Laboratory of Economics and Management
Sant'Anna School of Advanced Studies

Piazza Martiri della Libertà, 33 - 56127 PISA (Italy)
Tel. +39-050-883-343 Fax +39-050-883-344
Email: lem@sssup.it Web Page: http://www.lem.sssup.it/

LEM
Working Paper Series

Evolutionary Micro-dynamics and Changes in the Economic Structure

André LORENTZ [*]
Maria SAVONA [**]

* LEM, Scuola Superiore Sant'Anna, Pisa (Italy) and
BETA, UMR CNRS 7522, Université Louis Pasteur, Strasbourg (France)
** The Cambridge-MIT Institute, Cambridge University (UK) and
Faculté des Sciences Economiques et Sociales, Université Lille 1 (France)

2006/28 November 2006

ISSN (online) 2284-0400

Evolutionary Micro-dynamics and Changes in the Economic Structure*

André Lorentz[†]
Maria Savona[‡]

Abstract

The paper develops a growth model with evolutionary micro–founded structural change. The model endogenises both technical change and changes in final and intermediate demand as affecting macro-economic growth, through the structural change of the economy. The aim is to formally account for the empirical stylised fact of the changes in the sectoral structure of the economy which have led to the growth of services in most advanced countries over the last decades. At the meso-macro level of analysis, we investigate whether the structural changes leading to the growth of services are mainly demand-led, both in terms of final consumption and intermediate demand. At the micro-level of analysis, we explore whether demand constraints affect the degree of exploitation of technological opportunities. The simulated results are based on the use of the actual Input–Output coefficients in the case of Germany. Four scenarios have been identified, which account for the effects of a set of key parameters on the changes in the structure of the economy.

Keywords: Economic Growth, Structural change, Growth of Services, Evolutionary Micro–foundation, Input–Output
JEL classification: E11, L16, O14, O33, O41

*The authors are grateful to Marco Valente for his technical support and comments on an earlier draft of this paper. The usual disclaimers apply

†LEM, Scuola Superiore Sant'Anna, Pisa and BETA, UMR CNRS 7522, Université Louis Pasteur, Strasbourg, France. e–mail: lorentz@cournot.u-strasbg.fr

‡The Cambridge–MIT Institute, University of Cambridge, UK and Faculté des Sciences Economiques et Sociales, Université Lille 1, France. This work has been largely carried out during Maria Savona's stay at BETA, Université Louis Pasteur, Strasbourg, France, as a CNRS Post-doc Fellow in 2005. e–mail: M.Savona@cmi.cam.ac.uk

1 Introduction

The debate around the determinants and the economic impact of tertiarisation is age–old (Clark, 1940; Baumol and Bowen, 1966; Baumol, 1967; Fuchs, 1968). Yet, a recent collection of contributions on the economics of services (ten Raa and Schettkat, 2001) still refers to the 'service paradox' as an unresolved issue in the economic literature (see also Appelbaum and Schettkat, 1999; Pugno, 2006). The 'paradox' consists of the empirical fact that advanced economies are still experiencing sustained growth rates of real output and employment of service industries despite trends of increasing input costs and prices.

Since the debate around tertiarisation started, the growth of services' real output shares has been mainly attributed to shifts in private domestic consumption, which has in turn been claimed to be mainly sustained by a positive income effect, more than compensating a negative price effect. However, the demand for services has been overall steadily growing, whereas average real income growth rates have been slightly declining over time from mid–1970s onwards (ten Raa and Schettkat, 2001). The growth of services represents therefore the most relevant case of change in the economic structure of advanced economies and yet it still is the most under–investigated.

More in general, much effort has been devoted to the identification of the sources of structural change in the empirical literature, particularly amongst the contributions in the I–O tradition, starting with Leontief (1951) and Leontief (1953) seminal work. Within the I–O framework, and more generally in the economic literature (Pasinetti, 1973), a full empirical account of structural economic change relies on the assessment of changes in sectoral interdependencies.

