LEARNING-BY-DOING, GOVERNMENT SPENDING AND ECONOMIC GROWTH: A MODEL À LA MATSUYAMA-BARRO

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Abstract

Learning-by-doing and external productive effects of government spending are well-known engines of long-run economic growth. To the best of our knowledge, the interaction of these growth engines has not been analysed. This paper aims at filling this vacuum by combining the approaches of Matsuyama (1992) and Barro (1990). In the ensuing model, industrialization and growth are directly related. Governments may play a role in industrialization by adopting an optimal fiscal policy, and through improving efficiency. There is also room for industrial policies that lead to an optimal allocation of resources. The latter possibility is in contradiction to an open commercial regime that leads to deindustrialization. The model is used to think about some development experiences, specially about the slowdown of the Colombian economy since the 1980s.

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1. Introduction

1.1. Industrialization and Economic Growth in Colombia

After the adoption of an open trade regime in 1990, the GDP share of the Colombian manufacturing industry fell significantly, and the Colombian economy grew on average much slower than in the past. Is this a coincidence or there exists a connection?

Let us look at the data. Official Colombian statistics (Dane; DNP, 1998) show that the manufacturing industry GDP share fell continuously from 19.2% in 1990 to 14.3% in 1999 (15.3% in 2000). To gauge the magnitude of this fall, it must be considered that the manufacturing GDP share was quite stable around 22% during the 1980s.

In order to get rid of cyclical effects and measuring long-run growth trends of the Colombian GDP, I calculated annual average growth rates per decade as shown in Table 1. This estimation reveals that the 1990s exhibit the lowest annual average rate of economic growth since 1925: 2.7%.

Table 1
Long-Run GDP Growth of Colombia 1925-2000

Period	25-30	1930s	1940s	1950s	1960s	1970s	1980s	1990s
Annual Average Rate (%)	4.0 **(a)**	4.1	3.9	4.6	5.1	5.5	3.4	2.7

Sources: Own calculations based on DNP (1998) and DANE. Note: **(a)** Available official information on GDP starts in 1925.

Thus, the Colombian "apertura" (commercial openness) did not fulfil some great expectations.

The behaviour of the Colombian economy during the 1990s is not atypical. In fact, a direct relationship between industrialization and economic growth seems to be a structural feature of the Colombian economy. This hypothesis can be assessed by comparing the evolution of the GDP share of the manufacturing sector with the evolution of the long-run economic growth rate between 1925 and 2000. As Figure 1 shows, the GDP share of the manufacturing sector tends to increase from the 1920s to the 1970s –between 1974 and 1979 this share reaches its maximum values around a fairly constant 24%–; as mentioned above, the manufacturing GDP share falls during the 1980s to a quite stable value of 22%; and in the 1990s the manufacturing GDP share falls continuously until 1999 –there was a small recovery of the manufacturing activity in 2000 that does not offset the negative trend–. On the other hand, see Figure 2, the rate of long-run economic growth of Colombia, estimated by the moving average of 10 continuous years, behaves in the same way as the industrialization index: it increases steadily until the end of the 1970s, when it reaches values quite close to 6%; afterwards it tends to fall and in 2000 it reaches the level of 2.7%. This economic slowdown of Colombia begins in 1980 with a deindustrialization process; both phenomena are deepened in the 1990s.

The above comparison does not prove that economic growth in Colombia is driven by the manufacturing sector. However, no other sector is related with the trend of Colombian economic growth (see Figure 1): the GDP share of the primary sector decreases continuously from 1925 to 2000; and the GDP share of the service sector increases steadily during the same period. These trends of the primary and the service sectors are consistent with well-known patterns of economic development (see Chenery, Syrquin and Robinson, 1986).[1]

Further analytical evidence of the relationship between industrialization and economic growth in the Colombian economy is shown by the following regressions:

$$g_t = -0.053\,P_t + 0.317\,M_t + 0.152\,S_t - 15.902\,t$$

(-1.123) (3.487)*** (1.628) (-2.092)**

75 observations; Adjusted $R^2 = 0.091$; D.W. = 1.45; Q* = 4.62.

$$g_t = -0.071\,P_t + 0.348\,M_t + 0.162\,S_t - 17.005\,t + 0.247\,AR(1)$$

(-1.261) (3.099)*** (1.477) (-1.886)* (2.167)**

74 observations; Adjusted $R^2 = 0.153$;

Notes: * significant at the 10% level, **significant at the 5% level, ***significant at the 1% level.

In this exercise I run two OLS regressions of the Colombian GDP growth rate (g_t) against the GDP share of the primary sector (P_t), the GDP share of the manufacturing sector (M_t), the GDP share of the service sector (S_t), and a time trend (t). Since these shares add up to unity, a constant term is excluded from these regressions in order to avoid multicollinearity. The t-statistics are shown in parentheses. Both regressions yield that GDP growth is positively and significantly correlated with the manufacturing GDP share at any significance level; no other sector share has a significant coefficient. This result might imply that the main component of economic growth is the growth of the manufacturing activity. The time trend seems to be negatively related with GDP growth, but its coefficient is not significant at the 1% level in the first regression, and it is not significant at the 5% level in the second regression.

The Durbin-Watson statistic of the first regression falls in the uncertainty zone of the critical values associated to the hypothesis of no autocorrelation. Besides, the Box-Pierce-Ljung Q* statistic does not reject the hypothesis of no autocorrelation at the 3% level, but it does at the 4%. Thus, the second regression is run to correct the autocorrelation problem just in case it exists –it is assumed that the error term follows an autoregressive process of order 1–. The coefficient associated to the lagged residual in the second regression is significant at the 4% level but it is not at 3%. However, even if autocorrelation is present this second regression yields that the previously estimated coefficients are robust: the coefficient of the manufacturing GDP share is similar to the previous one, and it is the only significant regressor.

Finally, a standard test of stationarity for the regression residual of the first regression rejects the null hypothesis of unit root: the augmented Dickey-Fuller statistic is estimated as -6.78 against a critical value of -4.09 at the significance level of 1%. As

[1] Figure 1 reveals that changes in Colombian national accounting methods modified the GDP distribution among sectors in 1950, 1970 and 1990. Nevertheless, the long-run trends of the economic structure are not significantly altered by the discontinuities.

expected, a similar result is obtained for the second regression. Thus, these regressions seem to be valid econometric exercises.[2]

Still these exercises do not prove any direction of causation: does industrialization induce economic growth or the other way round? The experience of development seem to support the causality from industrialization to growth. I will quote later some historic analysis on development that support this viewpoint.

Let us look now at the experience of development as summarized by Kaldor (1967), and Chenery, Robinson and Syrquin (1986). In an essay on economic growth of 1967, Kaldor wrote that "fast rates of growth are almost invariably associated with the fast rate of growth of the secondary sector, mainly manufacturing, and… this is an attribute of an intermediate stage of development" (quoted by Nishimizu and Robinson, chapter 10, p. 289, in Chenery, Robinson and Syrquin, 1986). No many economists would doubt that the Colombian economy fits Kaldor´s condition of being at an intermediate level of development.

Chenery, Robinson and Syrquin (1986) also support Kaldor´s conclusion. In the end of their classical work on industrialization and growth, they ask themselves: "Is industrialization necessary to continued growth? Our models of the transformation suggest that the answer is generally yes" (p. 350). Afterwards they warn that this conclusion might not be true for economies in poverty traps, economies characterized by a persistent Dutch disease phenomenon, and economies locked in an early development of service exports. The first two conditions, say Chenery et al, are not probable; and the third condition, according to these authors, appears unlikely to offset the increasing demand of manufactures. "In summary, we conclude that –on both empirical and theoretical grounds– a period in which the share of manufacturing rises substantially is a virtually universal feature of the structural transformation" (Chenery et al, 1986, p. 350).

The Dutch disease phenomenon is the only exceptional condition mentioned by Chenery, Robinson and Syrquin that might help to explain the deindustrialization phenomenon of Colombia. As is well-known, after 1980 Colombia has been increasingly engaged in drug trafficking activities and it has concentrated this activity in the Andean zone (Rocha, 2001; Cárdenas, 2002). In addition, Cárdenas (2002) has claimed that the expansion of drug trafficking and the sequels of violence linked to this activity, together with the growing income inequality in Colombia, explain the Colombian economic slowdown.

