De-industrialization and Trade

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Abstract

This paper extends the Dornbusch-Fisher-Samuelson (1977) model to explain de-industrialization and trade; this extension follows Baumol's (1967) intuition on the service sector and growth. We show that trade improves welfare through the exploitation of the comparative advantages but accelerates the shift toward service slowing down the rate of growth. Trade can decrease welfare if manufacturing activities with learning-by-doing move abroad. In this case, some experience is lost and all countries lose.

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1. Introduction

The relationship between de-industrialization and the expansion of trade in all the industrialized economies have interested economists for a long time; the aim of this paper is to show how an extension of the standard Ricardian model with a continuum of goods can explain the relationship between de-industrialization and trade, and the welfare consequences of these structural changes.

The manufacturing sector has been contracting and the service sector expanding in all the industrialized economies in the recent decades.[1] In the US, the shares of employment in manufacturing and of manufacturing products over total production both reached a peak in 1966; the absolute number of workers in manufacturing reached a peak in 1979, see table 1.

[1] The concept of service industry has a long tradition in economics going back to Smith (for the history of services in economics see Delaunay and Gadrey, 1992). In this paper, I use the definition of the 'MIT dictionary of economics' where services are defined as untagible goods which are 'consumed' at the point of production and which are usually non-transferable.

For a review of the current trend toward services in developed and developing countries, see Wieczoreck, 1995.

Table 1: The decline of manufacturing

Country	**(a)**	**(b)**	**(c)**
West Germany	36.6 (1970)	33.6 (1969)	1970
France	27.2 (1974)	26.7 (1974)	1974
Italy	28.1 (1974)	32.6 (1980)	1980
Netherlands	27.9 (1962)	21.6 (1973)	1965
Belgium	31.3 (1964)	26.3 (1973)	1965
United Kingdom	33.1 (1960)	30.5 (1969)	1961
United States	26.1 (1966)	25.9 (1966)	1979
Japan	27.3 (1973)	35.4 (1980)	1973

Note: brackets show the year when the peak was realized.
(a) Share of manufacturing in employment in the peak year.
(b) Share of manufacturing in production in the peak year.
(c) Year of peak employment in manufacturing.
Source: Petit (1986).

Nowadays, in Australia, Canada, Sweden, United Kingdom, and United States, services account for more than 70 % of total employment (OECD statistics) and the trend is continuing. Economists have been discussing the causes of this structural movement toward a service economy for a long time. The conclusion of this long-lasting investigation is that the demand for services is inelastic to price so that the increase of the relative price of services has increased the share of income spent on services. Summers (1985), using the data from the Kravis-Heston-Summer tables, has estimated the demand for services in a cross-section analysis for 34 countries;[2] he has found that price elasticity of services is very low and not

[2] The countries are: Malawi, Kenia, India, Pakistan, Sri Lanka, Zambia, Thailand, Philippines, Korea, Malaysia, Colombia, Jamaica, Syria, Brazil, Romania, Mexico, Yugoslavia, Iran, Uruguay, Ireland, Hungary, Poland, Italy, Spain, U.K., Japan, Austria, Netherlands, Belgium, France, Luxembourg, Denmark, Germany, and the United States. The year used is 1975.

significantly different from 0, while the income elasticity is around 1.[3]

The growing importance of services in the industrialized economies has also drawn the attention to the issue of the productivity in the service sector. Several studies have found that services have experienced a lower productivity growth than other industries. Fuchs (1968) estimates that the average productivity gap for the period $1929 - 1965$ was about 1.1 percent for the United States, Kendrick (see Inman, 1985) finds that this gap was 1.9 for the period $1948 - 1981$, Bernard and Jones (1996), using different measures of productivity, find a gap of 1.2 percent for 14 $OECD$ countries in the period $1970 - 1987$. The output measurement of service sectors is quite problematic. Griliches (1992) analyzes several service sectors separately and finds that productivity could be under-estimated in some service sectors. In the present paper, we do not investigate this issue and we build on the conclusion of the studies mentioned before that services have on average a lower productivity than manufacturing.

The two stylized facts on the growing importance of services and on their smaller productivity growth are the starting point of the analysis of Baumol. His seminal paper about unbalanced growth (1967) explains how a sector with lesser

[3] These results reject the alternative hypothesis that the demand for services is non-homothetic so that an increasing income would be responsible for the increasing share of services.

productivity growth increasingly drives down the growth of the whole economy; the only necessary condition is that the demand for the products of that sector be inelastic to price. The reasoning is: technological progress, which is supposed to be bigger in manufacturing than in services, lowers the relative cost of manufacturing goods; the consumers will consume more services, which are inelastic to price. With time, the process drives more workers to the service sector and the growth of the economy, which is simply a weighted average of the two sectors, will slow down. This idea, discussed by Baumol almost thirty years ago, when the shift toward services was just beginning, seems to have become reality for the most developed economies.