In line with this literature, in our previous work (Savona and Lorentz, 2006) we decomposed sectoral output growth into the relative contribution of changes in technology coefficients and final domestic and foreign demand. We applied an I–O Structural Decomposition Analysis (SDA) technique (for an exhaustive review see Rose and Casler, 1996) to 13 selected macro–branches of the economy over the period between the end of the 1960s to the end of the 1990s for four OECD countries (Germany, Netherlands, UK and US).

The empirical stylised facts thereby identified can be summarised as follows:

1. Real output growth since the beginning of the '70s in most of the OECD countries has been positive for most of the service branches considered, and particularly for the Knowledge Intensive Business Services (KIBS). Further, this seems not to have crowded out the manufactur-

ing branches, except in the UK and USA, between the end of the '70s and the beginning of the '80s. This is in fact the only sub-period for which there seems to emerge a phase of de-industrialisation, though confined to the cases of these two countries.

2. The contribution of changes in intermediate coefficients to real output growth is much higher for service branches than for manufacturing ones. The sources of structural change leading to services' growth are linked to both intermediate and final demand, whereas the output growth of manufacturing branches is mainly due to final (private and public) consumption. Unlike in manufacturing branches, foreign demand has played a marginal role in the output growth of services, and this trend is confirmed in the 1990s.

3. As far as the branch of KIBS is concerned, the strong dynamics of real output growth have been sustained not only by final demand, but also particularly by the dramatic changes in the coefficients of intermediate demand. This confirms that the growth of KIBS represent the most important case of structural change driven by intermediate demand.

Our empirical findings support what ten Raa and Schettkat (2001) label as a 'change in demand conditions', which is claimed to dominate over the pure (final) income and price effects, in driving the 'service paradox'. However, the empirical literature based on the use of SDA techniques, though duly accounting for the relative contribution of demand and technology, does not disentangle the determinants of the different patterns of structural change. Phrased otherwise, an accounting empirical exercise of the sort of SDA does provide evidence on the presence and the dimension of a phenomenon, though does not allow to discriminate amongst its causal determinants.

This work builds upon the empirical stylised fact of the 'service paradox' by providing a formal model of economic growth with evolutionary micro-founded structural change. Our conjecture can be summarised as follows.

The 'service paradox', and particularly the black box of the 'change in demand conditions' is likely to be related to changes in the composition of intermediate demand for services. These latter follow changes in the inter–industry division of labour between services and the rest of the economy. Changes in intermediate links are argued here to complement — and in some case dominate — the role of income– and price–led change of final demand in accounting for the structural change leading to the growth of services.

More in particular, our model attempts to formally account for the following hypotheses:

1. The growth and composition of final and intermediate demand ultimately shape the structural changes of sectoral output growth in advanced economies. In particular, at the meso-macro level of analysis and within an input-output framework, a predominant role in determining the growth of services has to be attributed to the increase of demand for services as intermediate inputs for the whole economy (services themselves included);

2. Final demand and technology are self-reinforcing in determining the growth dynamics of firms, whereas intermediate demand factors account for the transmission of micro behaviours into macro-level consequences in terms of structural change. At the micro level of analysis, we expect favourable demand conditions to represent a necessary incentive for firms to respond to technological shocks, innovate and grow. On the contrary, we argue that the exploitation of technological opportunities, especially those provided by the pervasive use of Information and Communication Technologies, is not a sufficient condition for (service) firms and sectors to experience positive growth rates of output and employment.

The model developed in this paper is in line with the attempts to embracing in a unifying framework both neo-Schumpeterian and Keynesian line of thoughts in explaining economic growth (Verspagen, 2002a; Verspagen, 2002b).

The works of Schumpeter (1934) and Keynes (1936) stand in fact as the main response to the neoclassical orthodoxy which has dominated the debate over the causes of economic growth. The former called attention to the role of innovation for economic growth and development. The latter radically criticised the causal direction imposed by Say's Law — i.e. that supply always creates its own demand — and argued that the dynamics of demand might act as a constraint on the dynamics of macroeconomic growth, when resources are not fully employed.