It may be true that violence and income concentration impinge negatively on economic growth. However, one might be sceptical that these phenomena explain the whole picture of the Colombian slowdown since they, in turn, must also be explained. In any case, deindustrialization as an explanation of the growth slowdown does not necessarily conflict with other explanations. In fact, since the deindustrialization process and the upsurge of drug trafficking activities in Colombia began around 1980, they might

[2] According to standard econometric procedures, the integration order of the regressors should be verified first. Since the econometric model structure is given by a formal identity (the GDP growth rate is by definition a weighted average of the sectors´ growth rates), the analysis of the residual´s stationarity is sufficient for the descriptive purposes of this paper.

be the two sides of the same coin: the specialization process of the Colombian economy according to its comparative advantages in an increasingly integrated world.

I resort now to economic theory in order to argue for some causality from industrialization to growth. This analytical background may be helpful to improve our understanding of the Colombian economic performance after the "apertura".

1.2. Openness, Learning-by-Doing and Government Spending

Some models of economic growth and international trade that embody dynamic externalities from learning-by-doing are able to account for the behaviour of the Colombian economy in the 1990s (Krugman, 1987; Lucas, 1988; Young, l991; Grossman and Helpman, 1991; Matsuyama, 1992). These models show how openness to international markets may induce diverse growth effects across countries. In these models, a country specialization in traditional sectors of lower learning dynamics yields the unwanted effect that the country´s long-run economic growth is weakened; on the other hand, specialization in high-learning activities enhances the country´s economic growth. Specialization in traditional productive activities is a possible outcome of trade liberalization due to a country´s comparative advantages. In fact, it is nowadays hardly discussed that natural resource abundance may explain a country´s specialization in primary activities; since these economic activities have lower learning dynamics the country may be locked in a low level path of economic growth (Matsuyama, 1992; Sachs and Warner, 1995a; Landes, 1998). This seems the case of Colombia after 1990 as the economy has increased its dependency to mining and agricultural activities: petrol, coal, nickel, bananas, flowers, sugar, and illicit drugs (marihuana, cocaine and heroin).

Despite diverse theoretical possibilities of openness to international markets, the received wisdom after the Washington Consensus is that trade liberalization –in the sense of lower policy-induced barriers to international trade– necessarily enhances economic growth. In fact, a whole industry of econometric regressions were run in the 1990s in order to "prove" that trade liberalization is significantly associated with economic growth across less developed countries (Dollar, 1992; Edwards, 1993, 1998; Lee, 1993; Ben-David, 1993; Sachs and Warner, 1995b; among many others). Nevertheless, some recent theoretical and econometric analysis have challenged this conventional wisdom and the corresponding econometric exercises (see Rodríguez and Rodrik, 1999). These authors found that in many econometric studies the openness indicators were poor measures of trade barriers or were highly corrrelated with other sources of bad economic performance; in other cases, the econometric methods used to ascertain the link between trade policy and economic growth had serious shortcomings.

As shown above, the Colombian experience with the "apertura" is a case were the usual prescription of "open-your-markets-and-grow" did not work. On the contrary, this prescription led the country to deindustrialization and lower economic growth.

In this light it is valid to ask whether the government of a less developed country can do anything to enhance industrialization and economic growth in the era of globalisation. Are natural-resource rich countries condemned to primary economic activities due to the rule of comparative advantage? In order to make a contribution to answering this question I develop a growth model combining learning effects from industrialization à la Matsuyama (1992), and government spending with productive externalities à la Barro (1990). This model aims at analysing the impact of the government as provider of public goods on the pattern of trade.

With the exception of Rodriguez and Rodrik (1999), Matsuyama´s 1992 paper has not been given the attention it deserves. Nevertheless, it remains a substantial contribution to an understanding of the pattern of trade of less developed economies. His model embodies some basic characteristics of less developed countries. On the supply side, Matsuyama assumes that agricultural productivity depends basically on each country's particular natural conditions. He also assumes that cumulative experience of the manufacturing industry determines the sector's productivity. On the demand side, Matsuyama assumes that consumers require some minimum amount of food.

The assumption on agricultural productivity is fundamental to analyse the role of natural resources relative abundance on international trade and economic growth. The assumption on the manufacturing sector learning ability is consistent with the development experience of the newly industrialized countries; according to some analysts, learning-by-doing has been one of the most important engines of economic growth of the less developed countries (Amsden, 1989; Landes, 1998; Lucas, 1988, 1993). On the other hand, the assumption of the existence of minimum food requirements is consistent with one the most striking characteristics of underdevelopment: the poverty of a large portion of the population obliges the almost exclusive satisfaction of basic needs. This assumption is consistent with Engels´ law: the demand for basic goods is inelastic with respect to income.

Barro´s 1990 model on government spending with productive externalities has become a classical approach to study the role of government activity and long run growth. Hence, its choice as the analytical background for this paper does not require much explanation. It suffices to point out that Barro´s model includes both productive externalities and a long-run government budget constraint. The model embodies a sustainable fiscal policy and a role for government in the allocation of resources.

1.3. "Certain Things Will Never Happen if One Doesn't Make Them to Happen" (Landes, 1998)

There exist other reasons to justify the inclusion of the government in an international trade model. Government investments may be important for defining a country´s comparative advantage and inducing economic growth.

One of the most conspicuous characteristics of the Colombian change of trade regime towards liberalization was the scarce presence of the government. After lowering tariffs, the Colombian governments did little in order to support the exporting sectors. Actually, some policies were clearly biased against exports: exports subsidies were lowered, infrastructural investment was scarce, and the Colombian peso was strongly revaluated between 1990 and 1999. In addition, unstable fiscal policies were characteristic of this period: there was almost a fiscal reform every two years. In our view, the Colombian commercial openness lacked sufficient "good" government, and had an abundance of "bad" government. The "apertura" lacked investment in education, science and technology, health, roads, ports, etc.; and it had too much corruption and public inefficiency.

As a contrast, newly industrializing countries such as Japan, South Korea, Taiwan, Hong-Kong, Singapore, Indonesia, Israel and China, supported and protected their industries even before they began the conquest of external industrial markets. Their fundamental mechanisms of development were learning-by-doing, and economic diversification through the adoption of foreign technologies. In order for this to happen these countries had governments whose objectives included a strong commitment to investment in education. They committed themselves to enhancing agricultural efficiency through land reforms aimed at democratising the rural property and improving agricultural productivity [see Amsden (1989) and Landes (1998) for the cases of South Korea and Japan].

Thus, the inclusion of the government in a learning-by-doing model may help to understand not only the economic development of Colombia, a case of halfway industrialization, but also the development of newly industrialized countries.

Moreover, the inclusion of a government role allows a modelling of the historical criticism that David Landes (1998) aims at those nations that conform to the simple exploitation of their natural comparative advantages. Portugal, Spain and South American countries are his favourite targets. Landes is particularly critical of that neo-liberal vision that places comparative advantage as the rationale of economic growth. He emphasises the unavoidable role of the state in inducing an industrialization process as shown by the development experiences of Germany, Japan, South Korea and, in fact, all currently industrialized countries in their period of economic take-off. Landes´s dictum with respect to industrialization and development is that “certain things will never happen if one doesn't make them to happen” (Landes, 1998, chapter 20). That is the key. Since individual agents cannot transform a development pattern, the government must play a definitive role in the allocation of resources in order to achieve the required industrial transformations.

The rest of this paper is organized as follows. The model is developed in the second section. In the third section the competitive equilibrium in autarchy is solved. The world competitive equilibrium is solved in the fourth section. The optimal path of the balanced equilibrium is solved in the fifth section. The article ends with some conclusions in the sixth section.

2. The Model

2.1. Technologies

The technologies adopt the following Cobb-Douglas form:

(1) $$X_1 = A(1-n)^{\alpha}(\varepsilon g)^{\mathrm{a}}, \quad 0<\alpha \le 1,\ 0 \le \mathrm{a} < 1,\ 0 \le \varepsilon \le 1.$$

(2) $$X_2 = M n^{\beta}(\varepsilon g)^{\mathrm{b}}, \quad 0<\beta \le \alpha \le 1,\ 0 \le \mathrm{a} \le \mathrm{b} < 1.$$

The variables X_1 and X_2 represent the production of the primary sector and the manufacturing sector in the period of analysis. A and M are the respective indicators of productivity. The exponents α, a, β and b are non-negative parameters. Labour supply is assumed to be constant and normalized to 1. It is also assumed that wages are flexible (there is full employment). The share of the manufacturing sector in the labour demand is given by the fraction n. Government spending affects positively labour productivity in both sectors. Government spending in the period of analysis is given by g. The effective spending in productive public goods is given by εg, where ε is a positive fraction; the idea here is that the relevant variable for production is not the total amount of government spending but the fraction which is effectively transformed in highways, bridges, hospitals, professionals, public administration, etc. The remaining fraction corresponds to government's unproductive expenses –government consumption–, and also to deviation of resources –corruption–. Land and other natural resources are required for production of primary goods but they do not appear explicitly in the respective production function because they are assumed fixed. It is also assumed that relative abundance and quality of land is reflected directly in the productivity of the sector, A.

