The Determination and Development of Sectoral Structure

by

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Abstract.
The development over time of sectors in terms of value added and employment has common characteristics in all economies. We develop a simple Ricardian multi-sector general equilibrium model that allows for (i) non-unitary income elasticities, (ii) different paces of technological progress per sector, and (iii) endogenously determined technological progress per sector. A model with these ingredients allows us to replicate the sectoral developments that are found empirically, and which are shown to be the outcome of an interplay between factors of demand and supply. Under reasonable assumptions, deindustrialization is shown to be a natural and unavoidable consequence of increases in the wealth of nations.

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1. Introduction

Developments in the sectoral composition of countries share several common characteristics. Most pronounced in terms of sectoral changes are the reallocations of labour that take place as countries grow richer. Countries typically start with a large agricultural sector and end up with a large service sector. In the meantime, manufacturing employment follows a hump-shaped pattern. Developments in sectoral shares measured in GDP at constant prices are much less pronounced. The share of manufacturing in GDP measured at constant prices remains roughly constant. The agricultural share shows some tendency to decline, whereas the service sector has gradually increased its share. This latter change has taken place despite the continuously rising relative prices of services.[1] The existence of a

[1] There is a rich and mainly descriptive literature on the development of sectoral shares that we do not discuss here. This literature goes back to, amongst others, Chenery and Syrquin (1975) and Kuznets (1966). This literature has attempted to find normal patterns in the development of economies over time. We refer here to Van Gemert (1985) for an extensive overview and discussion of this literature as well as an empirical test of the normal-pattern hypothesis. The main emphasis in this paper is on theoretical models aiming to explain the

strong link between the degree of economic maturity and the structure of employment was already pointed out by Sir William Petty in 1691 and restated by Clark (1957, p. 492) when he wrote that ‘A wide, simple and far-reaching generalisation ... [is that] as time goes on and communities become more economically advanced, the numbers engaged in agriculture tend to decline relative to the numbers in manufacture, which in their turn decline relative to the numbers engaged in services’. How can these tendencies be explained and reconciled? This is the central question that we will address in this paper.

A topic that has gathered particular attention in the debate on sectoral developments is which factors are responsible for the observed drastic decline in manufacturing employment in the last 25 years. This decline, often referred to as deindustrialization, has recently been discussed in relation to increased unemployment in Europe and increased income inequality in the USA. At least five basic explanations for this experience of deindustrialization are available. The first relies on differences in productivity growth on a sectoral level. If productivity in the manufacturing sector is relatively fast-growing, less and less labour is required to produce a given relative amount of products. For this explanation to be relevant, goods produced in the broad sectors defined above need to be relatively bad substitutes. A second explanation relies on the operation of Engel’s law. If the income elasticities of the demand for goods produced in different sectors are unequal, the share of the sector producing the goods with the highest income elasticity has a tendency to increase as countries grow richer. A third explanation relies on the integration of the South and the North, resulting in the South specializing towards low-skilled labour-intensive manufacturing goods. Fourthly, and related to the third explanation, changing ‘endowments’ can play a role. Assuming, for example, that services are relatively skill-intensive and that the accumulation of skills is a particularly fast process in OECD countries may explain why OECD countries specialize in (tradeable) services and are experiencing a decline in manufacturing employment. Finally, outsourcing (or contracting out) of activities previously carried out within the manufacturing sector but now performed in the service sector or abroad may be part of the explanation (see

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empirical tendencies that we observe.

for example Feenstra and Hanson (1995) and De Groot (1998)).[2]

In a seminal theoretical contribution on the macroeconomics of unbalanced growth, Baumol (1967) studied the consequences of differences in productivity growth rates between sectors (known as differential productivity growth) for macroeconomic developments. Differential productivity growth rates are labelled as 'forces so powerful that they constantly break through all barriers erected for their suppression' (Baumol (1967, p. 415)). Based on a simple Ricardian model with only two sectors, one stagnant with zero productivity growth and one progressive with positive productivity growth, he concludes that the cost per unit of the stagnant sector will rise without limitation. This creates a tendency for demand to shift in favour of goods produced in the progressive sector. If, however, goods from different sectors are bad substitutes, more and more labour must be transferred to the non-progressive sector. Which tendency ultimately dominates in the determination of the sectoral composition of the economy depends on the evolution of consumers' preferences as income increases. The macroeconomic growth rate will ultimately tend to converge to the growth rate of the stagnant sector. The implications of this very simple model have become to be known as the 'cost disease of stagnant services'.

One of the objections which can be raised against Baumol's model is that its main focus is on supply factors (i.e., differential rates of productivity growth). Although Baumol considers the special cases in which (i) consumers spend constant shares of their income on all categories of goods available, and (ii) relative demand in volume terms for both goods categories is constant, he does not discuss in detail the importance of demand factors. Pasinetti (1981, p. 69) stresses the importance of considering both factors of demand and supply for a good understanding of macroeconomic sectoral

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[2] Recent empirical contributions on the driving forces behind deindustrialization are Rowthorn and Ramaswamy (1997) and Saeger (1997). Based on a panel of 21 industrial countries, the first two authors argue that there is evidence for a non-linear relationship between per capita income and the manufacturing share of employment. Furthermore, they conclude that the manufacturing share of employment is significantly affected by the trade balance in manufactured goods. They find little evidence of an important role of North-South trade in explaining the decline in manufacturing employment. A similar exercise is performed by Saeger. Based on panel data for OECD countries, he examines the relationship between deindustrialization and productivity growth, Dutch disease, human capital accumulation, and trade flows. Differential productivity growth and the Dutch disease account for about 40% of deindustrialization in the majority of countries, while about 25% is explained by North-South trade.

developments when he argues that '... to pretend to discuss technical progress without considering the evolution of demand would make it impossible to evaluate the very relevance of technical progress and would render the investigation itself meaningless. Increases in productivity and increases in income are two facets of the same phenomenon. Since the first implies the second, and the composition of the second determines the relevance of the first, the one cannot be considered if the other is ignored'. This point was taken seriously by, for example, Quibria and Harrigan (1996). They extended the model of Baumol by introducing a constant elasticity of substitution utility function. Their simple model allows them to replicate what they consider to be the stylized facts of sectoral developments, namely the rising relative prices of service goods, a rising share of service employment in total employment, a rising share of services in the value share of national income (in current prices), and a non-increasing share in the national real product. To arrive at these results, they assume the presence of differential productivity growth and a substitution elasticity of demand between services and manufacturing goods that is less than unity.

Although these simple two-sector models give interesting insights in the role of factors of demand (i.e. preferences) and supply (i.e. technological progress) in shaping sectoral structures, they are by definition not capable of capturing the type of sectoral development processes described at the beginning of this introduction. So in order to capture and explain these developments, multi-sectoral (i.e., more than two-sector) models are needed. In addition, the previously discussed models are simple one-factor models. Some recent attempts have been undertaken to fill these gaps. Most complete in this are Echevarria (1997) and Kongsamut, Rebelo and Xie (1997).[3] Again focusing on the regularities with respect to the growth process and the associated reallocation of labour, they develop three-sector models including capital as a factor of production. Their dynamic general equilibrium models are characterized by (i) different and non-unitary income elasticities of demand for goods from the distinguished sectors during the

[3] Three-sector models with only one production factor are developed in Cornwall and Cornwall (1994), and Rowthorn and Ramaswamy (1997). Both studies are able to replicate rich dynamics of structural change, but lack a clear and simple system of demand equations derived from optimizing consumer behaviour. In addition, the study by Rowthorn and Ramaswamy does not consider relative price changes. The importance of price effects in shaping sectoral structures is considered (explicitly) by Schettkat and Appelbaum (1997).

transition to the long-run equilibrium of the model, and (ii) differences in the exogenously given rate of technological progress on a sectoral level. A combination of these two elements results in models characterized by rich dynamics in structural change that are able to replicate empirically observed dynamics. The sectoral economic growth rates of labour productivity are given exogenously and attention is restricted to models where the elasticity of substitution between goods from different sectors is unity in the long-run equilibrium, implying constant sectoral employment shares and shares in nominal GDP in the long-run.

Given this state of affairs, the main goal of this paper is to develop a simple Ricardian model that allows us to understand part of the developments that take place on a sectoral level. We abstain from trade-based explanations of the observed trends and instead focus on differential productivity growth and increased maturity as potential candidates for explaining observed trends in sectoral developments. The model that we develop allows for non-unitary income elasticities of demand, non-unitary substitution elasticities between goods from different sectors, differential productivity growth (i.e., different paces of technological progress on a sectoral level), and endogenously determined technological progress on a sectoral level resulting from learning by watching. Previously performed studies that develop Ricardian models (in particular, Baumol (1967), Matsuyama (1992), and Quibria and Harrigan (1996)) are shown to be special cases of the general model developed in this paper. Compared to other existing studies (e.g., Gundlach (1994), and Rowthorn and Ramaswamy (1997)) our model has the advantage that it is derived from a well-specified system of demand-equations that is derived from optimizing consumer behaviour with clearly specified utility functions.