The neoclassical conceptual framework, though, has been recently reprised with the aim of releasing some of the most constraining assumptions (See among others Barro, 1991; Aghion and Howitt, 1992; Aghion and Howitt, 1994; Aghion and Griffith, 2005). Despite the label of New Growth Theory (NGT), it still dominates the academic debate, leaving the dynamic aspects and the effects of both technical and demand patterns changes on aggregate growth unaccounted for. To phrase it with Thirlwall (2003)[p. 47]:

> 'NGT lies squarely in the orthodox neoclassical camp in which growth is driven from the supply side. Saving leads to investment,

> a country's balance of payments looks after itself, and countries converge on their own natural rate of growth which is not itself explicitly dependent on the strength of demand within an economy (...) To assume that Say's Law of Markets holds is just not good enough'

It is far beyond the scope of this work to provide an exhaustive review of the critiques moved to the NGT theoretical (and empirical) implementations of the neo-classical framework. Rather, it suffices here to highlight the lines along which our contribution is aimed to be located within this debate. As Thirlwall (2002) argues, older vintages of (post-Keynesian) growth theorists have already provided robust answers to the *empasse* of neo-classical growth models (see also Panico, 2003). In particular, the Cumulative Causation Model and the technical progress function as both put forward by Kaldor has already provided a framework to endogenise capital accumulation and technical change as determinants of economic growth, though mainly at the macro-level of analysis (Kaldor, 1957; Kaldor, 1966).

The 'creative destruction' brought about by scientific discovery and the consequences of its economic applications have been at the core of Schumpeter's contribution (Schumpeter, 1934). The importance of technical change for growth and competitiveness of firms, sectors and countries has been emphasised and reprised within the neo-Schumpeterian stream of literature, starting from the seminal contribution by Nelson and Winter (1982) (See also, among others Dosi, Freeman, Nelson, Silverberg, and Soete, 1988; Silverberg and Verspagen, 1995). This stream of literature is however characterised by an almost exclusive focus on the nature and economic effects of technology adoption and diffusion at the micro-level of analysis, neglecting both the role of the demand-side determinants of firms' strategic behaviours and the consequences of macro-level demand constraints.

Both technical change and demand might disrupt the steady path of macroeconomic growth, as well as the structural composition of the economy (Pasinetti, 1981). Within the neo-Schumpeterian stream of literature, there are very few attempts to encompass both technology and demand as affecting economic growth (Fagerberg, 1994; Montobbio, 2002; Verspagen, 1993; Verspagen, 2000; Verspagen, 2002b; Verspagen, 2002a; Llerena and Lorentz, 2004b; Llerena and Lorentz, 2004a).

Interestingly, both Verspagen (1993) and Llerena and Lorentz (2004a and b) re-consider the Kaldorian Cumulative Causation mechanism. The former by introducing explicit 'evolutionary' selection processes within a cumulative causation framework. The latter by providing a micro-foundation of the process of emergence and diffusion of technologies.

However, the 'side effects' of both technical change and demand-constraints on the structural change of economies are not contemplated in depth by these studies, particularly at the micro- and meso-level of analysis. Nor, as a consequence, do they account for technology and demand as affecting the transmission of micro-behaviours into meso-level changes. Further, the conceptualisation of the nature of technical change and its impact on structural change and economic growth has been mainly confined to the manufacturing industries, despite the renewed and increasing awareness of the importance of the services domain of analysis (ten Raa and Schettkat, 2001; Parrinello, 2004; Schettkat and Yocarini, 2006).

The model developed in this work extends the one proposed in Llerena and Lorentz (2004b) by providing evolutionary micro-foundation to the structural change of the economy. On the one hand, we provide micro-foundation to the Kaldorian Cumulative Causation mechanism. On the other hand we account for (demand-related) macro-constraints as affecting the micro-behaviours of firms when deciding to adopt technology. Further, we account for the mechanisms transmitting the effects of micro-behaviours into macro-consequences, via changes in the sectoral composition of the economy. We aim to provide an explanation to the empirical stylised facts in terms of supply and demand contribution to structural change, and tertiarisation processes in particular, as found in Savona and Lorentz (2006).