The restrictions on the exponents of the production functions have several implications. First, labour has a decreasing or constant marginal productivity: $\alpha \leq 1$ and $\beta \leq 1$; as each firm assumes that government spending is constant –or it considers negligible its effect on aggregate government spending–, a competitive equilibrium may exist. Second, it is assumed that labour intensity of the primary sector is not inferior to that of the manufacturing sector: $\alpha \geq \beta$. Third, public goods have a decreasing marginal productivity in both sectors: a < 1 and b < 1. This assumption guarantees the stability of the model; on the other hand, it is not sensible to assume that public goods have extraordinary productive external effects. Fourth, it is assumed that the product elasticity of government spending in the manufacturing sector is not inferior to the product elasticity of the same spending in the primary sector: b ≥ a. As a justification of the latter assumption it can be mentioned that the industrial manufacturing sector depends more heavily than the primary sector on services which are usually provided for the government because of their high fixed costs and public character: technological services –energy, communications, science and technology, etc.–, and services related to the maintenance and expansion of the physical, social and institutional infrastructure of cities. Not in vain manufacturing industries tend to be located in big cities.

The scale elasticity of a Cobb-Douglas production function is measured as the sum of the exponents. Hence, in this model α + a is the scale elasticity in labour and effective government spending of the primary sector, and β + b is the scale elasticity of the manufacturing sector. Given the technological assumptions on these exponents, the scale elasticity is not restricted in any sector: it can be higher, equal or smaller to 1 (increasing, constant or decreasing scale returns, respectively).

All the above parameter restrictions conform to standard economic assumptions. Besides, they are consistent with an econometric study of the Colombian productivity (Sanchez, Rodríguez and Núñez, 1996). These authors assume a Cobb-Douglas technology specification for the GDP, the manufacturing GDP and the agricultural GDP. Their productive factors are divided between private factors (capital and labour), and external factors, which, in turn, are divided in public capital (public infrastructure) and human capital as measured by the educational level of the population. Sanchez et al postulate that these technologies are characterized by constant returns to scale with respect to private factors and public capital, whilst human capital impinges on productivity as a pure externality. Thus, their results imply increasing returns to scale at the aggregate level. They estimate the distribution of value added between labour and capital as follows: 63% and

37% in the manufacturing sector, 80% and 20% in the agricultural sector. Since these weights correspond to product elasticities in a Cobb-Douglas technology, these estimates are consistent with our assumption of a decreasing marginal productivity of private factors (the corresponding product elasticities are lower than 1); they are also consistent with the assumption that agricultural activities are more labour intensive than manufacturing activities.

With respect to the effects of external factors on productivity, the results of Sánchez et al are also consistent with the model assumptions. Table 2 summarizes their estimates of external factors impact on productivity growth:

Table 2
Impact of Public Capital and Average School-Enrolment Ratio on Productivity
Colombia

Sector	Period	Public Capital Elasticity (t-statistic)	School-Enrolment Elasticity (t-statistic)
GDP	1970-1994	0.15 (2.12)**	0.18 (2.30)**
Manufacturing GDP	1955-1994	0.55 (5.59)***	0.37 (5.27)***
Agricultural GDP (a)	1955-1994	0.29 (3.19)***	0.27 (3.02)***

Source: Sánchez, Rodríguez and Núñez (1996). Notes: (a) Includes cattle production; ** significant at the 5% level; *** significant at the 1% level.

This table shows that the impact of public infrastructure growth on manufacturing GDP growth seems to be almost twice the impact on agricultural growth (0.55 vs. 0.29), and more than three times the impact on GDP growth (0.55 vs. 0.15). Thus, manufacturing industry seems to be the economic activity most favoured by public capital accumulation. These results are also consistent with the model assumption that public capital have a decreasing marginal productivity (public-capital product elasticities are lower than 1). Similar results for the industrial activity of Colombia are reported by Cárdenas et al (1995).

Sanchez et al also estimate a positive impact of average educational attainment on productivity growth as shown by the fourth column of Table 2. Manufacturing industry is also the one activity most favoured by human capital accumulation.

2.2. The Manufacturing Learning Technology

One of the engines of growth in this economy is the learning-by-doing process of the industrial manufacturing sector. The process of productivity expansion in this sector adopts the following linear form:

(3) $$\dot{M} = \delta X_2 , \quad \delta > 0 ,$$

where a point on a variable indicates the derivative with respect to time, and δ is the learning index. Thus, M can be understood as the manufacturing productivity coefficient and also as the stock of the country manufacturing experience.

In the real world one cannot ignore the existence of learning processes in the primary sector of the economy. Nevertheless, it is usually assumed that the learning process of the primary sector is less dynamic because of a lower probability of introduction of new goods. Besides, it is also assumed that the productivity of the primary sector depends fundamentally on given natural conditions. Thus, as in Matsuyama (1992), here it is assumed that the coefficient of productivity in the primary sector, A, is constant.

2.3. Government Spending and Taxes

In order to provide public goods, the government taxes private incomes. As in Barro (1990), it is assumed that government spending, g, is contemporaneously balanced with public revenues:

(4) $$g = \tau (X_1 + pX_2) , \quad 0 \le \tau \le 1 ,$$

where τ is the income tax rate, and p is the relative price of the manufactured good. The product of the economy, $X_1 + pX_2$, and government spending, g, are measured in terms of the primary good.

The balanced budget is an appropriate assumption for a long-run horizon analysis: sooner or later the public debt that a fiscal deficit generates should be paid, and a fiscal surplus is consumed.

2.4. Preferences

In this economy the consumer derives utility from consumption of both the primary good and the manufactured good. These goods are assumed to be perishable. In consequence, for the moment it is only necessary to define the utility function of the representative consumer for the period of analysis:

(5) $$U = \theta \log(C_1 - \gamma) + \log C_2 , \quad \theta > 0, \ \gamma > 0 ,$$

where U is the measure of utility, C_1 is the consumption of the primary good, and C_2 is the consumption of the manufactured good. This utility function implies that the representative consumer requires a minimum consumption of the primary good equal to γ. The coefficient θ measures the consumer's bias toward the primary good.

For minimum consumption in this model it is understood not only the minimum nutritious requirement, like in Matsuyama's model, but also other basic consumptions of primary origin (e.g. fuel).

2.5. Equilibrium in the Markets of Goods

The final private demand in each market is equal to supply after taxes:

(6) $$C_1 = (1 - \tau) X_1 ,$$

(7) $$C_2 = (1 - \tau) X_2 .$$

Equations (1) to (7) define the structural form of the model.

3. Competitive Equilibrium in Autarchy

3.1. The Behaviour of Firms

Profits of the economic sectors are defined as after-tax income less labour costs: $\pi_1 = (1-\tau)X_1 - w(1-n)$, and $\pi_2 = (1-\tau)pX_2 - wn$, where w is the wage rate. Profit maximization requires that the after tax value of labour marginal productivity equals the wage:

(8) $$w = (1-\tau)\alpha A(1-n)^{\alpha-1}(\varepsilon g)^{a} \ ,$$

(9) $$w = (1-\tau)\beta\, p M n^{\beta-1}(\varepsilon g)^{b} \ .$$

To derive these equations it is assumed that firms take as given prices and government spending. The concavity of the production functions ensures that second order conditions for maximizing profits are satisfied. The labour distribution between sectors is derived from the previous expressions:

(10) $$\frac{n^{1-\beta}}{(1-n)^{1-\alpha}} = \frac{\beta}{\alpha}\frac{pM}{A}(\varepsilon g)^{(b-a)} \ .$$

It is necessary to point out that this equation is not yet a reduced expression: the relative price of the manufactured good, p, and government spending, g, are endogenous variables.