The general public and politicians are very concerned about the dangers of de-industrialization. Trade with poor countries is often considered as a factor that accelerates de-industrialization in the rich countries because the wage differential between rich and poor countries would induce national manufacturing industries to move overseas. Following this idea, some economic historians have ascribed Britain's relative economic decline after world war II to the loss of manufacturing industries (see Rowthorn and Wells, 1987). The debate is often peppered with considerations about "international competitiveness": losing the manufacturing sector means less growth in the long run or dependence on foreign imports for strategic sectors.

The purpose of this paper is to develop a model in which the links between the long-term movement toward a service economy and the effects of international trade (and consequent specialization) are considered explicitly. Trade, through comparative advantages, lowers the price of tradeable goods (largely manufacturing goods) and increases the real income of the trading partners. If the demand for services is inelastic to price, the share of income spent in services increases. This effect leads to a slower rate of growth, as in Baumol (1967).

The paper is structured in the following way. Section 2 extends a model of closed economy á la Baumol to an open economy in which countries trade because the technology used in their tradeable sectors is different; section 3 extends the model to consider learning by doing; section 4 concludes.

2. Model

We base our model on an extension of the standard Ricardian model with a continuum of goods as in Dornbusch-Fischer-Samuelson (D-F-S), 1977. The Ricardian approach provides a convenient way to analyze technological progress because there is just one factor of production and technological progress can be specified in a neutral way without committing to labor or capital-saving technological progress.

Our main departure from the standard model is the use of a *C.E.S.* utility function to introduce non-traded goods. The motivation for introducing non-traded goods in trade models is well known (see the 'Scandinavian models' in Dornbusch, 1980): there are sheltered goods that have high transportation costs such that trade is impossible; there are services (haircutting, housing, retailing, etc.) that typically cannot be traded internationally; and, finally, there are products that are protected by an explicit commercial policy (i.e. prohibitive tariffs on many articles). For sake of simplicity, we identify non-traded goods with services.

The motivation for using a *C.E.S.* utility function is that empirical evidence shows that services are inelastic to price; a Cobb-Douglas utility function would imply a unitarian elasticity.

2.1. Closed economy

Suppose an economy with a constant population normalized to 1 and with continuous time. There are two groups of goods: services, which are non-tradeable, and manufactured goods, which are tradeable;[4] neither type of goods can be stored.

[4] This is a simplifying hypothesis because there are many services that are actually traded and some manufactured goods which are not traded.

Services are homogeneous goods and are indicated by S_t. Manufactured goods are not homogeneous and M_t is the utility coming from the consumption of manufactured goods.

All the individuals share the same utility function and are endowed with a unit of labor per period, which they sell inelastically. The welfare function of the representative agent at time t is W_t:

$$W_t \equiv \int_0^{\infty} U_t e^{-\eta t} \mathrm{d}t$$

where η is the discount rate and U_t is the utility function with two tiers. At the first level, there is a *C.E.S.* utility function that has as arguments non-traded goods (S_t) and the utility from traded goods (M_t):

$$U_t \equiv \left(M_t^{\rho} + S_t^{\rho}\right)^{\frac{1}{\rho}} . \tag{2.1}$$

We assume that the elasticity of substitution between manufacturing and services $\left(\frac{1}{\rho-1}\right)$ is less than 1 in absolute value, or, equivalently, that $\rho < 0$, along with the empirical evidence mentioned before.

The second tier of the utility function is given by the sub-utility function for

M_t:

$$M_t \equiv e^{\int_0^1 \beta_z \ln(m_{zt}) \mathrm{d}z}. \tag{2.2}$$

Where m_{zt} represents the quantity of goods z consumed at time t, and the goods are indexed by z (with $0 \leq z \leq 1$). The function $\beta(z)$ has the following properties:

- $\int_0^1 \beta_z \, dz = 1$,
- $\beta_z > 0$.

The index of prices for the manufacturing sector is defined in this way:[5]

$$p_{mt} \equiv K e^{\int_0^1 \beta_z \ln(p_{zt}) \mathrm{d}z} \tag{2.3}$$

where K is a constant equal to $e^{-\int_0^1 \beta_z \ln(\beta_z) \mathrm{d}z}$.