The remainder of the paper is organised as follows. Next section develops a model of economic growth with evolutionary micro-founded structural change. Section 3 explains the methodology employed to simulate the model (3.1), details four simulation scenarios (3.2) and discusses the simulation results, as well as the coherence between the empirical stylised facts found for the case of Germany and the simulated results (3.3). Finally, Section 4 summarises the main findings, draws the conclusions and highlights future directions of research.

2 A Model of Evolutionary Micro-Founded Structural Change

2.1 The macro-economic framework

Drawing upon an I-O framework (Leontief (1951)), we decompose the sectoral output into three components: intermediate consumption, final domestic consumption and (net) foreign final consumption. The aggregate output is therefore a function of the sectoral structure of the economy, which in turn is determined by intermediate and final components of demand, in a Keynesian framework.

$$\begin{pmatrix} Y_{1,t} \\ \vdots \\ Y_{j,t} \\ \vdots \\ Y_{J,t} \end{pmatrix} = \begin{pmatrix} I_{1,t} \\ \vdots \\ I_{j,t} \\ \vdots \\ I_{J,t} \end{pmatrix} + \begin{pmatrix} C_{1,t} \\ \vdots \\ C_{j,t} \\ \vdots \\ C_{J,t} \end{pmatrix} + \begin{pmatrix} X_{1,t} \\ \vdots \\ X_{j,t} \\ \vdots \\ X_{J,t} \end{pmatrix} - \begin{pmatrix} M_{1,t} \\ \vdots \\ M_{j,t} \\ \vdots \\ M_{J,t} \end{pmatrix} \tag{1}$$

For each sector j the aggregate demand ($Y_{j,t}$) is decomposed in three components: Intermediate consumption ($I_{j,t}$), final domestic consumption ($C_{j,t}$) and net exports ($X_{j,t} - M_{j,t}$).

Intermediate consumption for sector j is defined as the sum of the demand of sector j product by firms and is defined as follows:

$$I_{j,t} = \sum_{k=1}^{J} Y^D_{j,k,t} = \sum_{k=1}^{J} a_{j,k,t} Y_{k,t} \tag{2}$$

where $Y^D_{j,k,t}$ represents the demand for sector j products by the sector k; $Y_{k,t}$ represents the production level of sector k, and the coefficients $a_{j,k,t}$ are computed as follows:

$$a_{j,k,t} = \sum_{i} z_{k,i,t} a_{j,k,i,t} \tag{3}$$

where $z_{k,i,t}$ represenents firm i from sector k market share as defined by equation 15 and $a_{j,k,i,t}$ represents the firm i in sector k intermediate consumption coefficient for sector j products.

Hence the vector I_t of intermediate consumption can be represented as follows:

$$\mathbf{I_t} \equiv \begin{pmatrix} I_{1,t} \\ \vdots \\ I_{k,t} \\ \vdots \\ I_{J,t} \end{pmatrix} = \begin{pmatrix} a_{1,1,t} & \dots & a_{1,k,t} & \dots & a_{1,J,t} \\ \vdots & \ddots & & & \vdots \\ a_{k,1,t} & \dots & a_{k,k,t} & \dots & a_{k,J,t} \\ \vdots & & & \ddots & \vdots \\ a_{J,1,t} & \dots & a_{1,k,t} & \dots & a_{J,J,t} \end{pmatrix} \begin{pmatrix} Y_{1,t} \\ \vdots \\ Y_{k,t} \\ \vdots \\ Y_{J,t} \end{pmatrix} \tag{4}$$

