation [5] is less than the right hand side, the good will not be introduced.

b) The maximization for consumers can be obtained as the solution of a standard optimal control problem. As it is well known, in models assuming Ramsey-type preferences

[13] Conceivably, the leader could be caught up or even overtaken by the follower (as in Brezis *et al.*, 1993). In other words, ε could be eventually equal or greater than one. Since this discussion is only relevant for convergence issues but it is not essential for the main point of the paper: i.e. the fact that the removal of the barriers to trade promotes growth, I shall not discuss the issue further.

the path of future consumption in the steady state can be expressed as a function of the parameters of the model, according to the following expression [6]:

$$\gamma_c = \frac{1}{\sigma}\left(r - \rho\right) \quad [6]$$

Where γ_c is the growth rate of consumption per capita.

c) L grows already at a constant rate by assumption. To ascertain the rate of growth of the rest of relevant variables, it is convenient to distinguish the two alternative scenarios.

3.2.1. Autarky.

Under autarky economic policy is inward oriented. High distortions that make the purchase of designs abroad more expensive (such as limited access to foreign currency, paperwork or financial constraints) pervade the economy. Denote by τ_1 the lump sum distortion associated to the entrance of a particular design. Under autarky τ_1 will be by assumption such that the present value of the M+1th good that a firm intends to bring into the country, is smaller than the lump sum cost of the design. Put it differently, condition [5] above can be rewritten as [7]. The design for the elaboration of the good will not be introduced since agents do not have incentives to produce and sell it.

$$V_{M+1} < \mu + \tau_1 \quad [7]$$

If no goods are introduced beyond the Mth variety, then the number of durables will be constant. Notice, however, that the equilibrium quantity of all the existing goods grows at the rate n (see equation [A3]).

Using the fact that the equilibrium quantity of the durables is x, K can be expressed as [8].

$$K = M \;\; x \quad [8]$$

Since M is constant under autarky, then the growth rate of K equals the growth rate of x, which is n.

To figure out the growth rate of output, it is convenient to use equation [8] to rewrite the production function [4] as:

$$Y = A \;\; M^{1-\beta} K^{\beta} L^{1-\beta} \quad [9]$$

Notice that the production function exhibits decreasing returns in each of the inputs K, M and L. It is homogeneous of degree one in K and L considered together, and also in K and M. Thus, the growth rate of output per capital will depend crucially on the growth rate of K, M, and L. Taking logs and differentiating with respect to time in [9] yields:

$$\gamma_Y = \beta \gamma_K + (1-\beta)n = n$$

Under autarky, therefore, output per capita, capital per capita and consumption per capita grow at a zero rate. Aggregate output and aggregate capital grow at the rate n. Since the introduction of new technology from abroad in the form of new varieties of intermediate goods is precluded by the inward orientated commercial policy, per capita variables stagnate.

Intuitively, in absence of changes in A, per capita growth could only come from an increase in the capital stock associated to the launch of a new variety of intermediate goods. But, because of the institutional framework, it is not possible to introduce and sell durables in such a way that they warrant positive profits to the monopolist. Since there are not available designs left in the economy to introduce new products, profits beyond the M^{th} type of good are zero, no new monopolists have incentives to operate in the economy and it settles down in a steady state characterized by no improvements in the level of welfare.

3.2.2. The open economy

Now let us suppose that the institutional framework changes because of a policy shock (for example, a political shift to a pro-market oriented government, as happened in the case of Spain in 1959) such that it is easier for agents to have access to ideas created elsewhere. This change is implemented through a reduction in the distortion from τ_1 to τ_2. Since the preferences' side is identical under both regimes, we shall only make explicit the assumptions on the production side of the economy.

Formally, the equilibrium condition for producers is now fulfilled with equality as in [10] and new varieties of good will enter into the country.

$$V = \mu + \tau_2 \quad [10]$$

The production function is now:

$$Y_2 = A \sum_{i=1}^{D} x_i^{\beta} L^{1-\beta} \quad [11]$$

$$0 < \beta < 1$$

$$M < D < \Lambda$$

$$i = 1,2,...D$$

Where i indexes again the different sorts of durables and the rest of arguments are as defined for equation [4].