This paper proceeds as follows. Section 2 illustrates the developments in sectoral shares, employing the OECD International Sectoral Data Base (1997). The similarity of the trends for the countries under consideration suggests that structural factors are at play. We develop a simple Ricardian model in section 3 that allows us to explain how developments as described in section 2 may come about as the outcome of an interplay between factors of demand and supply. To get a good feeling for the fundamental mechanisms that are at play, we present a two-sector version of the model in section 4. In section 5 we discuss the characteristics of a multi-sector variant of the model. This will be done against the background of the empirically found regularities. We conclude in section 6.

2. Empirical evidence

In this section, we briefly present and discuss some trends in sectoral developments in advanced countries. These trends are well-established in the literature (see for example Maddison (1991 and 1995), Van Ark (1996), Echevarria (1997), and Kongsamut, Rebelo and Xie (1997)). Our empirical investigation covers three countries (USA, Germany, and Japan)[4] and three sectors (agriculture, manufacturing and the service sector) over the period 1960-1995. Data were taken from the OECD International Sectoral Data Base (1997). We refer to the OECD (1997) for details on sectoral composition and construction of the data. The agricultural sector contains ISIC group 1 and includes hunting, forestry and fishing. Manufacturing contains ISIC group 3 (a broad aggregate of manufacturing industries). The service sector contains ISIC group 6 (wholesale and retail trade, restaurants and hotels), group 8 (finance, insurance, real estate and business services) and group 9 (community, social and personal services).[5]

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[4] We deliberately restrict the attention to these large and relatively closed economies in the hope that we can safely assume that developments are only to a small extent the result of external developments and are not strongly related to patterns of specialization. Other countries included in the ISDB are France, Italy, United Kingdom, Canada, Australia, Belgium, Denmark, Finland, Netherlands, Norway, and Sweden. From the inspection of patterns of development of small open economies, one can conclude that patterns of specialization play a sometimes important role in explaining developments of sectoral shares of these countries. In the Netherlands, for example, the 1980s have witnessed an increase in the GDP-share at constant prices of the agricultural sector which is likely to be due to relative specialization. Furthermore, developments in energy-intensive sectors were strongly influenced by the oil-crisis in the 1970s, whereas developments in the construction sector are strongly influenced by population growth and reconstruction after World War II. Since these developments are to a large extent the result of period-specific shocks, we omitted these sectors from the analysis.

[5] We omitted the transport- and communication sector from the aggregate of the service sector for reasons of heterogeneity. The communication sector is among the fastest growing sectors (in terms of labour productivity). This holds true for all countries. This sector could therefore, in our opinion, better be considered as a high-tech (manufacturing) sector than a service sector (Baumol, Blackman and Wolff (1989) label this kind of sectors as 'technologically progressive'). The distinction they make between technologically progressive and stagnant activities is based on intrinsic attributes of activities like the ease of standardization and the ease of formalizing the production process in a set of easily replicable instructions.

< Insert Figures 1-3 around here >

Time series for shares in total employment of sectoral employment levels, as well as shares in the total of domestic GDP measured in national currencies in constant prices of 1990, and in current prices, are depicted in Figures 1-3. From these data, we can establish the following trends:

1. Employment shares in the agricultural sector are declining, while they increase in the service sector. In Japan, we see a hump-shaped pattern of development of manufacturing employment, whereas manufacturing employment shares monotonously decline in the USA and Germany. Considering data over longer time periods reveals that the absence of increasing manufacturing employment shares in Germany and the USA is due to the advanced level of development already achieved at the starting point of our time series (e.g., Maddison (1991)). Based on an empirical study, Rowthorn and Ramaswamy (1997) establish that manufacturing employment shares reach their peak at a per capita income of approximately $8185 measured in 1986 US dollars (achieved by many European countries in the 1960s and in the USA around the 1950s).[6]
2. In current prices, the share of services in GDP is increasing, while it is decreasing in the agricultural and manufacturing sector.
3. In constant prices, the share of manufacturing in GDP is roughly constant, with the exception of Germany where it is slightly decreasing since the early seventies. The agricultural share in GDP at constant prices is slightly decreasing in Germany and the USA, and decreasing in Japan. Developments of these sectoral shares are less pronounced than those in GDP at current prices. The share of services in constant prices is increasing over time.[7]

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[6] This result is obtained by regressing the employment share in the manufacturing sector on (the logarithm of) GDP in constant prices (both linear and quadratic) and the overall trade balance in a pool of 21 industrial countries over the period 1960-1973. From the estimated regression coefficients corresponding to GDP, the peak of manufacturing employment as a function of GDP can be derived.

[7] Note that the overall evidence on the development of sectoral shares in constant prices of especially the service sector is inconclusive (see Quibria and Harrigan (1996)), and that there are measurement problems with respect to price indices that are not resolved in a satisfactory way according to, e.g., Kravis, Heston and Summers (1983).

As we have already argued, differential productivity growth between sectors is a potential candidate for explaining at least part of these developments. In Table 1, average annual growth rates of labour productivity over the period 1960-1995 in the respective sectors are given. Productivity is defined as value added at constant market prices of 1990 divided by total employment.[8] The pattern that emerges is that growth rates of labour productivity are largest in the agricultural sector and lowest in the service sector. The exception is productivity growth in Japan in the agricultural sector which is below productivity growth in manufacturing (Japan, Australia, and Canada are the only countries for which data are available in the ISDB in which growth in the agricultural sector is lower than in manufacturing).

Table 1 Average labour productivity growth 1960-1995 (in %)

	Agriculture	Manufacturing	Services
Germany	6,11	3,02	2,49
Japan (since 1970)	3,20	3,73	2,65
USA	2,89	2,46	0,80

Similar exercises as those performed for these three countries have been performed for all other countries available in the ISDB, and also for other subsectors of the economy. Inspection of these data reveals that trends are similar for all countries, and that the hump-shape in employment shares in the manufacturing sector is found for other countries (provided that countries start at a relatively low level of per capita income).

Having established what we consider the main trends in sectoral developments, we will now develop a simple Ricardian model which allows us to study the respective roles of demand and supply factors (i.e., preferences and technological opportunities) in shaping the sectoral composition of an economy.

[8] Ideally, one would like to measure productivity in hours, but the quality of these data, especially on a sectoral level, is so low that we restrict our attention to productivity in terms of employment. This could seriously affect our conclusions if *changes* in hours worked differ considerably between sectors. Since no data are available in the ISDB, there is no way to check how serious this bias is (hours per person are reported in the ISDB on sectoral levels, but they are taken to be equal to hours worked on a macroeconomic level!).

3. A simple model

In this section, we develop a model of an economy that consists of S production sectors, indexed i=1,...,S. Production in these sectors takes place under perfect competition and there is only one factor of production, namely labour (L), which is fully employed. We normalize the amount of labour at 100 so that we can conceive sectoral employment shares as percentage-shares in total employment. Consumer preferences are such that goods from all sectors are consumed. Income elasticities of demand may differ for goods from different sectors due to the presence of differing subsistence requirements. Labour productivity grows with a rate that is partly exogenous and partly depends on the scope for learning by watching. We will characterize the solution of the model in terms of the allocation of labour over the production sectors of the economy.