Final consumption is a function of the economy's real income level. Each sector j 's final consumption ($C_{j,t}$) corresponds to a share $c_{j,t}$ of the real income level:

$$C_{j,t} = c_{j,t} Y_t \tag{5}$$

The shares $c_{j,t}$ evolve as real income increases, and are function of fixed income elasticities (ε_j). These shares are computed as:

$$c_{j,t} = \frac{Y_{t-1}^{\varepsilon_j}}{Y_{t-1}}$$

Real income corresponds to real GDP and therefore to the sum of sector's nominal output deflated by the GDP deflator. The consumption level for each sector j can therefore be expressed as follow:

$$C_{j,t} = c_{j,t} \sum_{k=1}^{J} \frac{p_{k,t}}{\bar{p}_{t-1}} Y_{k,t}$$

where $\bar{p}_{t-1}$ represents the GDP deflator[1]. The vector C_t of final consumption is therefore computed as follows:

$$\mathbf{C_t} \equiv \begin{pmatrix} C_{1,t} \\ \vdots \\ C_{j,t} \\ \vdots \\ C_{J,t} \end{pmatrix} = \begin{pmatrix} c_{1,t}\frac{p_{1,t}}{\bar{p}_{t-1}} & \dots & c_{1,t}\frac{p_{j,t}}{\bar{p}_{t-1}} & \dots & c_{1,t}\frac{p_{J,t}}{\bar{p}_{t-1}} \\ \vdots & \ddots & & & \vdots \\ c_{j,t}\frac{p_{1,t}}{\bar{p}_{t-1}} & \dots & c_{j,t}\frac{p_{j,t}}{\bar{p}_{t-1}} & \dots & c_{j,t}\frac{p_{J,t}}{\bar{p}_{t-1}} \\ \vdots & & & \ddots & \vdots \\ c_{J,t}\frac{p_{1,t}}{\bar{p}_{t-1}} & \dots & c_{J,t}\frac{p_{j,t}}{\bar{p}_{t-1}} & \dots & c_{J,t}\frac{p_{J,t}}{\bar{p}_{t-1}} \end{pmatrix} \begin{pmatrix} Y_{1,t} \\ \vdots \\ Y_{j,t} \\ \vdots \\ Y_{J,t} \end{pmatrix} \tag{6}$$

For each sectors imports $(M_{j,t})$ correspond to a share $m_{j,t}$ of the total domestic demand of the sector $(I_{j,t} + C_{j,t})$. This share can be a proxy for the economy's international competitiveness. Hence, for each sector, net exports can be defined as follows:

$$X_{j,t} - M_{j,t} = X_{j,t} - m_{j,t}(I_{j,t} + C_{j,t})$$

Using equations 4 and 6 we can therefore express the vector of net exports $(X_t - Mt)$ as follows:

$$\mathbf{X_t} - \mathbf{M_t} = \begin{pmatrix} X_{1,t} \\ \vdots \\ X_{J,t} \end{pmatrix} - \begin{pmatrix} m_{1,t}\left(a_{1,1,t} + c_{1,t}\frac{p_{1,t}}{\bar{p}_{t-1}}\right) & \dots & m_{1,t}\left(a_{1,J,t} + c_{1,t}\frac{p_{J,t}}{\bar{p}_{t-1}}\right) \\ \vdots & \ddots & \vdots \\ m_{J,t}\left(a_{J,1,t} + c_{J,t}\frac{p_{1,t}}{\bar{p}_{t-1}}\right) & \dots & m_{J,t}\left(a_{J,J,t} + c_{1,t}\frac{p_{J,t}}{\bar{p}_{t-1}}\right) \end{pmatrix} \begin{pmatrix} Y_{1,t} \\ \vdots \\ Y_{J,t} \end{pmatrix} \tag{7}$$

Hence substituting equation 4, 6 and 7 in equation 1, we obtain the following expression for the vector of sectoral demand:

$$\begin{pmatrix} Y_{1,t} \\ \vdots \\ Y_{k,t} \\ \vdots \\ Y_{J,t} \end{pmatrix} = \begin{pmatrix} \alpha_{1,1,t} & \dots & \alpha_{1,k,t} & \dots & \alpha_{1,J,t} \\ \vdots & \ddots & & & \vdots \\ \alpha_{k,1,t} & \dots & \alpha_{k,k,t} & \dots & \alpha_{k,J,t} \\ \vdots & & & \ddots & \vdots \\ \alpha_{J,1,t} & \dots & \alpha_{1,k,t} & \dots & \alpha_{J,J,t} \end{pmatrix} \begin{pmatrix} Y_{1,t} \\ \vdots \\ Y_{k,t} \\ \vdots \\ Y_{J,t} \end{pmatrix} + \begin{pmatrix} X_{1,t} \\ \vdots \\ X_{k,t} \\ \vdots \\ X_{J,t} \end{pmatrix} \tag{8}$$