The supply side is quite simple because both kinds of goods are produced using just labor in fixed proportion:

$$S_t = L_{st} \qquad m_{zt} = a_{zt} L_{zt}. \tag{2.4}$$

Where L_{st} is the labor force employed in services and L_{zt} is the labor force used in the production of the goods z. We define L_t as the amount of labor force which

[5] The derivation of the price index is in Appendix A.

is employed in manufacturing in equilibrium $\left(\equiv \int_0^1 L_{zt}\mathrm{d}z\right)$. Note that $(1 - L_t)$ is the amount of labor force employed in services in equilibrium, given that the total population is normalized to 1. In both sectors there is perfect competition and constant return to scale, so prices are equal to their marginal and average costs.

The manufacturing sector experiences exogenous technological progress that is equal for each manufactured good:

$$\frac{\dot{a}_{zt}}{a_{zt}} = g_m > 0 \qquad 0 \leq z \leq 1. \tag{2.5}$$

The service sector does not experience technological progress. This simplification is convenient but not necessary; the only important condition for the results is that the manufacturing sector has a rate of technological growth greater than that of the service sector.

2.1.1. Equilibrium in a closed economy

The supply side determines the relative prices of manufactured goods and services, given the fixed coefficients of production and perfect competition. The wages are normalized to 1, so that the price of services is 1, and the price of the variety z of manufactured goods is $\frac{1}{a_{zt}}$.

The demand side determines the quantities produced; we use the index of prices of the manufactured goods defined in eq. 2.3 to find the quantities demanded. Maximizing eq. 2.1 yields the following condition:

$$\left(\frac{M_t}{S_t}\right)^{\rho-1} = p_{mt}. \tag{2.6}$$

Substituting in the budget constraint ($1 = p_{mt}M_t + S_t$) yields the total demand for the manufactured goods:

$$M_t = \frac{1}{p_{mt} + (p_{mt})^{\frac{1}{1-\rho}}} \tag{2.7}$$

The demand for services, which is equivalent to the labor force in services, is:

$$S_t = \frac{1}{1 + (p_{mt})^{\frac{\rho}{\rho-1}}} \tag{2.8}$$

We define the rate of growth of the economy as the rate of growth of the income at constant prices:

$$g_t \equiv \frac{\dot{M}_t p_{mt} + \dot{S}_t}{M_t p_{mt} + S_t} \tag{2.9}$$

Substituting in the formula above yields:[6]

$$g_t = g_m L_t. \tag{2.10}$$

The rate of growth of the closed economy slows down as less people work in the manufacturing sector.

Substituting eq. 2.7 and eq. 2.8 in eq. 2.1 yields the indirect utility function:

$$U_t = \left[1 + p_{mt}^{\frac{\rho}{\rho-1}}\right]^{\frac{1-\rho}{\rho}} \tag{2.11}$$

The utility function is bounded between 0, when the relative price of manufactured goods is high, and 1, when the relative price of manufactured goods is low. The instantaneous utility function is increasing monotonically with time because p_{mt} decreases. Figure C.1 in the appendix shows the evolution of utility over time.

2.2. Open economy

In this section, we introduce trade between two countries, North and South; we use an asterisk to denote the variables which refer to the foreign economy, the South. The two countries share the same preferences ($\rho = \rho^*$ and $\beta_z = \beta_z^*$) and

[6] The derivation is in Appendix B.

have the same technology for services but have different comparative advantages in manufacturing goods ($a_{zt} \neq a^*_{zt}$). We also allow for the two countries to have different populations: the population of the North is normalized to 1, while the population of the South is k. As before, L_t is the number of workers employed in the manufacturing sector at home. L^*_t is the ratio of workers employed in the manufacturing sector over total workers abroad, so that $L^*_t\ k$ is the number of workers employed in the manufacturing sector abroad.

The equilibrium with trade is given by two conditions: first, production must be split according to comparative advantages; second, trade must be balanced. These two conditions determine the range of goods produced in the North and in the South, and the relative wages between North and South. We define ω_t as the wage of the South in terms of the wage in the North $\left(\omega_t = \frac{w^*_t}{w_t}\right)$. Note that ω_t is also the ratio between the wages since the wage at home is normalized to 1.

We give a couple of useful definitions before finding the equilibrium conditions. We conveniently rank the manufacturing goods in order of diminishing home country comparative advantage; the relative unit labor requirement is:

$$A(z) \equiv \frac{a^*_{zt}}{a_{zt}} \tag{2.12}$$

with $\frac{\partial A(z)}{\partial z} > 0$. If $\frac{a_{zt}}{w_t} < \frac{a^*_{zt}}{w^*_t}$, or $\omega_t < A(z)$, the good z is produced in the South; the curve $\omega_t = A(z)$ defines the relatives wages that make it indifferent to produce the good z in the North or in the South; this curve gives us the first equilibrium condition as shown in Figure C.2 in the appendix. If both countries have the same rate of technological progress in the manufacturing sector, $A(z)$ does not change over time.