The steady state of the economy is radically different from the one attained in the autarkic regime. As we shall see, endogenous growth is now feasible in the model. In effect, the entrance of the new varieties of durables into the economy at the rate γ_D entails an increase in the capital stock at that same rate.

Notice that population growth in this regime is zero and therefore x is constant in the steady state. Nonetheless, the capital stock at every point in time increases because a new variety of durable arrives into the country. K can be written now as:

$$K = D x$$

It follows that

$$\gamma_K = \gamma_D$$

The force that drives growth in the model is the entrance of new products at the rate γ_D. The rate of growth of output also equals the rate of growth of D. This property is due to the fact that the model is an AK model in D and K. To see this, we can rewrite the production function as equation [12]

$$Y = A \ D^{1-\beta} K^{\beta} L^{1-\beta} \quad [12]$$

It is straightforward to prove that

$$\gamma_K = \gamma_D = \gamma_Y$$

As usual, consumption grows at the same rate of output in the steady state (otherwise equation [3] would not be fulfilled).

Intuitively, output grows since the introduction of a new variety of intermediate goods increases the capital stock, offsetting its decreasing marginal productivity. At the same time, an increase in K raises the expected profit of another intermediate good, favoring the entrance of the new one. Hence K, D and Y grow at the same rate.

Finally, using [6], [A3] and [A4] the rate of growth in terms of the parameters of the model can be expressed as equation [13]

$$\gamma_c = \frac{1}{\sigma}\left(\frac{\pi}{\mu+\tau_2} - \rho\right) = \frac{1}{\sigma}\left[\left(\frac{1}{\beta} - 1\right)\frac{1}{\mu+\tau_2} \, A^{\frac{1}{1-\beta}} \, \beta^{\frac{2}{1-\beta}} - 1 - \rho\right] \quad [13]$$

The rate of growth under the open regime is higher than zero as long as the rate of return exceeds the rate of time preference plus 1. It is positively related to the rate of return of the intermediate good: i.e. increasing in the profit and decreasing in the cost of purchasing the design, μ. The connection between the distortion and the rate of growth is negative, as should be expected: higher tariffs mean that a smaller subset of the available designs will be imitated since the rest does not bring about new profits.

3.2.3. Transitional dynamics and convergence

Two main points will be mentioned briefly since a more careful exploration of them is left for future research.

During the transition the economy will experience a high period of growth. When the tariffs are removed and products start entering into the country, both capital and labor will grow. Taking logs and differentiating in equation [12]:

$$\gamma_y = \gamma_D + n$$

This behavior will only be transitory. As soon as the country develops and the wage increases to w*, population growth will tend to zero and the model will settle in a steady state were all variables grow at the rate γ_D.

Convergence considerations can easily be discussed within this framework. As it is well known, convergence properties of the behavior of the economy crucially depend basically on two main issues.

The first one is the link between the cost μ of the design and the technological gap. If we denote by Λ/M the technological gap of a country or region with the leader, then we can establish the following relationship:

$$\mu = f\left(\frac{\Lambda}{M}\right)$$

Depending on the sign of f', the model will predict convergence or divergence.

If f' is positive (as in Barro and Sala-i-Martin, 1997), the model will display convergence. The intuition is the following: countries that are farther off the technological frontier find a larger pool of designs available for imitation. As they get closer to the frontier and the technological gap is reduced, the pool of designs decreases and imitation becomes more difficult and expensive.

Conversely, a negative sign of the derivative can suggest some kind of learning by doing effect. Countries can get better at imitation and the cost of acquiring a design decrease over time, because the level of human capital in the economy, for example, allows the purchase of designs with less effort, or because in a more developed economy less paperwork is necessary in order to buy the designs from abroad. In any event, this scenario implies that the larger the number of designs already introduced by the follower, the easier it gets to imitate other schemes. This kind of story will predict divergence or even taking over of the leader by the follower in the long run.