[1]The GDP deflator is computed as:

$$\bar{p}_t = \sum_{j=1}^{J} p_{j,t} \frac{p_{j,t} Y_{j,t}}{\sum p_{j,t} Y_{j,t}}$$

with

$$\alpha_{j,k,t} = (1 - m_{j,t})(a_{j,k,t} + c_{j,t}\frac{p_{k,t}}{\bar{p}_{t-1}})$$

From this last equation we can compute the reduced form of our model, assuming the short-run macroeconomic identity to hold:

$$\begin{pmatrix} Y_{1,t} \\ \vdots \\ Y_{k,t} \\ \vdots \\ Y_{J,t} \end{pmatrix} = \begin{pmatrix} 1-\alpha_{1,1,t} & \dots & -\alpha_{1,k,t} & \dots & -\alpha_{1,J,t} \\ \vdots & \ddots & & & \vdots \\ -\alpha_{k,1,t} & \dots & 1-\alpha_{k,k,t} & \dots & -\alpha_{k,J,t} \\ \vdots & & & \ddots & \vdots \\ -\alpha_{J,1,t} & \dots & -\alpha_{1,k,t} & \dots & 1-\alpha_{J,J,t} \end{pmatrix}^{-1} \begin{pmatrix} X_{1,t} \\ \vdots \\ X_{k,t} \\ \vdots \\ X_{J,t} \end{pmatrix} \quad (9)$$

Sector's demand vector is then only function of demand parameters, given in the short-run (but evolving over time), and of exports, assumed to be exogenously defined in our model.

2.2 Defining micro-behaviours

At the micro-level a firm's output is determined by its share of the sectoral demand. The production technology of a firm consists in a combination of all sectors products (including the sector in which the firm produces) and labour, as defined by the production function (equation 10). Firm's labour productivity dynamics is assumed to follow a Kaldor-Verdoorn Law (Verdoorn (1949); Kaldor (1966)). Firms set prices according to a mark-up mechanism. We therefore represent a technological shock by changes in firms' labour productivity, on the basis of a Kaldor-Verdoorn mechanism and, simultaneously, by changes in the structure of the intermediate coefficients. This allows us to endogenising technical change as having both a micro-level effect, on firms' productivity dynamics and market shares; a a meso-level effect on sector's production costs and therefore prices; and a macro-level effect on the structure of the economy via changes in the intermediate coefficients matrix.

A firm i active in a sector j is defined by the following production function:

$$Y_{j,i,t} = min\left(\frac{1}{a_{1,j,i,t}}Y^D_{1,j,i,t}, ..., \frac{1}{a_{k,j,i,t}}Y^D_{k,j,i,t}, ..., \frac{1}{a_{J,j,i,t}}Y^D_{J,j,i,t}, B_{j,i,t}L_{j,i,t}\right) \quad (10)$$

The production level a firm i in a sector j is defined as a share $z_{j,i,t}$ of sector j's demand:

$$Y_{j,i,t} = z_{j,i,t}Y_{j,t} \quad (11)$$

The firm's demand for sector k products is therefore defined as follows:

$$Y^D_{k,j,i,t} = a_{k,j,i,t} Y_{j,i,t} \tag{12}$$

And its demand for labour is defined as follows:

$$L_{j,i,t} = \frac{Y_{j,i,t}}{B_{j,i,t}} \tag{13}$$

$B_{j,i,t}$ represents firm's labour productivity. The latter is assumed to follow a Kaldor-Verdoorn Law. Hence labour productivity dynamics can be represented as follows:

$$\frac{\Delta B_{j,i,t}}{B_{j,i,t-1}} = \beta + \lambda_j \frac{\Delta Y_{j,i,t}}{Y_{j,i,t-1}} \tag{14}$$