The objective of the representative consumer in our model is specified as

$$\max_{C_i} C = \left[\sum_{i=1}^{S} a_i \left(C_i - \overline{C}_i \right)^{\rho} \right]^{1/\rho} \text{ where } \rho < 1,\ \rho \neq 0,\ \ C_i > \overline{C}_i \geq 0,\ \text{ and } \sum_{i=1}^{S} a_i = 1, \qquad (1)$$

where C is the consumption index, C_i is the consumed amount of goods from sector i, $\overline{C}_i$ is the subsistence requirement of consumption, and a_i is a distribution parameter. In the absence of subsistence requirements, 1/(1-ρ) is the elasticity of substitution between goods from different sectors. The budget constraint corresponding to this problem is

$$C P_C = \sum_{i=1}^{S} C_i P_{Ci} \leq wL \equiv Y, \qquad (2)$$

where P_C is the macroeconomic price index, P_{Ci} is the price of a good produced in sector i, w is the nominal wage rate which is equal for workers in all sectors, and Y is nominal income. Four remarks with respect to the choice of the utility function deserve attention. Firstly, the introduction of subsistence requirements in the utility function is an easy way of allowing for non-unitary income elasticities of demand that can differ between sectors. Secondly, a minor disadvantage of a utility function with subsistence requirements is that it is undefined for levels of C_i lower than $\overline{C}_i$, and marginal utilities go to infinity as C_i approaches $\overline{C}_i$ from above (e.g., Echevarria (1997)). This problem is not serious, assuming as we will do that countries are sufficiently advanced that they can fulfil their subsistence requirements (i.e., $\sum \overline{C}_i / h_{i0} < L$, where h_{i0} is the productivity level at time t=0). Thirdly, there is no need to assume $\overline{C}_i$ to be non-negative on theoretical grounds, but it gives these values a simple interpretation as subsistence requirements (e.g., Deaton and Muellbauer (1980)). Finally, in the special case in which $\rho \to 0$, the utility function boils down to a Stone-Geary utility function.[9]

Formulating the Lagrangian corresponding to optimization problem (1) and performing standard optimization yields demand for goods from sector i as a function of prices (see Appendix)

$$C_i = \overline{C}_i + \left(\frac{P_{Ci}}{a_i}\right)^{\frac{1}{\rho-1}} \frac{\left[Y - \sum_{j=1}^{S} P_{Cj}\overline{C}_j\right]}{\sum_{j=1}^{S} P_{Cj}\left(\frac{P_{Cj}}{a_j}\right)^{\frac{1}{\rho-1}}}. \tag{3}$$

The income elasticity of demand can be derived as

$$\frac{\partial C_i}{\partial Y}\frac{Y}{C_i} = \frac{Y}{\overline{C}_i \sum_{j=1}^{S} P_{Cj}\left(\frac{P_{Cj}}{P_{Ci}}\frac{a_i}{a_j}\right)^{\frac{1}{\rho-1}} + \left[Y - \sum_{j=1}^{S} P_{Cj}\overline{C}_j\right]}. \tag{4}$$

This expression reveals how sectoral demand changes if nominal income Y increases with one percent, keeping everything else constant. If there are no subsistence requirements, income elasticities are equal to one. The income elasticity of good i is larger when its subsistence requirement is smaller. A larger subsistence requirement of good j lowers the income elasticity of good i.

Producers of the consumption goods operate under perfect competition and produce with a constant returns to scale technology, only using labour which has labour productivity h_i . The production function

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[9] To be more precise, evaluating equation (1) at $\rho \to 0$ by taking logs on both sides and applying l'Hôpital's rule reveals that the optimization problem in the case where $\rho \to 0$ boils down to

$$\max_{C_i} C = \prod_{i=1}^{S} \left(C_i - \overline{C}_i\right)^{a_i} \;\; s.t. \;\; CP_C = \sum_{i=1}^{S} C_i P_{Ci} \le wL.$$

With no subsistence requirements, a Stone-Geary utility function becomes a standard Cobb-Douglas utility function. We refer to Klump and Preissler (1997) for an extensive discussion on the characteristics of various forms of CES-functions that are used in the literature.

thus looks like

$$C_i = h_i L_i . \tag{5}$$

Due to perfect competition, the price of the consumption good of sector *i* equals

$$P_{Ci} = \frac{w}{h_i}. \tag{6}$$

From this point onwards we take the wage rate as numeraire (*w*=1 so *Y*=*L*).

Finally, we propose the following 'engine of growth' describing the development of labour productivity

$$\frac{dh}{dt} = h_i g_i = h_i \left(\overline{g}_i + \xi_i L_i \right), \tag{7}$$

where $\overline{g_i}$ is the exogenously given part of the rate of technological progress. The parameter ξ captures in a stylized way the importance of 'learning by watching' in each sector (compare Matsuyama (1992)). This is the most simple way of incorporating an element of endogenous growth in the model. In this view, growth (partly) occurs because of workers working together and becoming better in producing by looking at each other's productive performance. The scope for learning, and thus for growth, is in this view determined by the amount of people working together in a particular sector. Knowledge results as an unintended by-product of producing. We use the term learning by watching instead of learning by doing since in our engine of growth, it is the number of workers that can learn from each other that matters for growth, and not the mass of products produced by these workers. This distinction is important for the following reason. One of the arguments put forward by Baumol (1967) as to why (exogenous) growth in manufacturing is persistently larger than in services is that scale effects are operating in this sector. It is important to be precise on the meaning of scale in this context. Scale may matter in the sense that the volume of production matters for growth (implying that learning by doing matters), but it may also matter in the sense that the number of producers is a driving force behind growth (implying that learning by watching matters). In this paper, we take the latter approach.

The model is now complete and we can establish the allocation of labour over sectors as a function of sectoral productivity levels by substituting the production function (5) and the price-equation (6) into the demand-equation (3)

$$L_i = \frac{\overline{C}_i}{h_i} + h_i^{\frac{-\rho}{\rho-1}} a_i^{\frac{-1}{\rho-1}} \frac{\left[L - \sum_{j=1}^{S} \frac{\overline{C}_j}{h_j} \right]}{\sum_{j=1}^{S} \left(h_j^{\frac{-\rho}{\rho-1}} a_j^{\frac{-1}{\rho-1}} \right)}. \qquad (8)$$

The complete model is now essentially reduced to equations (7) and (8) and we can study the characteristics of the model in more detail. This will be the topic of the next two sections.

4. The two-sector version of the model

In this section, we consider the model in a two-sector context (S=2). This serves two goals. First, it gives a feeling for the basic forces that are at play in shaping the sectoral composition of economies. This will be useful for understanding the developments in a multi-sector version (i.e. more than two) of the model which will be discussed in section 5. Secondly, it makes clear that existing two-sector Ricardian models on growth and sectoral structure developed previously can be seen as special cases of the model developed in this section.

Starting from equation (8), we can derive employment shares in a two-sector economy as

$$L_1 = \frac{\overline{C}_1}{h_1} + h_1^{\frac{-\rho}{\rho-1}} a_1^{\frac{-1}{\rho-1}} \frac{\left[L - \left(\frac{\overline{C}_1}{h_1} + \frac{\overline{C}_2}{h_2} \right) \right]}{h_1^{\frac{-\rho}{\rho-1}} a_1^{\frac{-1}{\rho-1}} + h_2^{\frac{-\rho}{\rho-1}} a_2^{\frac{-1}{\rho-1}}}, \quad L_2 = L - L_1. \qquad (9)$$

The number of cases we can now analyze is large, depending on the assumptions with respect to (i) the presence of subsistence requirements ($\overline{C_i}$), (ii) the presence of (differentiated) exogenous technological progress ($\overline{g_i}$), (iii) the presence of learning by watching (captured by ξ_i), and (iv) the elasticity of substitution between goods of the two sectors (which is related to ρ). Table 2 gives a classification of previous studies by Baumol (1967), Matsuyama (1992), and Quibria and Harrigan (1996), and of the two additional cases we will explicitly consider in this section.[10] The analysis of additional cases is deliberately restricted to the two basic cases of Stone-Geary preferences (ρ→0), and CES-preferences in which we allow for both exogenous and endogenous technological progress (assuming away the existence of subsistence requirements for simplicity). Discussion of the other cases one can consider does not yield additional insights as they are straightforward combinations of the two basic cases we present.

Table 2 Classification ofcases in the two-sector variant of the model

	$\overline{C_i}=0, \xi_i=0$	$\overline{C_i}>0, \xi_i=0$	$\overline{C_i}=0, \xi_i>0$	$\overline{C_i}>0, \xi_i>0$
ρ→0	Baumol (1967)	This section	-	Matsuyama (1992)[11]
ρ<0	Quibria and Harrigan (1996)	-	This section	-
ρ→-∞	Baumol (1967)[12]	-	-	-

In the case of a Stone-Geary utility function (ρ→0), we can describe the development of sectoral labour shares over time by taking the derivative of

[10] Table 2 does not contain a classification on the basis of exogenous growth rates. In all cases that we consider we assume that the exogenous growth rates are positive and different between the two sectors under consideration, unless otherwise stated.

[11] Matsuyama (1992) looks at a very special case in that he assumes (i) a Stone-Geary utility function, (ii) exogenous growth in both sectors to equal zero, (iii) an agricultural sector which has a positive subsistence requirement and no technological progress, and (iv) a manufacturing sector which has endogenous technological progress, but no subsistence requirements. This combination of assumptions results in a constant sectoral allocation of labour. Matsuyama was well aware of the specificity of his assumptions and acknowledges that his result depends on the absence of growth in the agricultural sector and the assumption of a Stone-Geary utility function. This will be further explained in the remainder of this section.