Since it is difficult to know on a priori grounds which effect is larger, it can also be the case that both effects do take place, canceling each other. Thus it is possible to treat the fixed cost as independent of the gap.

The other channel by which convergence could show up is the connection between the number of products available in the follower country, and the number of durables available in leading edge countries. In this model the connection is captured by the parameter ε. For the extreme case ε equal to one, catch up would be instantaneous and complete. If ε is high (small), the faster and more pronounced (slower and less intense) the degree of technological catching up will be. For ε higher than one, over-taking could occur.

4. CONCLUDING REMARKS

Many LDCs may lack the infrastructure and human capital necessary to innovate. However, they can recur to imitation as a potential way to access leading edge technology. In turn, this imitation can be done by purchasing from abroad designs that allow domestic production of *state of the art* intermediate goods. This paper describes how this strategy may be adopted, taking as a reference the Spanish performance in the 1950s and 60s, and employing Romer (1990) as the baseline model.

If the economy is under autarky and affected by high distortions, it can be the case that durables will not be introduced: expected profits entailed by domestic sales of the good may not cover the outlay (the patent plus the cost associated to the distortion) associated to the use of the design necessary to produce the durables. Since there are no incentives in this economy to bring in new designs, it is possible that technology in the country be reduced to a limited and constant number of varieties of good. If this is so, it is also feasible, at least theoretically, that the capital stock will not grow (or grow very little) in per capita terms, and diminishing returns of capital will condemn the economy to settle down in a steady state with zero growth and no welfare improvements. This was, precisely, what happened in Spain in the 1940s and early 50s: inward orientation, regulations and autarky impeded economic growth.

A reduction in the distortion will make some of these durables worthwhile to be produced by domestic firms. Firms will thus have incentives to elaborate new varieties of intermediate goods in the country. It is possible that, following a decrease in this distortion, the capital stock would increase over time. In this case endogenous and positive growth would be feasible, since the decreasing returns of capital are offset by the fact that this stock is growing over time.

Again, the Spanish behavior serves as a natural experiment to test and confirm this assertion. The Stabilization Plan of 1959 liberalized external trade, (i.e. reduced the distortions that affect imports) making it easier for entrepreneurs to import intermediate goods from abroad. In turn, these goods embedded more advanced technology (which Spain was unable, at that moment, to generate internally), that spilt over to the whole economy, improving efficiency and facilitating – together with other factors – a period of rapid growth in the country (the decade of 1960s).

Policy considerations can be summarized as follows:

1. All the measures that decrease the effective cost of introducing a design - removal of barriers to trade, ease of convertibility conditions, credit facilities to firms that import intermediate goods, and so forth – may foster the import of intermediate goods and hence allow the take off of a country and permit the transition from stagnation to development.
2. Policy makers can also influence the rate of growth: by ensuring a sounder and less distorted environment (lower τ), they establish the conditions favoring an increase in the number of new varieties of goods that will be worthwhile producing in the economy and this, in turn, could entail higher rates of technological progress and growth.
3. A crucial feature of the model is that the transition from stagnation to growth is not endogenous (as in other articles) but exogenous, and determined by a policy shock. In other words, policy makers may have a crucial role in development. Commercial policy is by no means immaterial: its correct design may have profound consequences on the level of welfare of societies.

It should be noticed that this paper has focused in one particular aspect of openness, the removal of distortions to facilitate the import of capital goods, while the notion of openness in itself is very wide and can be approached from different viewpoints. The messages of the paper, thus, do not necessarily carry over to all aspects concerning the link between a country and the rest. The Spanish experience is and may be illuminating for other countries, especially LDCs, but it should be kept in mind that, ultimately, every country is different from the rest to a certain extent. Thus, it would be dangerous to extract general conclusions from particular cases without making the necessary adaptations in the assumptions and in the recommendations.