We define $\vartheta(\bar{z}_t)$ as the fraction of the expenditure in manufacturing spent on goods in the interval $[0, \bar{z}_t]$: $\vartheta(\bar{z}_t) \equiv \int_0^{\bar{z}_t} \beta_z \, \mathrm{d}z$. The condition for balanced trade is that the domestic demand for imports of manufactured goods is equal to the foreign demand for manufactured goods produced at home. Note that the income spent on manufacturing goods is equal to the income earned by the workers employed in this sector.[7] This consideration allows a simplification because the total expenditure in manufacturing is equal to the payroll of manufacturing workers which is L_t at home and $\omega L^*_t k$ abroad. The balanced trade condition is:

$$[1 - \vartheta(\bar{z}_t)] \, L_t = \vartheta(\bar{z}_t)\omega_t L^*_t k. \tag{2.13}$$

[7] This is not a hypothesis, it is rather a consequence of the fact that there is just one factor of production and there are no profits; therefore, all the expenditure on manufacturing goods must be equal to the payroll of the workers employed in manufacturing

This equation does not imply a monotonous relation between $\vartheta(\bar{z}_t)$ and ω_t because L_t and L_t^* are not constant as ω and $\vartheta(\bar{z}_t)$ change, in contrast with Dornbusch-Fischer-Samuelson, 1977. In fact, an increase in ω_t implies a rise of the relative price of manufactured goods in terms of services at home and a decrease of the relative price of manufactured goods in terms of services abroad; since the demand of manufactured goods is inelastic to price, the share of expenditure on manufacturing goods increases at home and decreases abroad. For sufficiently low the elasticity of demand, it is possible that the balanced trade curve (given implicitly by eq. 2.13) is upwards sloping; we assume that the Marshall-Lerner conditions are satisfied and that the curve is monotonically downwards sloping.

The intersection of the two curves $\omega_t = A(z)$ and $\omega_t = \left[\frac{1-\vartheta(\bar{z}_t)}{\vartheta(\bar{z}_t)}\right] \frac{L_t}{L_t^*} \frac{1}{k}$ gives the equilibrium values of $\bar{z}_t$ and ω_t (Figure C.2 in the appendix). Given that all the goods in the interval $[0, \bar{z}_t]$ are produced at home and all the goods in the interval $[\bar{z}_t, 1]$ are produced abroad, the prices of the manufactured goods after trade in terms of domestic wages are:

$$\bar{p}_{zt} = \begin{cases} \frac{1}{a_{tz}} & z \in [0, \bar{z}_t] \\ \frac{\omega_t}{a_{tz}} & z \in [\bar{z}_t, 1]. \end{cases} \tag{2.14}$$

The price level at home for the manufactured goods after trade ($\bar{p}_{mt}$) is:

$$\bar{p}_{mt} = K e^{\int_0^1 \beta(z)\ln(\bar{p}_z)\mathrm{d}z} \tag{2.15}$$

$$= K\left(e^{\int_0^{\bar{z}_t} -\beta(z)\ln(a_{zt})\mathrm{d}z} * e^{\int_{\bar{z}_t}^1 -\beta(z)\ln(\frac{a^*_{zt}}{\omega_t})\mathrm{d}z}\right). \tag{2.16}$$

The ratio between the price after trade ($\bar{p}_{mt}$) and the price before trade (p_{mt}) is:

$$\frac{\bar{p}_{mt}}{p_{mt}} = \frac{e^{-\int_{\bar{z}_t}^1 \beta(z)\ln(\frac{a^*_{zt}}{\omega})\mathrm{d}z}}{e^{-\int_{\bar{z}_t}^1 \beta(z)\ln(a_{zt})\mathrm{d}z}} = e^{\int_{\bar{z}_t}^1 \beta(z)(\ln a_{zt} - \ln\frac{a^*_{zt}}{\omega})\mathrm{d}z} < 1 \tag{2.17}$$

because $\left(\frac{1}{a^*_{zt}}\omega_t\right)$ is smaller than $\left(\frac{1}{a_{zt}}\right)$ in the interval $[\bar{z}_t, 1]$.