[12] Due to the choice of the utility function in our model, we obtain the result that consumption shares in constant prices are equal (C_i=C_j) under Leontief-preferences (ρ→-∞). This result would not obtain once instantaneous utility would be specified as $\left[\Sigma\left[a_i\left(C_i-\overline{C}_i\right)\right]^{\rho}\right]^{1/\rho}$. In this case, however, expenditure shares would be equal in the case of Cobb-Douglas preferences$(\rho \to 0)$.

equation (9) with respect to time. The development of sectoral employment shares is then derived as

$$\frac{dL_1}{dt} = \frac{-dL_2}{dt} = \frac{-\overline{C}_1 g_1}{h_1} + a_1\left[\frac{\overline{C}_1 g_1}{h_1} + \frac{\overline{C}_2 g_2}{h_2}\right]. \tag{10}$$

Employment in sector 1 has a tendency to decrease due to the fact that increased productivity growth results in less labour being needed to produce subsistence requirements (captured by the term $-\overline{C_1}g_1 / h_1$). On the other hand, more labour becomes available for the production of goods over which consumers have discretionary choice. This amount of labour ($\overline{C_1}g_1 / h_1 + \overline{C}_2 g_2 / h_2$) is divided over the two sectors according to the distribution parameter a_i. So due to this effect, employment in sector 1 increases with an amount equal to $a_1\left[\overline{C}_1 \overline{g}_1 / h_1 + \overline{C}_2 g_2 / h_2\right]$. It is evident from this expression that when *each* sector is characterized by the absence of productivity growth *or* the absence of subsistence requirements (or both), the allocation of labour is constant over time. In more general cases in which there is at least one sector with both subsistence requirements *and* growth, the allocation of labour is no longer constant. Changes in relative prices due to different growth rates are then no longer exactly offset by equiproportionate and opposite changes in relative demand, which results in changing allocations of labour.

Table 3 summarizes all possibilities that can emerge in the two-sector version of the model with a Stone-Geary utility function, and the associated developments of the employment share in sector 1 (L_i/L). We restrict the attention to cases with exogenously given sectoral growth rates.[13] As time approaches infinity, the share of sector 1 in total employment (L_1/L) will converge to a_1. This is explained since less and less labour is needed to produce subsistence requirements as time proceeds. In the limit, all labour is employed for the production of goods over which consumers have

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[13] The results reported in Table 3 also apply in the case of endogenous technological progress, provided that the growth rates satisfy the restrictions on the growth rates indicated in the upper row at any point in time. When growth is absent in both sectors of the economy, employment in sector 1 equals $\overline{C}_1 / h_{10} + a_1\left[L - \overline{C}_1 / h_{10} - \overline{C}_2 / h_{20}\right]$. In the case where one of the growth rates equals zero (say g_2), the equilibrium amount of labour in sector 1 converges to $a_1\left(L - \overline{C}_2 / h_{20}\right)$. The equilibrium amount of labour in sector 1 is then a constant fraction a_1 of the amount of labour that is ultimately left after subsistence requirements of sector 2 in which there is no growth have been produced.

complete free choice.

Table 3 Development of employment share in sector 1 over time (ρ→0)

	$\bar{g}_1 > \bar{g}_2$	$\bar{g}_1 < \bar{g}_2$
$a_1 \bar{C}_2 \bar{g}_2 / h_{20} > (1-a_1)\bar{C}_1 \bar{g}_1 / h_{10}$	increasing	hump-shape
$a_1 \bar{C}_2 \bar{g}_2 / h_{20} < (1-a_1)\bar{C}_1 \bar{g}_1 / h_{10}$	U-shape	decreasing

Note: h_{10} is the value of labour productivity in sector 1 at time t=0.

With relatively large subsistence requirements in sector 2 (the upper row in Table 3), the employment share in sector 1 starts to increase. To understand this, it is important to recall that there are two opposite forces that affect employment shares. Shares are *positively* affected by the fact that productivity growth increases the amount of labour that is available for the production of consumption goods over which consumers have free choice. They are *negatively* affected by the fact that less labour is needed to produce subsistence requirements due to growth of labour productivity. With relatively large subsistence requirements in sector 2, the former effect more than offsets the latter effect and employment in sector 1 increases at time t=0. If the growth rate of sector 1 is relatively high, the relative weight of the latter effect (which was already minor) declines relatively fast and employment in sector 1 continues to rise. If, however, productivity growth in sector 2 is relatively high, the importance of the former force decreases at a relatively fast rate and at some point in time, the reduction of employment in sector 1 due to the reduced amount of labour needed to produce subsistence requirements will start to dominate.[14] The employment share of sector 1 then follows a hump-shaped pattern. Exactly the opposite reasoning applies to the second row of Table 3.

The second case we consider is the case in which goods produced in the two sectors are relatively bad substitutes (which holds if ρ<0). The

[14] This point is reached at time T where it holds that $a_1 \bar{C}_2 \bar{g}_2 / h_{2T} = (1-a_1)\bar{C}_1 \bar{g}_1 / h_{1T}$.

development of sectoral shares over time, assuming $\overline{C}_i$ to be zero for simplicity, than reads as

$$\frac{d\,L_1}{dt} = \frac{-d\,L_2}{dt} = \frac{\rho L(g_2 - g_1)\left(\frac{a_2}{a_1}\right)^{\frac{-1}{\rho-1}}\left(\frac{h_2}{h_1}\right)^{\frac{-\rho}{\rho-1}}}{(\rho-1)\left[1+\left(\frac{a_2}{a_1}\right)^{\frac{-1}{\rho-1}}\left(\frac{h_2}{h_1}\right)^{\frac{-\rho}{\rho-1}}\right]^2}. \tag{11}$$

This equation reveals that when growth rates are constant over time but different between sectors, the sector with the largest growth rate ultimately will vanish in terms of labour (a result which also obtains in the presence of subsistence requirements). This result does not necessarily apply once we allow for endogenous technological progress (ξ_i>0). The allocation of labour will then be constant once growth rates in the two sectors are equal. In this case, the share of labour in the first sector of the economy converges to[15]

$$L_1 = \frac{\xi_2 L + \overline{g}_2 - \overline{g}_1}{\xi_1 + \xi_2} \quad \text{where } L \geq \max\left[\frac{\overline{g}_1 - \overline{g}_2}{\xi_2}, \frac{\overline{g}_2 - \overline{g}_1}{\xi_1}\right]. \tag{12}$$

The parameter restriction is made to ensure that L_1 is non-negative and does not exceed the total labour force (L). If this restriction does not apply, we end up in the type of corner solutions as we discussed in the case in which we assumed endogenous growth to be absent. The expression reveals that in the presence of endogenous growth, the allocation of labour is ultimately fully determined by supply factors. The more powerful the 'engine of growth' of sector 1 (i.e., the larger its exogenous growth rate ($\overline{g}_1$), and/or the larger the scope for learning by watching (ξ_1)), the smaller the sector will be once the allocation of labour has converged to a constant.

The cases considered in a two-sector context by Baumol (1967), Matsuyama (1992), and Quibria and Harrigan (1996) will now be discussed as special cases of the two-sector model developed in this section. Both the solution of the model of Baumol and the model of Quibria and Harrigan can be characterized by equation (11) since they assume the absence of both subsistence requirements and endogenous technological progress ($\overline{C}_i = \xi_i = 0$). In the second sector, Baumol assumes the presence of

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[15] Equality of growth rates implies that $g_1 = \xi_1 L_1 + \overline{g}_1 = g_2 = \xi_2 (L - L_1) + \overline{g}_2$ from which we can solve for L_1.

exogenous technological progress, which is absent in the first sector ($\overline{g}_1 = 0$, $\overline{g}_2 > 0$). The two cases he then considers in order to describe the development of sectoral shares are (i) a case with unitary elasticity of demand and constant relative outlays (ρ→0; i.e. Cobb-Douglas preferences), and (ii) a case where relative output is constant (ρ→-∞; i.e. Leontief preferences). In case (i), the sectoral shares of labour remain constant whereas the output ratio ($C_1 / C_2 = h_1 L_1 / h_2 L_2$) declines to zero as time passes. In the second case, labour will ultimately be fully employed in the first sector of the economy. Quibria and Harrigan (1996) study the intermediate case in which the elasticity of substitution between goods from different sectors is between zero and one. The basic results they arrive at were already discussed in this section. More and more labour will be allocated towards the slowly growing service sector until ultimately all labour is employed in this sector. The relative prices of services will rise without bound.