Limitations of the paper relate as well to some of the assumptions of the model, in particular the pattern of population growth, the fact of A being constant and preferences remaining the same before and after the transition. Other variables that can be relevant for the adoption of technology (the cost of information, the institutional set up, the entrepreneurial spirit, the education policy and so forth) have not been handled with explicitly here. Notice also that issues about dependency and the behavior of income inequality have not been covered here, and therefore the conclusions of the paper could be slightly rewritten if these issues are taken into account. To deal with these and other points opens avenues for future research.

This piece of research does not pose, either, that in all cases poor growth can be traced back to autarky, nor that a secure solution to grow is always and everywhere to remove distortions. Reductions of tariffs to imported capital good may be useless if the country lacks the social capacity necessary to benefit from more advanced technology. Anyhow, what the model designed here conveys is that, other aspects being equal, in particular institutions, social capacity and entrepreneurial spirit, a decrease in the barriers to external trade may enhance growth.

The set up describe here, while simple, is versatile enough to permit the exploration of some interesting issues in future research. The desire to make very clear the main message of the paper advised not to pursue all these avenues but rather focus in the main point in the simplest way possible.

APPENDIX 1. ROMER'S (1990) MODEL

A simplified sketch of Romer's model will be presented next. For lack of space, this section states discusses the assumptions and the main properties of the growth rate.

1. ASSUMPTIONS

1.1. Preferences

The economy is composed by infinitely lived agents. They maximize their utility, which is of the CRRA type (as in Ramsey, 1928). Thus the problem for the agent is to maximize over time the following equation.

$$u(0)=\int_0^\infty e^{-\rho t} u\left[c(t)\right]L(t)dt$$

$$\rho > 0$$

$$u\left[c(t)\right]=\frac{c(t)^{1-\sigma}-1}{1-\sigma}$$

$$\sigma \in [0,\infty)$$

Where ρ is the discount rate, L(t) is the size of the family, c(t) per capita consumption and σ represents the relative risk aversion coefficient. Population does not grow.

1.2. The Production side

There are three sectors in the economy. The first one is the R&D sector. Its inputs are the stock of ideas, A, and a part, L_A, of the endowment of human capital in the economy. Thus

$$\dot{A} = \varphi L_A A \quad [A1]$$

This function is linear in L for convenience. It is linear in A in order for the model to generate endogenous growth at a constant rate.

The second sector produces intermediate goods x_i. Its inputs are designs and foregone output. In other words, the production function for xi and Y is the same. There is one firm that produces each i^{th} good. Once a firm generates a design for a durable, a patent is obtained over the design. The owner of the patent produces the durable in an imperfect competition setting, and sells it at a price that maximizes profit.

The third sector employs the rest of labor and the intermediate goods in order to produce the final output y, according with the following production function:

$$Y = K^{\alpha} \left(AL_y\right)^{1-\alpha}$$

$$0<\alpha<1$$

The capital stock is the sum of all the intermediate goods or durables (A2). It does not depreciate for simplicity. The amount of durables is determined at each point in time by the technology prevailing at that time. Durables are perfect substitutes, and because of the symmetry in the model, they are all produced at the same equilibrium level x*.

The growth of technology entails that more durables are available.

$$K = \sum_{i=1}^{A} x_i \quad [A\,2]$$

2. DYNAMICS OF THE ECONOMY AND SOLUTION OF THE MODEL

The fundamental dynamic equation is the law of motion of the capital stock,

$$\dot{K} = Y - c \quad [A3]$$

Romer defines the Balanced Growth Path as that situation in which a) Y, K, c and A grow at the same constant rate. b) Prices and quantities are such that all markets are in equilibrium. C) The amount of labor allocated to the sectors of research and final output is constant.

According to equation (A3), and as it is the norm in most growth models, in order for a balanced growth path to exist K, Y and c must grow at the same rate, g.