The labor used in the manufacturing sector at home is:[8]

$$\bar{L}_t = \frac{1}{1+\bar{p}_{mt}^{\frac{\rho}{1-\rho}}}. \tag{2.18}$$

The labor force in the manufacturing service is less after trade ($\bar{L}_t < L_t$) because of the hypothesis on the elasticity of the utility function ($\rho < 0$) and the fact that $p_{mt} > \bar{p}_{mt}$.

The de-industrialization in the closed economy happens because technological

[8] The derivation for the labor used in manufacturing in trade is analogous to the derivation used for the closed economy.

progress makes manufactured goods cheap; given that demand is inelastic to price, that increases the share of income spent on services. In the open economy, trade makes a range of manufactured goods even cheaper because of the exploitation of comparative advantages. Note that the shift of demand from manufacturing to services is due to the change in relative prices and not to the non-homotheticity of the demand. That is in line with the empirical results described by Summer, 1985.

The effect of trade would be even bigger if the elasticity of substitution within the manufactured goods sector were more than 1; in this case the price index of manufactured goods would decrease further and the share of income spent on services would increase even more.

The rate of income growth at the opening of trade is lowered immediately by the changes in relative prices between manufactured goods and services, and the reallocation of the labor force to services; its evolution afterwards is more complex because it depends on the rate of technological innovation, as in the closed economy, and on the dynamics of the price of the imported goods. The price of imports depends on the relative wages, which are determined by the balanced trade condition (eq. 2.13).

In contrast with Dornbusch-Fischer-Samuelson (1977), the ratio between the size of the manufacturing sectors at home and abroad, $\frac{\bar{L}_t^*}{\bar{L}_t}$, is not constant. Rewriting this ratio using eq. 2.18 and the fact that the price for manufactured goods abroad in term of foreign wages is $\frac{\bar{p}_{mt}}{\omega_t}$:

$$\frac{\bar{L}_t^*}{\bar{L}_t} = \frac{1+\bar{p}_{mt}^{\frac{\rho}{1-\rho}}}{1+\bar{p}_{mt}^{*\frac{\rho}{1-\rho}}} = \frac{1+(\frac{1}{\bar{p}_{mt}})^{\frac{\rho}{\rho-1}}}{1+(\frac{\omega_t}{\bar{p}_{mt}})^{\frac{\rho}{\rho-1}}}. \tag{2.19}$$

Plugging 2.19 in eq. 2.13 yields:

$$\frac{1-\vartheta(\bar{z}_t)}{\vartheta(\bar{z}_t)} = \frac{1+(\frac{1}{\bar{p}_{mt}})^{\frac{\rho}{\rho-1}}}{1+(\frac{\omega_t}{\bar{p}_{mt}})^{\frac{\rho}{\rho-1}}}\omega k. \tag{2.20}$$

Suppose the home country has higher wages ($\omega_t < 1$); as $\bar{p}_{mt}$ decreases as a result of technological progress, the ratio $\frac{\bar{L}_t^*}{\bar{L}_t}$ rises and the balanced trade curve moves downwards.

The movement of the balanced trade curve changes the initial equilibrium (Figure C.3 in the appendix): the range of goods produced domestically shrinks and the relative wage abroad declines. With time, the market share of the home country ($\vartheta(\bar{z}_t)$) shrinks as a result of the declining foreign wage.

2.3. Growth and welfare considerations

The opening of trade is beneficial for both countries because they have immediate static gains from the exploitation of the comparative advantages. The indirect utility, which is computed as in the case of autarchy, is:

$$\overline{U}_t = \left[1 + \bar{p}_{mt}^{\frac{\rho}{\rho-1}}\right]^{\frac{1-\rho}{\rho}} \tag{2.21}$$

Given that $\bar{p}_{mt} < p_{mt}$, it follows that $\overline{U}_t > U_t$ for every t. Figure C.4 shows the evolution of utility in either country with trade and without trade. Given that technological progress is exogenous, both countries are better off with trade, at any point in time. The next section extends the model to the case where technological progress is endogenous.

3. Learning by doing

This section introduces dynamic scale economies through learning by doing. The motivation to introduce learning is that empirical studies such as Bernard and Jones (1996*b*) show that different manufacturing sectors show little evidence of convergence in productivity across countries and countries seem to specialize and to improve productivity in the sectors in which they specialize.