Matsuyama (1992) incorporates an element of endogenous growth in a two-sector model with an agricultural and a manufacturing sector (say sector 1 and 2, respectively).[16] His basic model is characterized by constant shares of labour. This result is due to his very specific parametrization of the model. His economy is characterized by (i) the absence of technological progress in the agricultural sector (g_1=0), (ii) endogenous growth in the manufacturing sector (ξ_2>0), and (iii) a Stone-Geary utility function (ρ=0) with subsistence requirements in the agricultural sector ($\overline{C}_1 > 0$) and no subsistence requirements in the manufacturing sector ($\overline{C}_2 = 0$). It is immediately evident from equation (10) that in such a specific case, employment shares are constant over time. This is not considered as a problem by Matsuyama since the main focus in his paper is not on the dynamics of structural change, but on the effects of an increase in the (exogenously given and non-growing) productivity of the agricultural sector for growth in the manufacturing sector. It is clear from equation (9) that an increase in the productivity level of the agricultural sector (h_1) which has a

[16] The basic Ricardian model of Matsuyama differs from our model in two respects. First, Matsuyama employs production functions with diminishing returns to scale with respect to labour. Compared to our way of modelling, this does not affect the basic results arrived at (in a closed economy setting). Secondly, he assumes consumers to have an intertemporal utility function with a subjective discount rate. Again, this does not affect the comparability of his results with the results in this paper and is only of importance for the welfare evaluation in his paper.

positive subsistence requirement releases labour that will be employed in the dynamic manufacturing sector. Since this sector is characterized by learning by watching in the model of Matsuyama, growth will increase in this sector. This is the basic result arrived at by Matsuyama in the closed economy version of his model.[17]

5. The model in a multi-sector context

Although the simple two-sector version of the model as discussed in the previous section gives insights in the basic forces shaping the sectoral composition of economies, this model does not allow us to replicate the typical dynamics that characterize the sectoral developments of industrialized economies. For this aim,we have to resort to a multi-sectoral version of the model. As in the previous section, our analysis will start with considering the Stone-Geary utility function ($\rho \rightarrow 0$) as a special case to gain some further insights in the working of the model and the processes that are at play. In turn, we will generalize to the case of CES-preferences (for simplicity, we assume away subsistence requirements). Again, all other cases that we can distinguish are straightforward combinations of these two basic cases. We conclude this section by presenting some numerical experiments with a three-sector version of the model. The aim of these exercises is to mimic part of the empirically found trends described in section 2.

[17] In addition, he shows that a negative relation between growth and agricultural productivity prevails in a small open economy. This is due to the fact that a small open economy that experiences a productivity improvement in the agricultural sector will specialize more in the production of agricultural goods, taking away labour from the manufacturing sector and depressing the growth rate of the economy. Finally, he also considers the dynamics of structural change by allowing for non-unitary elasticities of substitution. Due to the assumed absence of growth in the agricultural sector, Matsuyama has to assume agricultural goods to be relatively good substitutes for manufacturing goods in order to be able to explain the declining share of agricultural employment. Both the assumption of agricultural growth being lower than manufacturing growth and the assumption of good substitutability between goods from broadly defined sectors seems at odds with empirical evidence.

5.1 Stone-Geary utility function ($\rho \to 0$)

In the case of a Stone-Geary utility function, we can derive Marshallian demand as

$$P_{Ci} C_i \;=\; P_{Ci} \overline{C}_i + a_i \left(L - \sum_{j=1}^{S} P_{Cj} \overline{C}_j \right). \tag{13}$$

This reveals that consumers spend on good *i* an amount needed to fulfil subsistence requirements plus a fraction a_i of the income that is available for discretionary choice (that is the income that is left after all subsistence requirements have been fulfilled).[18] From equation (8), we derive that the allocation of labour is governed by

$$L_i \;=\; \frac{\overline{C}_i}{h_i} + a_i \left(L - \sum_{j=1}^{S} \frac{\overline{C}_j}{h_j} \right). \tag{14}$$

The employment share of sector *i* thus consists out of two parts. The first is the amount of labour that is required to produce the subsistence requirements. The second is a fraction a_i of the total amount of labour that is left after subsistence requirements of all goods from all sectors have been produced. Several results are worth noticing. With positive growth in all sectors, sectoral employment shares and GDP-shares measured at current prices ultimately converge to a_i, independent of whether growth is determined exogenously or endogenously. This is caused by the fact that weight of subsistence requirements in determining sectoral employment shares tends to zero as time proceeds ($\overline{C}_i / h_i \to 0$). It is then evident from equation (14) that $L_i/L = C_i P_{Ci} / CP_C \to a_i$. The share of the fastest growing sector in total output measured at constant prices converges to one, while the share in the other sectors tends to zero. Sectoral growth rates converge to

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[18] The macroeconomic price index can be determined as

$$P_C = \prod_{i=1}^{S} \left(\frac{P_{Ci} L}{a_i \left[L - \sum_{j=1}^{S} \overline{C}_j P_{Cj} \right]} \right)^{a_i}$$

Taking the derivative of this expression with respect to time, we can determine the growth rate of real consumption which equals $-(dP_C/dt)/P_C$. With exogenous growth rates, real consumption growth starts at a high level and declines to its steady growth level which equals $\sum a_i \overline{g}_i$.

$\overline{g}_i + \xi_i a_i L$. Relative prices of the slowest growing sector tend to infinity, while those of the fastest growing sector tend to zero. Income elasticities ultimately all converge to one.

So far, attention has been restricted to the long-run in which employment shares are constant and income elasticities of demand equal one. However, for long periods during the transition to a situation with constant employment shares income elasticities may be unequal to one. In particular, the income elasticity of demand of the sector with the lowest (largest) initial subsistence requirement starts at a level larger (smaller) than one. In the light of the deindustrialization debate, we are particularly interested in the short-run behaviour of employment shares. It is easily derived that these shares are not constant and may behave non-monotonously. This is seen by taking the derivative of equation (14) with respect to time which results in

$$\frac{d\,L_i}{dt} \;=\; -\frac{\overline{C}_i g_i}{h_i} + a_i \sum_{j=1}^{S} \frac{\overline{C}_j g_j}{h_j}. \tag{15}$$

This equation reveals that with positive growth rates, employment shares in all sectors indeed converge to a constant since $\overline{C}_i / h_i$ tends to zero as time proceeds. Let us now restrict the attention to a three-sector version of the model (S=3), and consider the case in which the subsistence requirement of goods from the first sector (say the agricultural sector) is largest, while that from the third sector (say the service sector) is zero. The rate of technological progress is assumed to be largest in the first sector and lowest in the third sector. Assuming that at t=0 it holds that $a_2\left[\overline{C}_1 g_1 / h_1 + \overline{C}_2 g_2 / h_2\right] > \overline{C}_2 g_2 / h_2$, employment in the manufacturing follows a hump-shaped pattern. The interpretation of this condition is the same as in section 4 and relies on the fact that sectors become larger due to the fact that more labour becomes available for the production of consumption goods over which consumers have free choice, while sectors become smaller due to the fact that less labour is needed to produce subsistence requirements. Similarly, we can derive that employment in the service sector is continuously increasing, while agricultural employment initially strongly declines. In other words, if relatively much labour is required initially to produce the subsistence requirement of the good produced in sector 1 and this sector is characterized by large productivity growth, so much labour is freed up initially that the employment share in both the second and the third sector start to increase. Ultimately, all employment shares converge to their long-run shares (a_i).

5.2 CES-preferences

The next step is to characterize the solution of the model for the case in which the goods produced in the sectors under consideration form relatively bad substitutes (ρ<0).[19] For analytical tractability, we restrict attention to the case in which there are no subsistence requirements ($\overline{C}_i = 0$) and in which there is no endogenous technological progress (ξ_i=0). Employment shares are then easily determined from equation (8).

The dynamics as well as the steady state to which to model converges can be described as follows. With productivity growth in all sectors, the economy converges to a situation in which the total labour force is ultimately fully employed in the sector with the lowest productivity growth. The other sectors ultimately vanish in terms of employment. The development of relative prices is the same as described in the previous section. In terms of sectoral shares in GDP measured at current prices, the fastest growing sector ultimately vanishes, while measured at constant prices it ultimately dominates the economy. During the transition, sectoral developments can again be non-monotonous. Taking the derivative of equation (8) with respect to time results in

$$\frac{d\,L_i}{dt} = \frac{L\rho\sum_{j\neq i}(g_j - g_i)\left(\frac{a_j}{a_i}\right)^{\frac{-1}{\rho-1}}\left(\frac{h_j}{h_i}\right)^{\frac{-\rho}{\rho-1}}}{(\rho-1)D^2} \text{ where } D \equiv \sum_{j=1}^{S}\left(\frac{h_j}{h_i}\right)^{\frac{-\rho}{\rho-1}}\left(\frac{a_j}{a_i}\right)^{\frac{-1}{\rho-1}}. \qquad (16)$$

This reveals that employment of the fastest growing sector is continuously decreasing, while employment in the slowest growing sector is continuously increasing. Again concentrating on the three-sector case and assuming that the second sector is characterized by intermediate growth, it is easily derived from this equation that in the case in which at time t=0 it holds that $(g_1 - g_2)/(g_2 - g_3) > (a_3/a_1)^{\frac{-1}{\rho-1}}(h_3/h_1)^{\frac{-\rho}{\rho-1}}$, employment of sector 2 starts to

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19 The case in which the elasticity of substitution is larger than one is not considered since this case is not interesting for the study in the underlying paper, neither from a theoretical nor from an empirical point of view. Sectors are defined in such a broad way that it is reasonable to assume that goods produced in these sectors form relatively bad substitutes.

increase. At some point in time it reaches a top and ultimately converges to zero. This result reveals that the development of sectoral employment shares can behave non-monotonously in a world in which there are sectoral productivity differentials and goods are relatively bad substitutes. In particular, if differential productivity growth between the agricultural and manufacturing sector is large relative to differential productivity growth between manufacturing and the service sector, manufacturing employment will follow a hump-shaped pattern (otherwise all labour would be reallocated towards the service sector from the outset).