Now, from equation (A2) above, and using the symmetry property among the durables, we can express K as

$$K = Ax^*$$

Since x* is constant in the steady state, K and A also grow at the same rate g. This rate can be obtained from equation (A3) as

$$g = \frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} = \frac{\dot{A}}{A} = \varphi\, L_A$$

APPENDIX 2. DETERMINATION OF THE EQUILIBRIUM PRICE AND QUANTITY OF DURABLES

The i^{th} monopolist produces the intermediate good x_i in order to maximize profits, π_i [A4] at every point in time. The profit is computed as the difference between the value of sales (the price of the design p_i times the quantity of the design, x_i) and costs. Costs, in turn, are foregone output (on a one by one basis) and a fixed component. The fixed cost is denoted by $\mu+\tau$, where τ captures the distortions associated to the commercial regime prevailing in the country.

$$\pi_i = p_i(x_i)\; x_i - x_i - \mu - \tau \quad [A4]$$

Since the final good is sold in competitive markets, the price of the intermediate good x_i will equal its marginal product in the production of the final output. The inverse demand curve of the good x_i can be obtained by means of equating its price p_i to its marginal product.

Differentiating with respect to x_i in [4] yields

$$p_i = A\beta\, x_i^{\beta-1} L^{1-\beta} \quad [A5]$$

A general result of models that deal with increases in the variety of goods (Romer, 1990; Barro and Sala-i-Martin, 1997) is that the equilibrium quantity and price of all intermediate goods is the same because all monopolists behave in a symmetrical way. Hence the subindex i can be dropped.

It is straightforward to get the optimal amount of the intermediate good x. From the first order condition associated to the maximization of profit, we obtain an expression [A6] for the equilibrium quantity of good x:

$$x = L\, A^{\frac{1}{1-\beta}}\, \beta^{\frac{2}{1-\beta}} \quad [A6]$$

Plugging [A6] in equation [A5] yields the optimal price, [A7]:

$$p = \frac{1}{\beta} \quad [A7]$$

The monopoly price is a mark up over the marginal cost of the durable, 1, where the mark up is the inverse of the elasticity of output with respect to the intermediate good.

APPENDIX 3. IMPLICATIONS OF THE FREE ENTRANCE CONDITION

The present value V of a durable is given by expression [A8].

$$V = \pi \int_0^{\infty} e^{-\int_t^s r(\varpi)d\varpi}\, ds \quad [A8]$$

Solving equation [A8] yields [A9]:

$$V = \pi \int_0^{\infty} e^{-\int_t^s r(\varpi)d\varpi} ds \quad = \pi \int_0^{\infty} e^{-r(s-t)} = \pi \frac{1}{r} \quad [A9]$$

Where the mean value theorem has been used to approximate the second integral in [A9] by r(s-t).

Now, in accordance with the literature on this subject, I shall assume that the domestic market for designs is competitive. This means, in turn, that there is free entry in the durables sector and therefore the zero profit intertemporal condition holds (Grossman and Helpman, 1989). In other words, in equilibrium the cost of the design must equal the present discounted value of the expected flow of net revenues (condition [A10] below). Combining [A9] and [A10] yields [A11]

$$V = \mu + \tau \quad [A10]$$

$$r = \frac{\pi}{\mu + \tau} \quad [A11]$$

As it should be expected, equation [A11] states that the rate of return of the design must equal the ratio between the profit and the fixed cost of getting the design.

REFERENCES

AGHION, P. AND HOWITT, P. (1992) "A Model of Growth Through Creative Destruction" *Econometrica* 60, 2, 323-351.

BARRO, R. AND SALA-I-MARTÍN, X. (1997) "Technological Diffusion, Convergence and Growth", *Journal of Economic Growth* 2, June, 1-26.

BARRO, R. AND BECKER, G. (1989) "Fertility choice in a model of economic growth" *Econometrica* 57,2, 481-501.

BECKER, G. AND BARRO, R. (1988) "A reformulation of the economic theory of fertility", *Quarterly Journal of Economics* 103, February, 1-25.

BECKER, G. MURPHY, K. AND TAMURA, R. (1990) "Human capital, fertility and economic growth", *Journal of Political Economy* 98, part 2, S12-S37

BENGOA, M. (2003) "Inversión directa extranjera y crecimiento economico", Ph.D. Dissertation, Universidad de Cantabria.

BREZIS, E., KRUGMAN, P. AND TSIDDOM, D. (1993) "Leapfrogging in International Competition: A Theory of Cycles in National Technological Leadership", *American Economic Review* 83, 5, 1211-1219.