We introduce dynamic scale economies in the same manner as Krugman (1987). Let's first define the index of cumulated experience K_{zt} that depends on the past domestic and foreign cumulated productions:

$$K_{zt} = \int_{-\infty}^{t} (m_{z\tau} + \delta m^{*}_{z\tau}) d\tau \tag{3.1}$$

where $0 \leq \delta \leq 1$.[9] The parameters a_{zt} and a^{*}_{zt}, which define the productivity of a country in a specific sector z, are no longer exogenous but depend on the past cumulated production:

$$a_{zt} = K^{\epsilon}_{zt} \qquad \text{and} \qquad a^{*}_{zt} = K^{*\,\epsilon}_{zt} \tag{3.2}$$

where $0 < \epsilon < 1$. The dynamic scale economies change the comparative advantages because the country that is currently producing a manufactured good increases its technological advantage in the production of that manufactured good. The rate of technological progress in the production of good z at home is given

[9] For the foreign country, the cumulated experience is given by the analogous expression: $K^{*}_{zt} = \int_{-\infty}^{t} (m^{*}_{z\tau} + \delta m_{z\tau}) d\tau$.

by differentiating a_{zt} with respect to time:

$$\dot{a}_{zt} = \varepsilon K_{zt}^{\epsilon-1}\,\dot{K}_{zt} \tag{3.3}$$

$$\dot{a}_{zt} = \varepsilon K_{zt}^{\epsilon}\frac{(m_{z\tau}+\delta m_{z\tau}^{*})}{K_{zt}} \tag{3.4}$$

$$g_{zt} \equiv \frac{\dot{a}_{zt}}{a_{zt}} = \varepsilon\frac{(m_{z\tau}+\delta m_{z\tau}^{*})}{K_{zt}} \tag{3.5}$$

Current production at home, $m_{z\tau}$, and abroad, $m_{z\tau}^{*}$, increases the technological progress in the production of good z, g_{zt}, at home. The coefficient ε measures the efficiency of the learning process. Foreign production is included to take care of the possible international spill-over, δ measures the strength of these spill-over. If $\delta = 1$, the curve $\omega = A(z)$ does not change because there is no country-specific learning ($g_{zt} = g_{zt}^{*}$ for every z); in this case, the analysis is the same as in the previous section; for this reason, we just consider the case $0 \leq \delta < 1$. If $\delta = 0$, the curve $\omega = A(z)$ moves because the technology evolves at different speed in the two countries ($g_{zt} \neq g_{zt}^{*}$); the parameter ε magnifies the speed of change. The analytical treatment of the case with endogenous productivity growth is quite complicated; however, the graphical treatment is quite simple and useful.

The introduction of endogenous productivity growth affects curve A in figure C.5: the section $(0, \bar{z}_t)$ of the A curve, which corresponds to the goods produced at home, moves downwards, while the section $(\bar{z}_t, 1)$ moves upwards. The magnitude of international spill-over (δ) and of the learning process (ε) determine the speed of this splitting; if $\delta = 1$, the curve does not change at all because the comparative advantages do not change; if $\delta = 0$, the two pieces of the curve move fast apart. The bigger ε is, and the bigger the effect of learning is.

In contrast with Krugman (1987), also the curve B moves because the relative prices of manufactured goods change in both countries.[10] This can change the pattern of specialization over time; each time the pattern of specialization changes the not-transferable experience is lost.

Two different factors determine the evolution of the terms of trade: the learning-by-doing which crystallizes the current patterns (curve A) and the change of the relative demands for tradeable goods (curve B). The welfare implications depend on which effect is prevalent. As the relative demands for manufactured goods change and the curve of balanced trade moves, the relative wage of the South must go down to maintain the trade balanced.[11] If the curve B moves downwards faster than the curve A upwards, the relative wages decrease, the pattern of trade

[10]Note that in Krugman (1987) changes of specialization are due to changes in economic policy or to exogenous factors such as natural resources, while here they are due to an internal dynamic of the model.

[11]ω_t is the ratio between the two nominal wages. The real wages actually converge, since in the long run, consumers in both countries spend an increasing share of income in the service sector where productivity is the same in the two countries.

shifts and the South starts producing some goods that were previously produced by the North, i.e. $\bar{z}_t$ moves to the left.[12] The learning that was accumulated in the production of the range of goods that were previously produced in the North and now are produced in the South, namely the goods between $\bar{z}_t'$ and $\bar{z}_t''$ in the Figure C.5, is dissipated. The loss is proportional to $(1-\delta)$, the fraction of learning by doing which is not transferable.

The possibility of a loss depends on the slope of the curve A; if the initial ratio of productivity between the two countries is almost the same for different goods, the curve A is initially almost flat and the possibility that the pattern of trade changes is higher. Conversely, if the two countries have well defined comparative advantages, the curve A is steep and the possibility of a change in the terms of trade is lower.