Let us now introduce endogenous technological progress. The previous analysis has made clear that as long as growth rates are not equalized, employment shares are changing. This continues until in the limiting case the two fast-growing sectors have vanished. By endogenizing growth rates, they may converge. This occurs if employment shares are such that the differences in exogenously given productivity differentials are compensated by endogenously determined productivity differentials which are due to different scopes for learning by watching. In general, convergence of growth rates obtains once sectoral employment shares satisfy (provided that all ξ's are positive)

$$L_i = \frac{L - \bar{g}_i \sum_{j=1}^{S} \frac{1}{\xi_j} + \sum_{j=1}^{S} \frac{\bar{g}_j}{\xi_j}}{\xi_i \sum_{j=1}^{S} \frac{1}{\xi_j}}. \qquad (17)$$

A meaningful solution requires that $0<L_i<L$. If this restriction is not satisfied, we end up in corner solutions in which some sector takes over the whole economy in terms of employment and is still characterized by a lower growth rate than the other sectors. If there is no learning by watching in one sector (say in sector j ($\xi_j=0$)), growth rates will converge when employment shares in the other sectors equal $L_i = \left(\bar{g}_j - \bar{g}_i\right)/\xi_i$. These exercises reveal that in the presence of endogenous growth, the allocation of labour is ultimately fully determined by supply factors. Previously derived results that the labour force is ultimately fully employed in one sector when goods are bad substitutes hence depend on the assumption of the absence of endogenous technological progress on a sectoral level. Once learning by watching is introduced, a minimal sectoral scale in terms of employment is required to be and to remain a fast-growing sector.

5.3 A numerical experiment with a three-sector version of the model

We conclude this section by presenting some numerical experiments with the model. The aim of this experiment is to show that the model can replicate the empirically observed stylized facts of (i) the hump-shaped development of the employment share of the manufacturing sector, (ii) a roughly constant share of the manufacturing sector in terms of its share in GDP in constant prices, (iii) declining shares of the agricultural sector in terms of employment and GDP in constant prices, and (iv) increasing shares of the service sector in terms of employment and GDP in constant prices.

We take the following parametrization of the model: ρ=-9, L=100, $\bar{g}_1$=0.018, $\bar{g}_2$=0.007, $\bar{g}_3$=0.022, ξ_1=0.001, ξ_2=0.0006, ξ_3=0, $\bar{C}_1$=40, $\bar{C}_2$=18, $\bar{C}_3$=0, a_1=0.05, a_2=0.25, a_3=0.7. The developments of sectoral shares in terms of employment and GDP in constant prices are depicted in Figures 4 and 5 respectively.[20] So we assume that goods from different sectors form relatively bad substitutes, we assume subsistence requirements to be largest in the agricultural sector and lowest in the service sector, and we assume the absence of learning by watching in only the service sector. Growth rates will hence converge to the (exogenously given) growth rate in the service sector.

< Insert Figures 4 and 5 around here >

The relatively large growth rate in the agricutural sector that prevails at time t=0 frees up so much labour from this sector that initially both the service sector and the manufacturing sector increase in size. As time proceeds, this process comes to an end and the service sector continues to expand, but now at the expense of both the agricultural and the manufacturing sector. This result illustrates once again that with differential productivity growth and relatively bad substitutability of goods, employment shares may behave

[20] Not depicted are growth rates and sectoral shares in GDP in current prices. In the numerical example presented here, growth rates in the service sector are constant, they are hump-shaped in the manufacturing sector and declining in the agricultural sector. Over the whole period, growth rates are largest in agriculture and lowest in the service sector. GDP-shares in current prices follow the same pattern as employment shares (since $C_i P_{Ci} = L_i$).

non-monotonously (recall that we do not need endogenous growth nor subsistence requirements for this result). Due to the presence of endogenous growth, the growth rates ultimately converge to the (exogenously given) growth rate of the service sector. When growth rates have converged, relative prices are constant and employment shares have converged to values that are fully determined by supply side factors. This result is in contrast with models with only exogenously given technological progress. Those models predict that the slowest growing sector ultimately dominates the whole economy in terms of employment. The roughly constant/slightly increasing share of manufacturing in GDP in constant prices results from a parameter choice in the model (in particular the choice of subsitence requirements) that results in an income elasticity of demand for manufacturing goods which is close to one. The specific result that sectoral shares in real GDP converge to 1/3 is due to the particular choice of the utility function (see footnote 12). Inspection of the shares of agricultural and service goods in GDP in constant prices reveals that despite increasing prices of services relative to agricultural goods, the share of services in real GDP increases relative to the share of services. This result is due to the fact that the subsistence requirement for agricultural goods is large, which results in a low income elasticity of demand (without subsistence requirements, declining relative prices result in increasing relative shares in real GDP).

To conclude, the simple numerical experiment with the model performed in this section has revealed that the sectoral developments described in section 2 can roughly be replicated with our simple Ricardian model. Non-unitary income elasticities and differing growth rates on a sectoral level are crucial and sufficient elements in explaining these developments.

6. Conclusions

This paper has developed a simple Ricardian general equilibrium model that allows us to determine the sectoral composition of an economy as the outcome of factors of supply and demand. Differential productivity growth rates, non-unitary income elasticities and non-unitary substitution elasticities between goods from different sectors were considered as important explanatory factors in empirically observed sectoral changes. The model allowed for the presence of endogenously determined rates of technological progress resulting from the presence of learning by watching.

Previously developed two-sector Ricardian models on growth and sectoral structure of Baumol (1967), Matsuyama (1992), and Quibria and Harrigan (1996) were shown to be special cases of our model. With goods from different sector being relatively bad substitutes, differential productivity growth results in declining employment shares in fast growing sectors (agriculture) and increasing employment shares in slowly growing sectors (services). Differential productivity growth was also shown to suffice for explaining the empirically observed hump-shaped development of the share of manufacturing employment. In particular, if the growth rate of the fast-growing agricultural sector is sufficiently large compared to the other growth rates, so much labour may be released initially from this sector that all other sectors may become larger in terms of employment. This effect is reinforced once we allow for income elasticities in the agricultural sector that are smaller than one. Ultimately, only the slowest growing sector will increase in size at the expense of all other sectors. The result that slow-growing sectors ultimately dominate the whole economy was shown not to arise necessarily once allowance is made for endogenously determined technological progress as a result of learning by watching. We may then arrive in a situation in which sectoral growth rates converge and sectoral employment shares converge to constants (which are unequal to zero or one).

In the end, we can draw the conclusion that the empirical stylized facts on sectoral developments can basically be replicated by a simple Ricardian model in which we do not have to rely on trade-related explanations for sectoral developments. This is not to deny that trade-based explanations have some role to play in explaining sectoral compositions of economies. Countries that have a comparative advantage in a particular sector as a result of for example differences in endowments will specialize in production in these sectors. We wanted to emphasize, however, that changes in sectoral compositions which are experienced by all countries can simply be the resultant of differential productivity growth, non-unitary income elasticities, and relatively bad substitutability between goods from different sectors. The recently observed deindustrialization can hence be an inherent and unavoidable part of the development of maturing economies.

Appendix. Derivation of demand functions.