Figure 3: Labour Distribution and Wage Determination

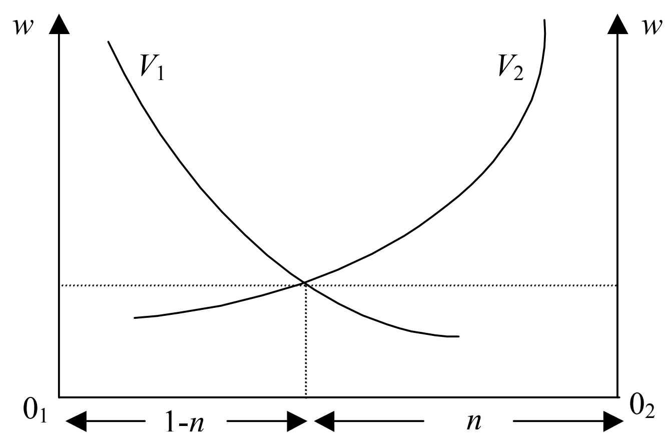


Figure 3 shows the determination of wage and labour allocation. Equalization through economic sectors of the after-tax value of marginal product (V) determines both variables, w and n.

3.2. Effective Government Spending

To start solving the effective spending in public goods, equations (1), (2), (4) and (10) are combined. This procedure yields:

(11) $$(\varepsilon\, g) = \left[\frac{1+(\alpha-\beta)\,n/\beta}{(1-n)^{1-\alpha}}\right]^{1/(1-a)} (\varepsilon\,\tau A)^{1/(1-a)} \;.$$

This is not a reduced expression either, as the share of the manufacturing sector in labour demand, n, is an endogenous expression. Nevertheless, it is convenient to advance that effective government spending, εg, increases with the share of labour supply in the manufacturing sector, n. Recall that $\alpha > \beta$.

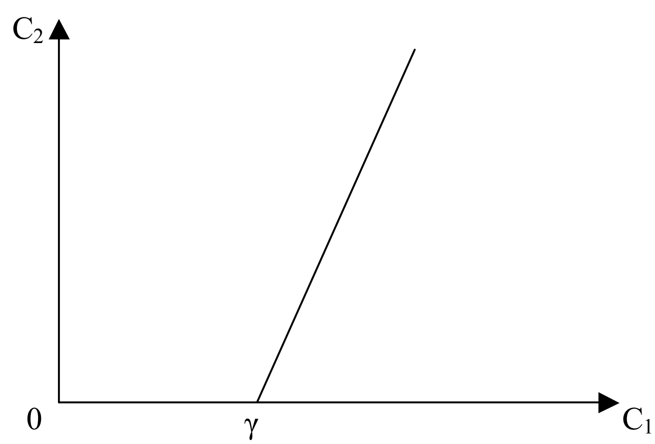
3.3. Engel´s Law

The representative consumer assigns his income so that the ratio of marginal utilities is equal to the relative price: $(\partial U/\partial X_2)/(\partial U/\partial X_1) = p$. Developing the previous expression yields the line of consumption expansion:

(12) $$C_1 = \gamma + \theta\, p\, C_2 \;.$$

The minimum level of consumption of the primary good is given by γ units. It implies a minimum level of income. As income increases, the consumption of both goods grow along the expansion line as shown in Figure 4.

Figure 4: The Relative Demand



Thus the relative demand for the manufactured good increases with income: the slope of an imaginary line between the origin and the line of consumption expansion increases with the level of income. Therefore, the utility function satisfies Engel´s law: income elasticity of demand for the primary good is inferior to 1.

3.4. Labour Allocation

Substitution of the equilibrium equations of the markets of goods [equations (6) and (7)], in equation (12), and using equation (10), yields

$$\frac{(1-n) - \alpha\theta\, n/\beta}{(1-n)^{1-\alpha}} = \frac{\gamma}{(1-\tau)\, A\,(\varepsilon\, g)^{a}} \;.$$

A similar expression to this is derived in Matsuyama´s model. In fact, in his model the right-hand side of the previous equation is reduced to γ/A, as he does not consider the existence of government (τ = a = 0). As the left-hand side expression is decreasing in n, Matsuyama deduces a positive relationship between the primary productivity index, A, and the industrialization level, n. Notice that the assumption of minimum requirements of primary consumption, $\gamma > 0$, is fundamental for this result.

In this way Matsuyama models the intuition of development economists who relate agricultural productivity with industrialization (Nurkse, 1953; Rostow, 1960). Different arguments have been thought about to explain the positive relationship between agricultural productivity and industrialization. A high agricultural productivity releases labour force for urban manufacturing activities. Besides, higher agricultural productivity allows a lower labour force in the rural areas to feed a bigger urban population. Finally, it has also been claimed that high revenues in the agricultural sector contribute to create a domestic demand for industrial products and contribute to generate the savings to finance industrialization. Since durable goods are not included in Matsuyama´s model, it does not capture the savings effect, but it does capture the other effects. Matsuyama states that the direct causation between agricultural productivity and industrialization is valid in the context of a closed economy, but it ceases to be valid, as it will be seen below, in an open economy environment.

To obtain the reduced expression for the manufacturing share in labour demand, n, the expression for the effective government spending, equation (11), is substituted in the previous expression:

$$(13) \qquad \frac{\left[(1-n) - \alpha\theta\, n/\beta\right]\left[1 + (\alpha-\beta)\, n/\beta\right]^{a/(1-a)}}{(1-n)^{(1-\alpha)/(1-a)}} = \frac{\gamma}{\left[(1-\tau)^{1-a}\,\tau^{a}\,\varepsilon^{a} A\right]^{1/(1-a)}} .$$

As it is not possible to obtain an analytical solution for n, it is convenient to analyse the form of the previous expression.

Figure 5: Labour Distribution

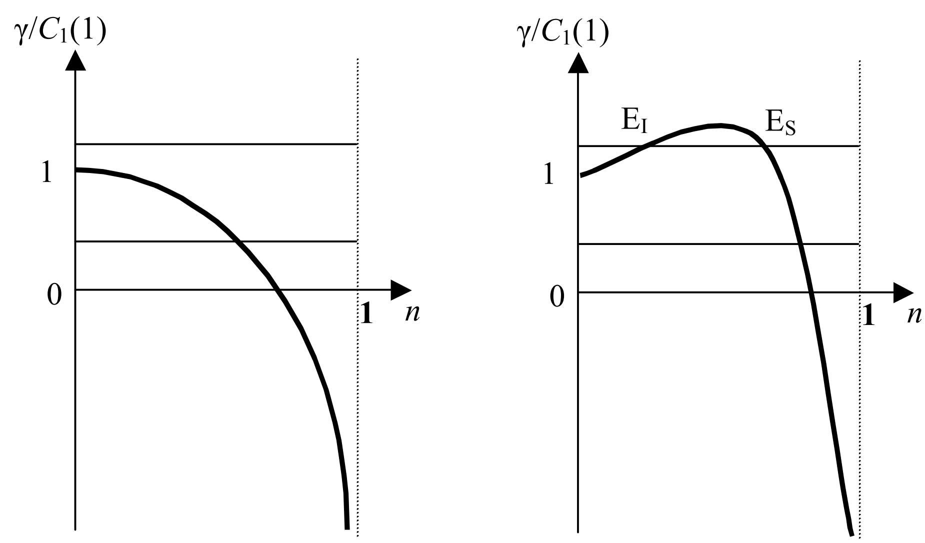


***Figure 5.1:* a $\leq (\beta+\theta)/(1+\theta)$** ***Figure 5.2:* a $> (\beta+\theta)/(1+\theta)$**

The first thing to define is that the right-hand side of equation (13) can be rewritten as $\gamma/C_1(1)$: the ratio of the minimum consumption of the primary good, γ, to the after-tax production of the same good when the whole available labour is devoted to primary activities, $C_1(1)$. This ratio is an index of the economy´s primary capacity (it measures the economy´s ability to fulfil the basic requirements of the population in the extreme case that all resources should be allocated to the primary sector): the higher this ratio the lower the primary capacity of the economy. The ratio $\gamma/C_1(1)$ is measured in the vertical axis of Figures 5.1 and 5.2; it depends on structural parameters of the economy (τ, ε, γ and A); and it is represented by a horizontal line.

The thick line in Figure 5 represents the value of the left-hand side of equation (13) for n between 0 and 1. This value is equal to 1 when $n = 0$; it is nil when $n = \beta/(\beta+\alpha\theta)$, and it tends to minus infinity when n tends to 1. If the impact of effective government spending on primary productivity is relatively weak, a $\leq (\beta+\theta)/(1+\theta) < 1$, the left-hand side of equation (13) is always decreasing in n (Figure 5.1). But if this impact is sufficiently strong, a $> (\beta+\theta)/(1+\theta)$, the left-hand side of equation (13) increases initially with n and decreases afterwards (Figure 5.2).