CARRERAS, A. AND TAFUNELL, X. (2005) *Estadísticas históricas de España* (2ªedición), Fundación BBVA, Bilbao.

DASCHER, K. (2000) "Trade, FDI and congestion. The small and very open economy", *CEPR Working Paper* 2526, August.

EDWARDS, S. (2002) "Capital mobility, capital controls and globalization in the Twenty-First Century", *Annals of the American Academy of Political and Social Science*, vol. 579, January, 261-70.

FUENTES QUINTANA, E. (1988) "Tres decenios de la economía española en perspectiva" en García Delgado, J.L (ed.) *España Economía*, Espasa Calpe, Madrid.

GALOR, O. AND WEIL, D. (1993) "The gender gap, fertility and growth", *American Economic Review* 86, 3, 374-387.

GALOR, O. AND WEIL, D. (2000) Population, technology and growth: from the Malthusian regime to the demographic transition and beyond", *American Economic Review* 90, 806-828.

GONZALEZ, M.J. (1979) *La economía política del franquismo (1949-1970*), Tecnos, Madrid.

GROSSMAN, G. AND HELPMAN, E. (1989) "Product development and international trade", *Journal of Political Economy* 97, 1261-83.

______________________(1991) *Innovation and Growth in the Global Economy*, MIT Press, Cambridge, MA.

HANSEN, G AND PRESCOTT, E. (2002) "Malthus to Solow", *American Economic Review* 92, 1205-1217.

HAVEMAN, J., LEI, V. AND NETZ, J. (2001). "International integration and growth: A survey and empirical investigation", *Review of Development Economics* 5, 2, 289-311.

JONES, C. (2001) "Was the Industrial Revolution inevitable? Economic growth over the very long run" *Advances in Macroeconomics* 1, 2, article1.

KREMER, M. (1993) "Population growth and technological change: One Million B.C. to 1990", *Quarterly Journal of Economics* 108, 3, 681-716.

LAITNER, J. (2000) "Structural change and economic growth", *Review of Economic Studies* 67, 545-562.

LIEBERMAN, S. (1995) *Growth and crisis in the Spanish economy*, 1940-93, Routledge, London.

LUCAS, R. (1998) "The industrial revolution: past and future", mimeo, University of Chicago.

LEE, J.W. (1995) "Capital Goods Imports and Long Run Growth", *Journal of Development Economics* 48, 91-110.

MOLERO, J. (1983) "Foreign technology in the Spanish economy: an analysis of the recent evolution", *Research Policy* 12, 5, 269-285.

PROUDMAN, J. AND REDDING, S. (1998) *Openness and growth*, Bank of England, London.

RAMSEY, F. (1928) "A Mathematical Theory of Saving", *Economic Journal* 38, 543-559.

RIVERA-BATIZ, L. AND ROMER, P. (1991) "Economic Integration and endogenous growth". *Quarterly Journal of Economics* 106, 2, 531-555.

RODRIK, D., SUBRAMANIAN, A., AND TREBBI, F. (2004) "Institutions rule: The primacy of institutions over geography and integration in economic development", *Journal of Economic Growth* 9, 131-165.

ROMER, P. (1986) "Increasing returns and long run growth" *Journal of Political Economy* 94,5, 1002-1037.

_______(1990) "Endogenous Technological Change ", *Journal of Political Economy* 98, part II, S71-S102.

SANCHEZ-ROBLES (2002) "Does equality reduce growth? A theoretical justification" SSRN Working Paper, http://ssrn.com/abstract=315021.

TAMURA, R. (2002) "Human capital and the switch from agriculture to industry", *Journal of Economic dynamics and control* 27, 2002, 207-242.

TEMPLE, J. (1999) "The New Growth Evidence", *Journal of Economic Literature* 37, 1, 112-156.

TEMPLE, J. AND WÖBMANN, L. (2004) "Dualism and cross-country growth regressions", *Discussion Paper 4/560, University of Bristol.*