The Lagrangian corresponding to optimization problem (1) reads as

$$\Lambda = \left[\sum_{i=1}^{S} a_i \left(C_i - \overline{C}_i\right)^{\rho}\right]^{1/\rho} + \lambda\left(wL - \sum_{i=1}^{S} C_i P_{Ci}\right). \tag{A.1}$$

Taking derivatives results in

$$\frac{\partial \Lambda}{\partial C_i} = \frac{1}{\rho}\left[\sum_{i=1}^{S} a_i \left(C_i - \overline{C}_i\right)^{\rho}\right]^{\frac{1}{\rho}-1} \rho a_i \left(C_i - \overline{C}_i\right)^{\rho-1} - \lambda P_{Ci} = 0 \quad \forall i = 1,\ldots,S. \tag{A.2}$$

We can thus derive that

$$\frac{a_1 (C_1 - \overline{C}_1)^{\rho-1}}{P_{C1}} = \ldots = \frac{a_i (C_i - \overline{C}_i)^{\rho-1}}{P_{Ci}} = \ldots = \frac{a_S (C_S - \overline{C}_S)^{\rho-1}}{P_{CS}}. \tag{A.3}$$

Rewriting yields expenditures on good j

$$C_j P_{Cj} = P_{Cj} \overline{C}_j + P_{Cj} \left(\frac{P_{Cj}}{a_j}\right)^{\frac{1}{\rho-1}} \left(\frac{P_{Ci}}{a_i}\right)^{\frac{-1}{\rho-1}} \left(C_i - \overline{C}_i\right). \tag{A.4}$$

Substituting this expression in the budget constraint and rewriting yields Marshallian demand for good i

$$P_{Ci} C_i = P_{Ci} \overline{C}_i + P_{Ci} \left(\frac{P_{Ci}}{a_i}\right)^{\frac{1}{\rho-1}} \frac{\left[wL - \sum_{j=1}^{S} P_{Cj} \overline{C}_j\right]}{\sum_{j=1}^{S} P_{Cj} \left(\frac{P_{Cj}}{a_j}\right)^{\frac{1}{\rho-1}}}, \tag{A.5}$$

so that demand for goods from sector i can be written as

$$C_i = \overline{C}_i + \left(\frac{P_{Ci}}{a_i}\right)^{\frac{1}{\rho-1}} \frac{\left[wL - \sum_{j=1}^{S} P_{Cj} \overline{C}_j\right]}{\sum_{j=1}^{S} P_{Cj} \left(\frac{P_{Cj}}{a_j}\right)^{\frac{1}{\rho-1}}}. \tag{A.6}$$

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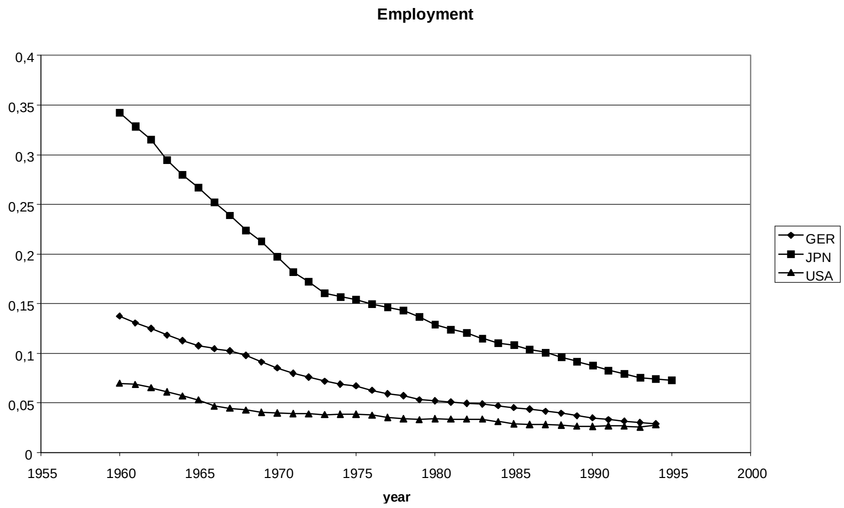


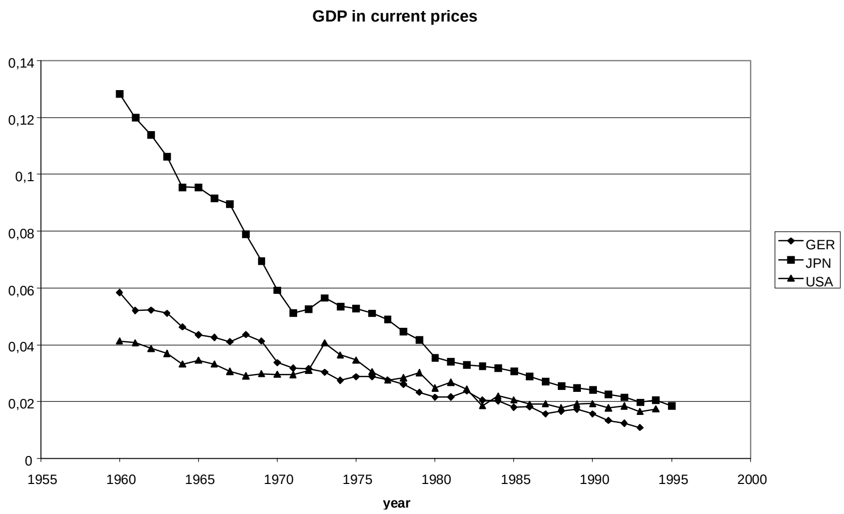


Figure 1. Shares of Agricultural sector

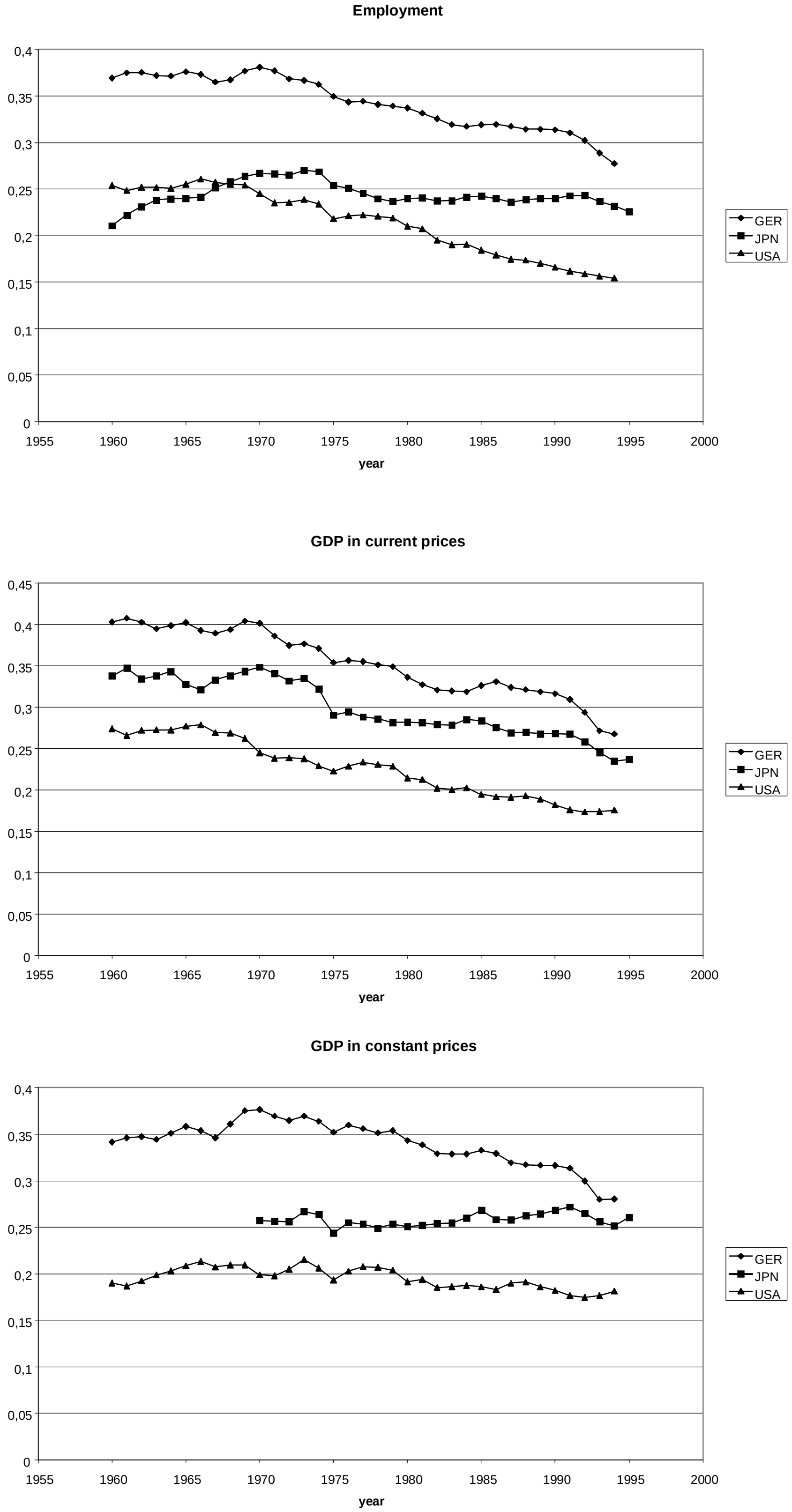
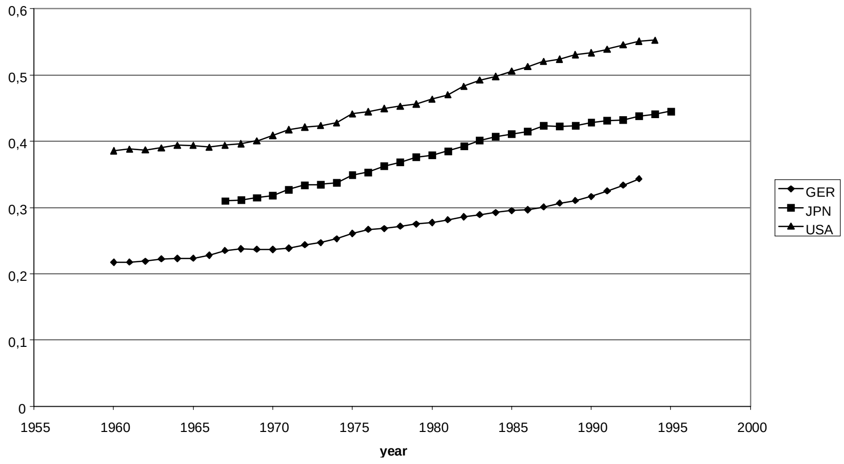
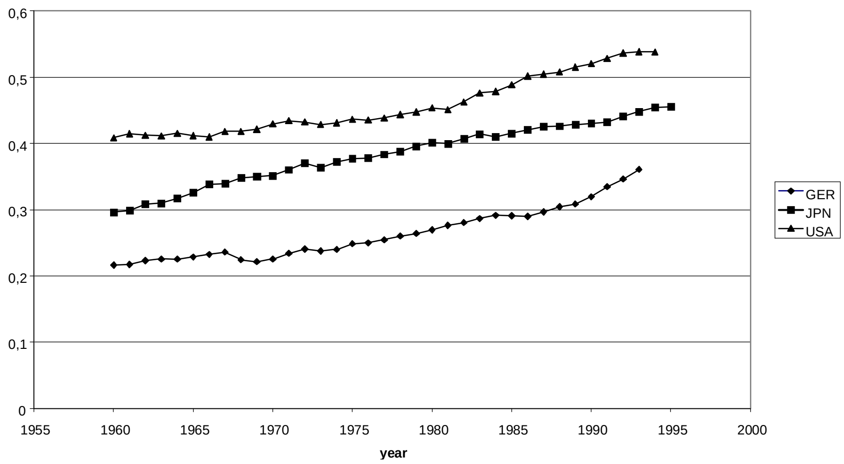