The first case coincides analytically with Matsuyama´s model because it does not consider any external effect of government spending. The second case, Figure 5.2, does not seem realistic: it implies a big impact of effective government spending on the productivity of the primary sector, and an even bigger impact on the manufacturing sector if the hypothesis that this sector receives the biggest benefits from effective government spending is to be maintained. What seems likely is that external effects from government spending induce a bias in favour of industrialization but the thick line in Figure 5 preserves its negative slope.

The first conclusion obtained from the right-hand side of equation (13) is that the minimum requirements of primary consumption, γ, and the productivity of the primary sector, A, are just two of the decisive factors of labour allocation. The tax rate, τ, and government efficiency, ε, are also decisive factors. So, given τ, ε, γ and A, the labour distribution between the manufacturing sector, n, and the primary sector, $1-n$, is solved. Therefore, in the context of autarchy the government has a role to play in the resource allocation.

Suppose now that these parameters, τ, ε, γ and A, are given. Thus the ratio $\gamma/C_1(1)$ is given and it is represented by a horizontal line in Figure 5. In the first case shown in Figure 5.1 –weak impact of government spending in the primary sector–, there are two possibilities. The economy can be industrialized only if the after-tax production of the primary sector is sufficiently high: the minimum primary consumption requirements can be satisfied allocating all the available labour force to the primary sector: $\gamma/C_1(1) < 1$. If this condition is not fulfilled, $\gamma/C_1(1) > 1$, all available labour is allocated to the primary sector but the society does not even satisfy its basic requirements, and economic growth is nil –it is possibly the situation of some African countries where the low productivity of the primary sector is combined with deficient government action–. This last possibility could take place for several reasons: low productivity of the primary sector ($A \approx 0$), low government efficiency ($\varepsilon \approx 0$), a disastrous fiscal policy ($\tau \approx 0$ or $\tau \approx 1$), or a combination of the previous reasons.

In the second case, see Figure 5.2, the external effects of government spending are strong. If satisfaction of basic requirements is always fulfilled, $\gamma/C_1(1) < 1$, the analysis is exactly equal to the previous one, but in this case industrialization is stronger. If the previous condition is not fulfilled, $\gamma/C_1(1) > 1$ –whenever the inequality is not too big–, the economy finds two equilibria: an inferior equilibrium with low industrialization (E_I), and a superior equilibrium with higher industrialization (E_S). In the inferior equilibrium there would be a poverty trap, because bigger primary productivity, or higher government efficiency induces deindustrialization. In the superior equilibrium the previous analysis is equivalent to the case of Figure 5.1.

Henceforth the possibility of a poverty trap is ignored; it would imply simultaneously several extreme conditions: a very strong impact of government spending in the whole economy, scarce primary productivity, a disastrous fiscal policy, and a mistaken choice of labour allocation. Thus from now on it is assumed that the thick line of Figure 5 –the left-hand side of equation (13)– diminishes with industrialization, *n*. Under this assumption equation (13) implies, like in Matsuyama's 1992 model, that a higher primary productivity induces, *ceteris paribus*, a higher industrialization: $\partial n/\partial A > 0$. As in Barro's 1990 model, equation (13) implies that an optimal tax rate exists: $\tau_{\text{optimal}} = a$, as this tax rate maximizes the expression $(1-\tau)^{1-a}\tau^{a}$ and, *ceteris paribus*, maximizes industrialization of the economy, *n*. In addition, higher government efficiency induces, *ceteris paribus*, higher industrialization: $\partial n/\partial \varepsilon > 0$.

A historical comparison. Japan and South of Korea had efficient governments that invested in education, health, infrastructure, etc. Besides, their governments induced an improvement of agricultural productivity through land reform; if the primary sector experiences a land constraint because of rural property concentration and inadequate use of land, a land reform process may release unused resources and improve agricultural productivity. Thus, land reform may be equivalent to an expansion of the *A* coefficient, the index of primary productivity. According to this model, both government efficiency and improvement in agricultural productivity induce industrialization within a context of autarchy. The situation of Colombia before the "apertura" was completely the opposite: inefficient governments and failed land reforms. Consequently, the model predicts that Colombian industrialization was lower than feasible before the "apertura".

3.5. Economic Growth

The dynamics of the economy is given by the learning process in the manufacturing industry. Combining equations (2) and (3) yields the growth rate of manufacturing productivity:

(14) $$\dot{M}/M = \delta\, n^{\beta}\, (\varepsilon\, g)^{b} > 0\ .$$

As effective government spending, εg, increases with *n*, the growth rate of the industrial productivity increases with industrialization.

In this economy primary production is fixed and manufacturing production increases at the rate given by equation (14). Therefore, industrialization increases social welfare:

$$\dot{U} = \dot{C}_2 / C_2 = \dot{X}_2 / X_2 = \dot{M} / M \ .$$

3.6. Relative Prices

Before proceeding to the analysis of international trade it is necessary to examine how relative prices are determined in the closed economy case. Substituting equation (11) into equation (10) one deduces

$$(15) \qquad \phi(n) \equiv \frac{\alpha\, n^{1-\beta} / \beta}{(1-n)^{(1-\alpha)(1-b)/(1-a)} \left[1 + (\alpha - \beta)\, n / \beta\right]^{(b-a)/(1-a)}} = \frac{p\, M\, (\tau\, \varepsilon)^{(b-a)/(1-a)}}{A^{(1-b)/(1-a)}} \ .$$

Given the restrictions in the model parameters, the function *ϕ(n)* is an increasing function in *n*: *ϕ´(n)* > 0. In fact, when *n* = 0, *ϕ* = 0; and when *n* tends to 1, *ϕ* tends to infinity. Therefore, industrialization implies a higher relative price of the manufactured good, *p*.

4. International Trade

Consider a large quantity of countries that share identical technologies and preferences. It is assumed that marginal productivity of labour is decreasing in both economic activities: $\alpha < 1$, and $\beta < 1$. Given their natural and historical conditions each country possesses characteristic coefficients of productivity *A* and *M*. Likewise, each country defines its coefficients of economic policy. Given the distribution of countries, one may define a representative country whose coefficients of primary and manufacturing productivity are given by *A** and *M**; its level of government efficiency is given by *ε**, and its tax rate is given by *τ**. All countries are small. Therefore, the terms of trade are determined competitively. Suppose that no costs of transport exist and that international migration of labour is forbidden. It is also assumed that no country learns from other people's experience.

Now consider a small country that is initially in autarchy and then opens its doors to the world markets. Its production functions are identical to those of the rest of the world, but they are characterized by some technological and political parameters: *A*, *M*, *ε* and *τ*. The consumer's preferences of this country are identical to those of the rest of the world. The terms of trade are defined for the relative price of the manufacturing good and denoted with the letter *q*.

The rest of the world behaves as the closed economy that was previously analysed. The terms of trade should satisfy equation (15):

$$(16) \qquad \phi(n^*) = \frac{q\, M^* (\tau^* \varepsilon^*)^{(b-a)/(1-a)}}{(A^*)^{(1-b)/(1-a)}} \ .$$

The small country labour allocation should also satisfy equation (15) for the given terms of trade:

(17) $$\phi(n) = \frac{q\,M\,(\tau\,\varepsilon)^{(b-a)/(1-a)}}{A^{(1-b)/(1-a)}} .$$

Eliminating the terms of trade, q, one obtains:

(18) $$\frac{\phi(n)}{\phi(n^*)} = \left(\frac{\varepsilon\ \tau}{\varepsilon^*\tau^*}\right)^{(b-a)/(1-a)} \left(\frac{M}{M^*}\right) \Big/ \left(\frac{A}{A^*}\right)^{(1-b)/(1-a)} .$$

Before analysing the right-hand side of this equation (RHS hereafter), it is useful to deduce the domestic allocation of labour relative to the rest of the world labour allocation. Since *ϕ(n)* is an increasing function in n –the industrialization index–, n is higher than n^* if RHS is higher than 1, n is equal to n^* if RHS is equal to 1, and n is smaller than n^* if RHS is smaller than 1.