When the patterns of trade change and some experienced is lost, the rate of growth of utility slows down compared to the case of exogenous technological progress. This effect could be so strong that the utility in autarchy may be higher than the utility in trade after a certain period. Figure C.6 illustrates this extreme case by comparing the evolution of the utility of North in the case of autarchy and in the case of trade from time 0. At time 0, the utility with trade is higher than the

[12] International trade also contributes to growth by concentrating production in one country.

utility in autarchy; however, the rate of growth of the utility with trade could be significantly lower if the pattern of trade changes as in Figure C.6. Even if the two curves cross, this does not mean that autarchy dominates trade because welfare depends on the discounted some of future instantaneous utility. In the short-run, when the static comparative advantages dominate, the utility with trade is certainly higher than the utility in autarchy; the possible crossing happens only after a certain time, and the possible decrease in utility must be discounted with the discount rate η. A higher discount rate reduces the weight of possible future losses. We focused the analysis on the North, but analogous considerations hold for the North. In particular, it is worth noting that both countries lose when some experience is lost.

Summarizing, trade can have negative effects on welfare in the context of this model if: 1) learning experience is not transferable, i.e. if δ is small; 2) relative productivity differences are almost the same for all goods, i.e. where $A(z)$ is almost identical for all goods; 3) the elasticity of services to price is low, i.e. the curve B shifts rapidly; 4) the discount rate is very low, i.e. η is small.

4. Summary and conclusions

The model shows how non-traded goods *without* a unitary elasticity of substitution (e.g. without using the unitary elasticity implicit in the Cobb-Douglas function) can explain important stylized facts on growth and trade. The data on the demand for services justify the assumption that the price elasticity of services is quite low.

Trade, through comparative advantages, lowers the price of tradeable goods. The share of income spent on services increases, given that the demand for services is inelastic to price. This effect leads to a higher level of welfare and to a slower rate of income growth. Afterwards, the home country increases the consumption of services more rapidly than the foreign country; this shifts the balanced trade curve and decreases the wages abroad relatively to the domestic wages. This creates further de-industrialization because the home country loses some border industries in favor of the less developed country as a consequence of higher wages. The de-industrialization itself effect does not decrease welfare if the technological progress is exogenous; if, however, the technological progress is endogenous, the de-industrialization decreases welfare because some sectors where the home country enjoys accumulated experience are moved abroad. The overall effect of trade on welfare depends on a variety of supply and demand factors such as: the extend to which the learning experience is not transferable, relative productivity differences are almost the same for all goods, the elasticity of services to price, and the discount rate. We should stress that the welfare losses due to de-industrialization are of second order with respect to the gains from trade.

This paper shows the richness of the conclusions that can be obtained form the standard D-F-S model by introducing non-traded goods in a non-trivial way building on the existent empirical literature on services. Future research should focus on evaluating empirically the extend, if any, of these possible welfare losses.

A. Price index

The price index for manufactured goods p_{mt} is defined by:

$$\text{index of price of manufactured goods} \equiv p_{mt} = \frac{E_t}{M_t} \tag{A.1}$$

where M_t is the utility of manufactured goods, E_t is the expenditure in manufactured goods, and p_{mt} is the price index. In this appendix, we drop the subscript for the time since every variable is contemporaneous.

First, we show that the property of the Cobb-Douglas that the proportion of income spent on a certain good is constant $\left(\beta_z = \frac{p_z m_z}{E}\right)$ holds also in the case of continuum of goods. We use the first order conditions of the utility coming from the consumption of manufactured goods $\left(\max M_t \text{ s.t. } \int_0^1 p_z m_z dz = E\right)$:

$$e^{\int_0^1 \beta_z \ln(m_z)\mathrm{d}z} \frac{\beta_z}{m_z} = \lambda p_z. \tag{A.2}$$

λ is eliminated by taking the ratio between F.O.C.'s for any two different goods ($m_{z''}$ and $m_{z'}$):

$$\frac{m_{z''} p_{z''}}{\beta_{z''}} \beta_{z'} = p_{z'} m_{z'}. \tag{A.3}$$

Integrating over z' both sides yields:

$$\frac{m_{z''} p_{z''}}{\beta_{z''}} \int_0^1 \beta_{z'} \mathrm{d}z' = \frac{m_{z''} p_{z''}}{\beta_{z''}} = \int_0^1 p_{z'} m_{z'} \mathrm{d}z' \equiv E. \quad \blacksquare \tag{A.4}$$