Figure 2. Shares of Manufacturing sector.

Employment



GDP in current prices



GDP in constant prices

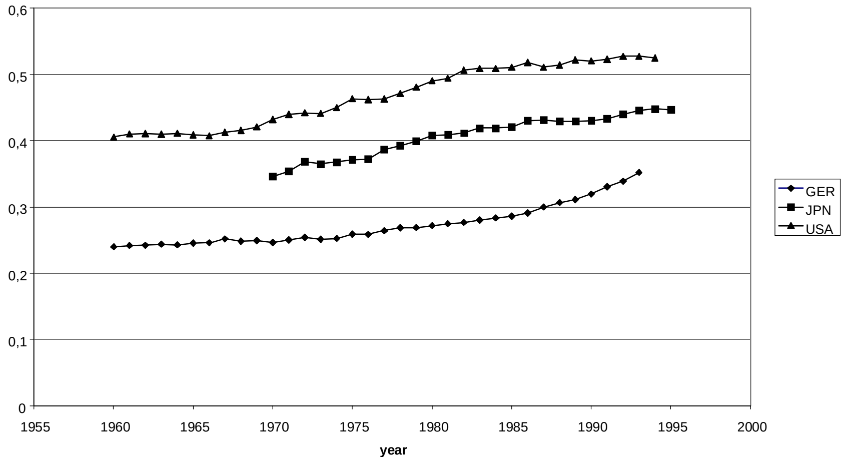


Figure 3. Shares of Service Sector.

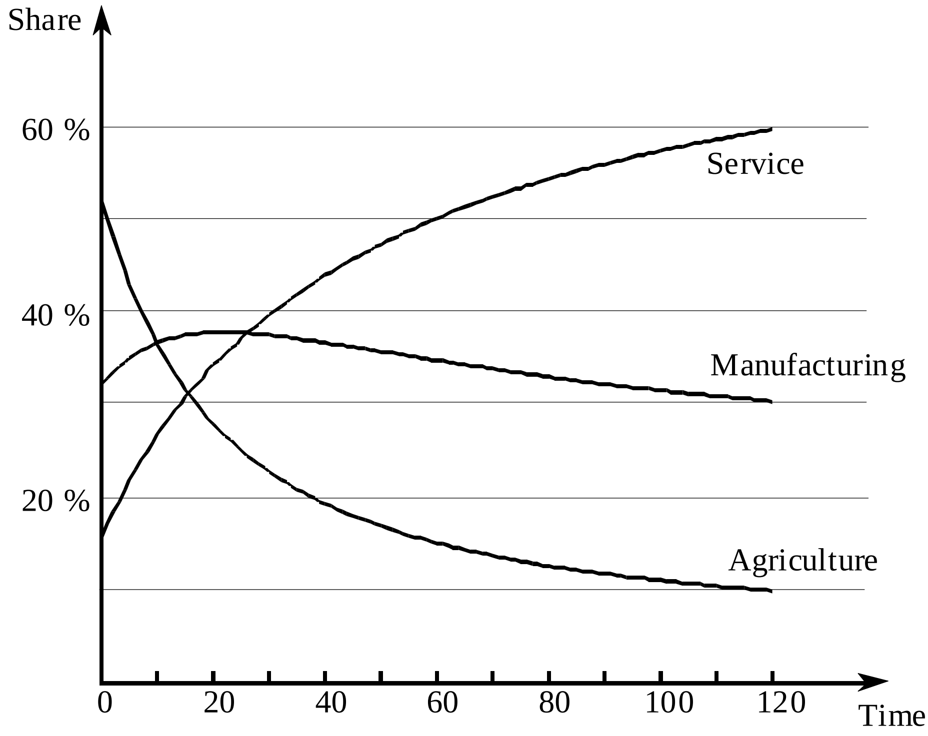


Figure 4. Development of Employment shares.

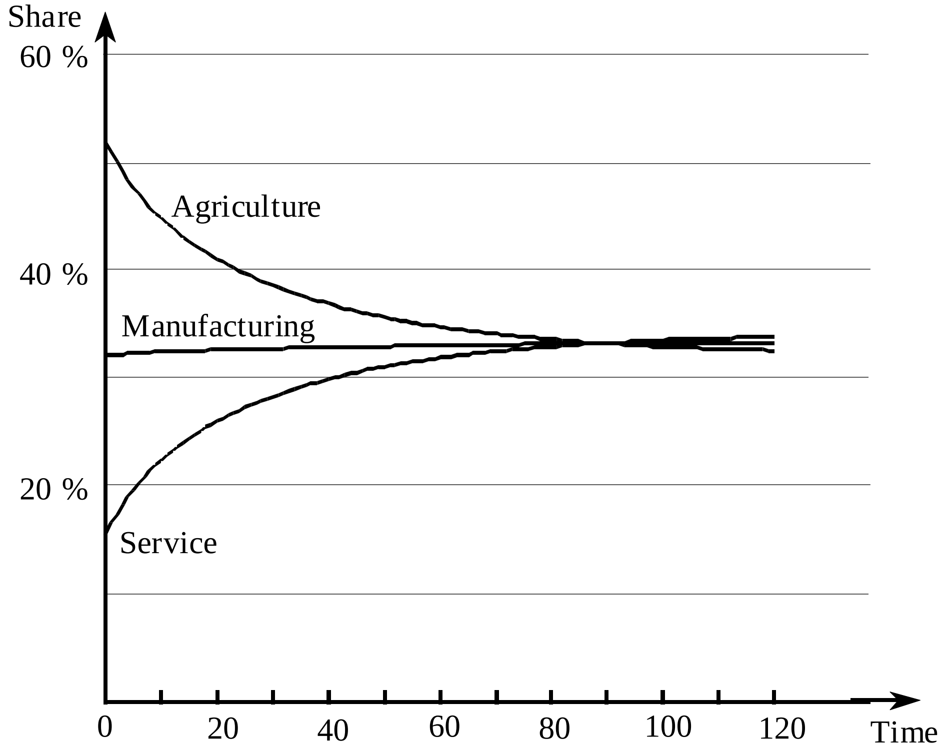


Figure 5. Development of shares in Real GDP.