In the third case, RHS < 1, which corresponds to an open economy with comparative advantage in primary activities –like the Colombian case–, the domestic economy is less industrialized than the world economy, $n < n^*$. Moreover, this economy grows slowly than the rest of the world:

$$\dot{M}/M = \delta\, n^{\beta}\, (\varepsilon\, g)^{b} < \dot{M}^*/M^* = \delta\,(n^*)^{\beta}\,(\varepsilon^*\, g^*)^{b} .$$

This result is based on the knowledge that economic growth increases with industrialization (section 3.5). Even more, the specialization pattern is reinforced. In order to deduce this result take logarithms of equation (18) and differentiate with respect to time bearing in mind that n^*, A, A^*, ε, ε^*, τ and τ^* are parameters given by the technologies and the economic policy of the country and of the rest of the world. This operation yields:

$$\left(\frac{n\phi'(n)}{\phi(n)}\right)\frac{\dot{n}}{n} = \frac{M}{M} - \frac{M^*}{M^*} < 0 .$$

Since $\phi'(n) > 0$, n decreases in time, thus domestic deindustrialization intensifies and, in consequence, economic growth of the domestic economy is weakened.

This model does not only generate a gap between the growth rate of less industrialized countries and the growth rate of industrialized countries, but also the gap grows in time until reaching a maximum differential. These results are owed to Matsuyama (1992).

Now, let us analyse the factors affecting the allocation of domestic labour in equation (18). Firstly, this equation implies that home allocation at home depends on the country's relative productivities, A/A^* and M/M^*; it also depends on home economic policies compared with external policies, $(\varepsilon\tau)/(\varepsilon^*\tau^*)$. Secondly, equation (18) generates the result that a high relative productivity of primary activities in the country, A >> A*, can induce *ceteris paribus* a specialization of the country in primary activities; this result is contrary, like Matsuyama showed, to the result in autarchy. Under conditions of commercial openness the law of comparative advantage rules; the primary sector competes with the secondary sector for labour, if the primary sector is highly productive it can hire more labour. In the third place, given the external effects of government expenditures, it is not strange that the model yields the possibility that home economic policy plays an active role in allocating resources even under commercial openness. Nevertheless, it must be said that if government spending affects the productivity of sectors in a neutral form, that is the case when coefficients a and b are equal [see equations (1) and (2)], equation (18) is reduced to the equation deduced by Matsuyama in 1992: $\phi(n)/\phi(n^*) = (M/A)/(M^*/A^*)$, which depends exclusively on comparative advantages. In such a case the government cannot affect the domestic allocation of resources. Hence, for a role of the government in allocating resources in a context of international trade, the external impact of government spending on manufacturing productivity should be stronger than the external effect on the primary sector productivity; that is to say, it should be true that b > a, as it was assumed from the beginning.

Then, assuming that the government has a role to play, the country pattern of production and international trade will depend both on relative productivities and relative economic policies. In this situation, the ratio between home primary productivity and international primary productivity, A/A^*, is not as important as the ratio between international industrial productivity and home industrial productivity, M^*/M, because the first one is raised to an exponent lower than 1: $(1-b)/(1-a) < 1$. Besides, a relative improvement in home economic policy efficiency ($\varepsilon/\varepsilon^*$ increases), contribute to compensate the relative advantage of the country in the primary productivity. Finally, it has to be said that a naive reading of equation (18) could lead to the wrong conclusion that it would be optimum for a small country looking for its industrialization in the context of international commercial openness to fix the maximum income tax (100%). However, in the Annex it is proved that for this country the optimal tax rate is $\tau_{\text{optimal}} = a$, as in the closed economy case.

5. The Optimal Command

5.1. External Effects and Inefficiency of the Competitive Equilibrium

This economy involves two types of externalities: the effect of government spending on the economy productivity, and the learning effect of industrial activity on industrial productivity. From the point of view of social welfare, the growth path of the decentralized economy is inferior to the optimal path of growth because firms ignore the external effects in their decisions of labour allocation. Hence, the competitive equilibrium exhibits a scarce industrialization.

To prove the previous statements a function of intertemporal utility is required; only in this way the learning impact of industrial activity on the economy can be valued. For the case it is enough to postulate as an objective function the discounted sum of instantaneous utilities over an infinite horizon:

$$\int_0^\infty e^{-\rho t}\, U(t)\, dt \,, \tag{19}$$

where the instantaneous utility, $U(t)$, is defined by equation (5), and ρ is the discount rate.

Given the complexity of the interactions considered in this model, the calculation of the economy optimal path becomes a mathematically intractable problem. Therefore, with the reader's bow, in this paper the optimal command of this economy is solved only for the particular case in which marginal labour productivity is constant (Ricardian technology).

The sacrifice in generality is compensated with tractable mathematical expressions and a simple allocation of labour in the open economy case.

Before analysing the optimal allocation of resources it is convenient to examine the decentralized equilibrium.

5.2. The Competitive Equilibrium of the Ricardian Economy

The competitive equilibrium of the Ricardian economy corresponds to the peculiar case of the model in which the exponents of labour in the production functions are equal to unity: $\alpha = \beta = 1$. Given the constancy of marginal productivity of labour in the economic sectors, the equilibrium price and effective government spending becomes independent of labour allocation: $p = (A/M)(\varepsilon g)^{a-b}$, and $(\varepsilon g) = (\varepsilon \tau A)^{1/(1-a)}$ [equations (10) and (11) for $\alpha = \beta = 1$]. From equation (13) one deduces that the labour allocation to the manufacturing industry in the Ricardian economy is given by:

(20) $$n_c = n_{max} / (1 + \theta),$$

where n_{max} is the maximum labour allocation to the manufacturing industry, i.e. the labour allocation which is consistent with the satisfaction of the minimum primary good consumption: $C_1(1-n_{max}) = \gamma$. Developing this expression one deduces

(21) $$n_{max} = 1 - \gamma \Big/ \left[(1-\tau)^{1-a} \tau^{a} \varepsilon^{a} A \right]^{1/(1-a)} \leq 1 \ .$$

5.3. The Static Optimisation

A benevolent but shortsighted dictator –subject to Landes criticism– would only allocate labour in order to maximize the representative consumer's instantaneous utility. Substitution of equations (1) and (2), for $\alpha = \beta = 1$, into equations (6) and (7), and these in turn into the instantaneous utility function, equation (5), yields this dictator's objective function:

(22) $$U(t) = \theta \log \left[(1-\tau) A (1-n_t)(\varepsilon g)^{a} - \gamma \right] + \log \left[(1-\tau) M_t n_t (\varepsilon g)^{b} \right].$$

The first order condition for maximization is obtained by differentiating this expression with respect to n_t and equating to 0:

(23) $$\frac{-\theta(1-\tau)A(\varepsilon g)^{a}}{(1-\tau)A(1-n_t)(\varepsilon g)^{a} - \gamma} + \frac{1}{n_t} = 0 \ .$$

Solving for n_t yields exactly the same solution of the competitive equilibrium as defined by equations (20) and (21): n_c. Therefore, the competitive equilibrium of the Ricardian economy is optimal from the point of view of a benevolent dictator who ignores the learning process of the industrial sector. In order to get this solution, use is made of the fact that effective government spending, εg, is constant in this Ricardian economy (see section 5.2). The second order condition for maximization is satisfied automatically by the concavity of the function objective.

5.4. Dynamic Optimisation

A benevolent and completely informed dictator maximizes the intertemporal utility function, equation (19), keeping in mind that utility at time t is defined by equation (22) and that dynamics of industrial learning is given by equation (14). The control variable in the moment t is the labour allocation, n_t, and the state variable is the accumulated experience of the industrial manufacturing sector, M_t, from which the productivity coefficient of the same sector depends on. The Hamiltonian equation related to this problem is the following:

$$H = e^{-\rho t}\left\{\theta \log\left[(1-\tau)A(1-n_t)(\varepsilon g)^{\mathrm{a}} - \gamma\right] + \log\left[(1-\tau)M_t n_t (\varepsilon g)^{\mathrm{b}}\right]\right\} + \lambda_t\left[\delta M_t n_t (\varepsilon g)^{\mathrm{b}}\right],$$

where λ_t is the shadow price of accumulated experience in the industrial activity. It is convenient to recall that effective government spending is constant in this Ricardian economy. Thus the variable εg does not require a time subscript. The first order conditions at moment t for maximization of intertemporal utility are given by the following equations:

(24) $$\partial H / \partial n_t = 0 \;\therefore\; \frac{-\theta(1-\tau)A(\varepsilon g)^{\mathrm{a}}}{(1-\tau)A(1-n_t)(\varepsilon g)^{\mathrm{a}} - \gamma} + \frac{1}{n_t} = -\delta\,\lambda_t\, M_t (\varepsilon g)^{\mathrm{b}} e^{\rho t} \;(< 0),$$