Going back to eq. A.1 and plugging $m_z p_z = \beta_z E$ from eq. A.4:

$$\begin{aligned} p_m &= \frac{E}{M} = \frac{E}{e^{\int_0^1 \beta_z \ln(m_z)\mathrm{d}z}} && \text{(A.5)} \\ &= \frac{E}{e^{\left(\int_0^1 \beta_z \ln(E)\mathrm{d}z + \int_0^1 \beta_z \ln \beta_z \mathrm{d}z - \int_0^1 \beta_z \ln(p_z)\mathrm{d}z\right)}} && \text{(A.6)} \\ &= \frac{E}{E e^{\int_0^1 \beta_z \ln(\beta_z)\mathrm{d}z} e^{-\int_0^1 \beta_z \ln(p_z)\mathrm{d}z}} = e^{\int_0^1 \beta_z \ln(p_z)\mathrm{d}z} K && \text{(A.7)} \end{aligned}$$

where K is $e^{-\int_0^1 \beta_z \ln(\beta_z)\mathrm{d}z}$ (note that K is a constant because depends only on the parameters of the utility function).

B. Rate of growth

The rate of growth of output at constant prices is defined as:

$$g_t \equiv \frac{\dot{M}_t p_{mt} + \dot{S}_t}{M_t p_{mt} + S_t} \tag{B.1}$$

Total expenditure ($M_t p_{mt} + S_t$) must be equal to total wages which is 1 given that the labor force is 1 and the wage is normalized to 1. So that B.1 can be simplified to:

$$\begin{aligned}
g_t &= p_{mt}\dot{M}_t + \dot{S} && \text{(B.2)}\\
&= p_{mt}\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{1}{p_{mt} + p_{mt}^{\frac{1}{1-\rho}}}\right) + \frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{1}{1 + p_{mt}^{\frac{\rho}{\rho-1}}}\right) && \text{(B.3)}\\
&= -\left[1 + \frac{1}{1-\rho}p_{mt}^{\frac{\rho}{1-\rho}} + \frac{\rho}{\rho-1}p_{mt}^{\frac{\rho}{1-\rho}}\right]\frac{1}{\left[1 + p_{mt}^{\frac{\rho}{1-\rho}}\right]^2}\frac{\dot{p}_{mt}}{p_{mt}} && \text{(B.4)}\\
&= -\frac{1}{\left[1 + p_{mt}^{\frac{\rho}{1-\rho}}\right]}\frac{\dot{p}_{mt}}{p_{mt}} && \text{(B.5)}
\end{aligned}$$

The term $\dot{p}_{mt}$ is:

$$\begin{aligned}
\dot{p}_{mt} &= K\frac{\mathrm{d}}{\mathrm{d}t}\left(e^{\int_0^1 \beta_z \ln(p_{zt})\mathrm{d}z}\right) = Ke^{\int_0^1 \beta_z \ln(p_{zt})\mathrm{d}z}\int_0^1 \beta_z \frac{\dot{p}_{zt}}{p_{zt}}\mathrm{d}z && \text{(B.6)}\\
&= -Ke^{\int_0^1 \beta_z \ln(p_{zt})\mathrm{d}z}\int_0^1 \beta_z g_m \mathrm{d}z = -p_{mt}g_m && \text{(B.7)}
\end{aligned}$$

Substituting the expression for $\dot{p}_{mt}$ in B.7:

$$g_t = \frac{1}{1 + p_{mt}^{\frac{\rho}{1-\rho}}}g_m \tag{B.8}$$

Note that the labor force in manufacturing is:

$$L_t = 1 - S_t = \frac{1}{1 + p_{mt}^{\frac{\rho}{1-\rho}}} \tag{B.9}$$

Therefore, the rate of growth can be expressed as:

$$g_t = L_t g_m \tag{B.10}$$

The evolution of the rate of growth is:

$$\begin{aligned} \dot{g}_t &= \dot{L}_t \, g_m = -\frac{\rho}{1-\rho} \frac{(p_{mt})^{\frac{\rho}{1-\rho}-1}}{\left[1+p_{mt}^{\frac{\rho}{1-\rho}}\right]^2} g_m \, \dot{p}_{mt} && \text{(B.11)} \\ &= \frac{\rho}{1-\rho} L_t^2 p_{mt}^{\frac{\rho}{1-\rho}} g_m^2 && \text{(B.12)} \end{aligned}$$

which is negative because $\rho < 0$.

C. Figures

Figure C.1: utility over time

Figure C.2: static equilibrium with trade

Figure C.3: dynamic equilibrium with trade

Figure C.4: utility with exogenous technological progress

Figure C.5: dynamic equilibrium with endogenous technological progress

Figure C.6: utility with endogenous technological progress

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