(25) $$-\dot{\lambda}_t = \partial H / \partial M_t \quad \therefore \quad \frac{\dot{\lambda}_t}{\lambda_t} = \frac{-e^{-\rho t}}{\lambda_t M_t} - \delta\, n_t (\varepsilon g)^{\mathrm{b}},$$

(14) $$\dot{M}_t / M_t = \delta\, n_t^{\beta} (\varepsilon g)^{\mathrm{b}}.$$

Moreover, the optimal trajectory of the economy should satisfy the following transversality condition:

(26) $$\lim_{t\to\infty} \lambda_t M_t = 0 .$$

The last four equations determine the optimal growth path. This system of equations has a non-linear structure that prevents its analytical solution. Nevertheless, some results can be obtained. Firstly, comparison of equations (23) and (24) reveals that the optimal labour allocation in a dynamic context –the solution to equation (24)– implies a higher industrialization than the competitive equilibrium –the solution to equation (23)–; this result is easily deduced from the fact that the left-hand side expression of these equations is decreasing in n, the industrialization index. Secondly, in the balanced dynamic equilibrium of this economy all variables should grow at constant rates and labour allocation should be stable, n_o. Consequently the right-hand side expression of equation (24) should be constant along the path of balanced equilibrium. Differentiating this expression with respect to time and equating to 0 yields that the variables λ and M should satisfy the following differential equation along the balanced path equilibrium:

$$\dot{\lambda}_t / \lambda_t + \dot{M}_t / M_t + \rho = 0 .$$

Substituting the equations (14) and (25) in this expression solves for the value of experience along the balanced path equilibrium:

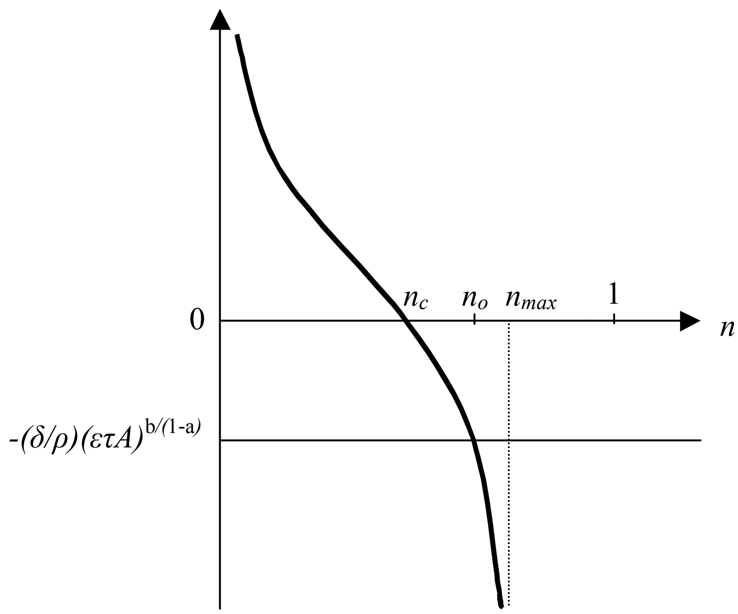
(27) $$\lambda_t M_t = e^{-\rho t} / \rho .$$

This equation shows that the transversality condition is satisfied along the balanced equilibrium: when t goes to infinity the value of experience tends to nil. Besides, by combining equations (24) and (27) it is deduced that the optimal labour allocation along the balanced path equilibrium, n_o, solves the following equation:

$$(28) \qquad \frac{-\theta(1-\tau)A(\varepsilon g)^{\mathrm{a}}}{(1-\tau)A(1-n_{\mathrm{o}})(\varepsilon g)^{\mathrm{a}}-\gamma}+\frac{1}{n_{\mathrm{o}}}=-\frac{\delta}{\rho}(\varepsilon g)^{\mathrm{b}}=-\frac{\delta}{\rho}(\varepsilon\tau A)^{\mathrm{b}/(1-\mathrm{a})}\ .$$

This is a quadratic equation that can be solved explicitly for n_{o}. But it is convenient to show the graphic solution.

Figure 6: Optimal Labour Allocation



The value of the left-hand side expression of equation (28) is represented with the thick line of Figure 6 for n between 0 and n_{max}. The optimal solution for labour allocation is given by the intersection of the thick line with the line that expresses the value of the right-hand side of equation (28). The competitive solution to labour allocation is found where the thick line intersects the horizontal axis [see equation (23)]. Hence the optimal labour allocation to the manufacturing industrial activity is found between the competitive allocation and the maximum allocation: $n_c < n_o < n_{max}$. Thus, the optimal allocation to manufacturing activities increases with the learning capacity of the industrial sector ($\partial n_o/\partial\delta > 0$); it diminishes with the discount rate ($\partial n_o/\partial p < 0$) –impatience does not help industrialization–; it increases with government efficiency ($\partial n_o/\partial\varepsilon > 0$) and also with the productivity of the primary sector ($\partial n_o/\partial A > 0$).

6. Summary and Conclusions

6.1. Inheritances

The model developed in this paper embodies some basic characteristics of Matsuyama's 1992 model of learning-by-doing and comparative advantage, and Barro's 1990 model of government spending. Like in Matsuyama, this model preserves the result that high primary productivity induces industrialization and economic growth under autarchy; on the other hand, comparative advantage of the primary sector induces deindustrialization and a smaller economic growth in the context of an open economy. As in Barro, this model generates the existence of an optimal tax rate; this is equal to the elasticity product of effective government spending in the primary sector. The growth path of the competitive equilibrium is sub-optimal because firms do not take into account the external productive effects of government spending, and the learning effects derived from the manufacturing activity. In this paper the long-run optimal labour allocation is revealed for the special case of an economy with constant labour productivity (Ricardian economy).

6.2. Learning and Government Spending in Autarchy

The analysis of the interaction of both growth mechanisms, the specific object of this paper, permits to conclude that government efficiency induces industrialization of the country under autarchy. Besides, the government may support the trend to industrialization by fixing the optimal tax rate.

Some interpretations based on the model for closed economies follow:

(1) The situation of some African countries can be understood from the point of view of the model as cases of low primary productivity, deficient fiscal policy, and inefficient public administration. As a result the region does not attain an economic take-off and remains trapped in primary activities of low productivity.

(2) Efficient governments, and improvements in agricultural productivity by means of technological change and land reforms, may have enhanced industrialization in Japan and South Korea before they started to export manufacturing goods to the international markets.

(3) Inefficient governments and failure of land reform may contribute to explain the relatively scarce industrialization of Colombia before the "apertura".

6.3. Learning and Government Spending under an Open Trade Regime

The interaction of both learning-by-doing and government spending in an open economy yields the following results. Comparative advantage is the fundamental determinant of resource allocation in a small country. The government may play a role in the country industrialization if and only if the impact of government spending on the industrial manufacturing sector is stronger than it is on the primary sector. An empirical analysis for Colombia support this result (Sanchez et al, 1996).

An interpretation of the Colombian "apertura" in the light of our model follows. It has already been outlined how the failures of the Colombian governments may have prevented a further industrialization process before the commercial openness. This history matters. Based on equation (18), it can be claimed that commercial barriers to foreign competition were lowered before Colombia had the opportunity to accumulate a sufficiently high stock of manufacturing experience: $M/M^* < 1$. The primary comparative advantages were imposed: $A/A^* >> 1$. Besides, low local government efficiency, $\varepsilon/\varepsilon^* < 1$, and unstable fiscal policies –there were almost a fiscal reform every two years during the 1990s–, prevented the governments to compensate the comparative advantage of the primary sector. As a consequence deindustrialization was deepened, and economic growth was weakened.

6.4. Industrial Policy

A dynamic exercise showed that there exists a space for industrial policy in autarchy. Subsidies to the manufacturing industrial production financed with neutral taxes can industrialize the country and induce a higher economic growth. In the context of an open trade regime governments authorities lose control of the allocation of resources; for example, in the case of the Ricardian open economy complete specialization is imposed. Consequently, the comparative advantage of the primary sector can act against any industrial policy.

6.5. Some Warnings

This paper should not be interpreted as a call for protectionism. In the past industrial protectionism gave an opportunity to the Colombian industrial elites to exploit the benefits of the state –subsidies, subsidized credits, partial or total government financing, state covering of the private risk– with no government requirements in terms of technological investment or export targets. Given the protection, it was common for the industrial manufacturing sector to use its market power to raise prices above international levels. Hence, although arguments for protection of strategic infant industries are not inconsistent with our model, it also contains arguments in favour of industrial policies, sound government action for the provision of public goods, adoption of optimal tax schemes, reduction of corruption and other leakages of the government spending policies, and, last but not least, land reform (see the Annex).

Another warning. It is evident that not all countries that open up to international trade can become industrialized countries. In such a case the deterioration of the terms of trade for industrialized countries would be of such a magnitude that some countries would find it convenient to return to primary activities. Therefore, in this model history matters. The first industrialized countries take the lead.

The process of learning-by-doing here modelled is not the learning of a single technology; sooner or later this type of learning is exhausted. Something like this is not consistent with the linear learning technology of equation (3). The learning process should be understood as a process of acquisition of productive abilities in an environment characterized by the introduction of new goods (Lucas, 1988, 1993). In this way, the new products set a permanent learning challenge to the industrial sector. For the case of underdeveloped countries the own innovation may not be important, but the adoption of foreign technologies substitutes the necessity to innovate. This mechanism is also compatible with a linear technology of learning.

Finally, this paper gives a partial explanation of the slowdown of the Colombian economy since 1980. Although this explanation is consistent with the Colombian experience in industrialization and economic growth (see Figures 1 and 2, and Tables 1 and 2), more empirical work is needed. Nevertheless, this paper contributes to build an alternative vision of development that emphasises industrialization and good government as required factors of economic growth.

Annex: The Optimal Tax Rate of a Small Country under an Open Trade Regime

In an open trade regime the manufacturing relative price is given by the terms of trade: $p = q$. The representative consumer allocates his available income, I, between primary goods and manufacturing goods according to the solution of the equation system given by the line of consumption expansion, $C_1 = \gamma + \theta q C_2$ [equation (12)], and the budget constraint, $C_1 + qC_2 = I$. It is easily deduced that both consumption types increase with available income: $C_1 = \gamma + \theta (I-\gamma)/(1+\theta)$ and $C_2 = (1/q)(I-\gamma)/(1+\theta)$. Substituting in the instantaneous utility function, the indirect function of utility is deduced: $U(I,q) = log[\theta^{\theta}/(1+\theta)^{1+\theta}] + (1+\theta)log(I-\gamma) - log(q)$. Instantaneous utility increases with available income. Therefore, since the terms of trade are exogenously determined, the maximization of social welfare depends on the maximization of available income, which is given by the following expression: $I = (1-\tau)(X_1+qX_2)$. Substituting the production functions in the previous expression [equations (1) and (2)], and combining the result with the equation (10) for $p = q$, and the equation (11), it is deduced that available income is given by

$$I = \left[(1-\tau)^{1-a}\tau^{a}\varepsilon^{a}A\right]^{1/(1-a)}\left[\frac{1+(\alpha-\beta)n/\beta}{(1-n)^{1-\alpha}}\right]^{1/(1-a)}.$$

Consequently, the tax rate that, *ceteris paribus*, maximizes available income and social welfare is given for $\tau_{\text{óptimal}} = a$, as in the case of the country in autarchy. The last expression also shows that even under an open trade regime the country obtain gains from a higher primary productivity, A. Thus, land reform is a desirable objective even after the “apertura”.

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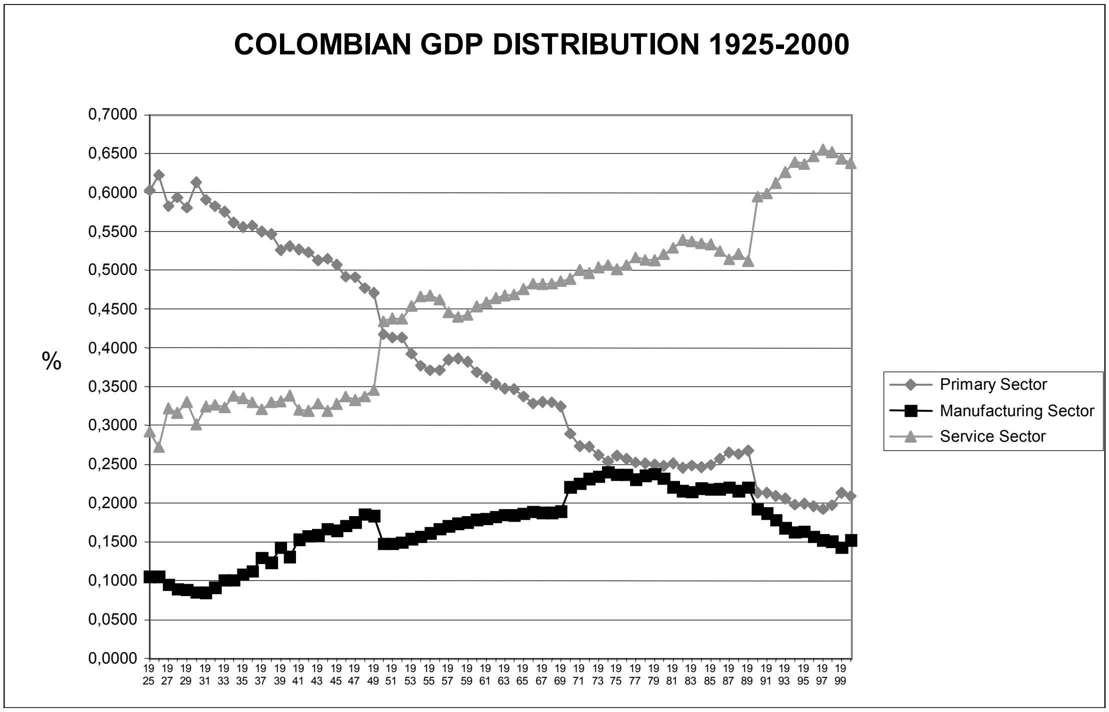
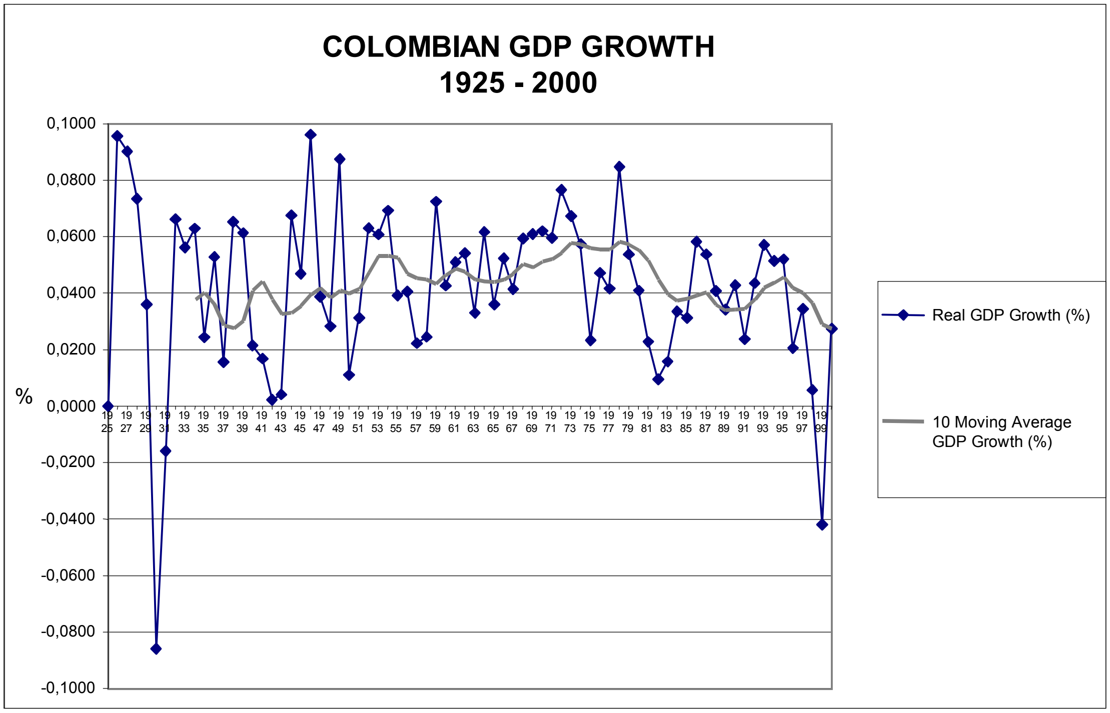
Figure 1



Source: DNP (1998), DNP statistics (in www.dnp.gov.co) and DANE statistics (in www.dane.gov.co).

Figure 2



Source: DNP (1998), DNP statistics (in www.dnp.gov.co) and DANE statistics (in www.dane.gov.co).