The firm's market share is defined through a replicator dynamic, defined as follows:

$$z_{j,i,t} = z_{j,i,t-1} \left(1 + \phi \left(\frac{E_{j,i,t}}{E_{j,t}} - 1\right)\right) \tag{15}$$

where $E_{i,j,t}$ and $E_{j,t}$ respectively represent the firm's competitiveness and the average competitiveness of the sector j. Firm's competitiveness is defined as the inverse of firm's price level:

$$E_{j,i,t} = \frac{1}{p_{j,i,t}} \tag{16}$$

Firms set prices applying a mark-up ($\mu_{j,i}$) to their unitary production costs ($\kappa_{j,i,t}$). The latter are defined as follows:

$$\kappa_{j,i,t} = \sum_{k=1}^{J} a_{k,j,i,t} p_{k,t} + \frac{w_{j,t}}{B_{j,i,t}} \tag{17}$$

where $p_{k,t}$ represents the average price in sector k :

$$p_{k,t} = \sum_i z_{k,i,t} p_{k,i,t}$$

and $w_{j,t}$ the wage rate applied in sector j at time t. Hence prices are set by firms as follows:

$$p_{j,i,t} = 1 + \mu_{j,i} \left(\sum_{k=1}^{J} a_{k,j,i,t} p_{k,t} + \frac{w_{j,t}}{B_{j,i,t}} \right) \tag{18}$$

Wages are set at the sectoral level. For a given sector j wage dynamics will be correlated to sector j productivity growth rate ($\frac{\Delta B_{j,t}}{B_{j,t-1}}$) and to the entire economy productivity growth rate ($\frac{\Delta B_t}{B_{t-1}}$). The effect of these two variables on wage dynamics is weighted by the parameter $\nu \in [0;1]$, such that :

- When $\nu = 1$, the wage dynamics for every sector only depend on the macro-level productivity growth rate. (i.e. as a centralised wage negotiation system)

- When $\nu = 0$, the wage dynamics for every sector only depend on the sector-level productivity growth rate. (i.e. as a sectoral wage negotiation system)

Wage dynamics of the sector j, in the economy c is represented as follows:

$$\frac{\Delta w_{j,t}}{w_{j,t-1}} = \nu \frac{\Delta B_t}{B_{t-1}} + (1 - \nu) \frac{\Delta B_{j,t}}{B_{j,t-1}} \tag{19}$$

With

$$B_t = \frac{Y_t}{L_t} \text{ and } B_{j,t} = \frac{Y_{j,t}}{L_{j,t}}$$

Note that the wage level defined with this process during the period t is applied by firms at period $t + 1$. Wage dynamics in our model act as a second macro-constraint on firms. Hence, it affects directly firms competitiveness and then the effect of the selection mechanisms on firms. Firms in a given sector of an economy will loose competitiveness if their own productivity growth rate is slower then the average one. Moreover, when $\nu \neq 0$, wage dynamics generate a selection process among sectors. Hence, if the average productivity of a sector grows slower then the average productivity growth rate of the entire economy, through wage dynamics, this sector looses competitiveness. The amplitude of this effect directly depends on the value of the parameter ν.

Technical change at the level of the firms consists in changes in labour productivity as defined by Equation 14 and by changes in the coefficient defining intermediate demand ($a_{k,j,i,t}$). The changes in intermediate demand coefficients are assumed to be stochastic. Formally the changes in intermediate coefficients is represented by the following algorithm:

1. Firms draw a number from a Uniform distribution on [0 ; 1].

2. If this number is contained in the interval $[0 ; \sigma]$, a technological shock occurs. σ is the fixed probability of a technological shock to occure.

3. If a technological shock occurs, every coefficients change following the procedure that follows :

$$a'_{k,j,i,t} = a_{k,j,i,t-1} + \epsilon_{k,j,i,t} \tag{20}$$

$$\epsilon_{k,j,i,t} \sim N(0; \rho) \tag{21}$$

where ρ is given.

The new set of coefficient $(a'_{1,j,t}, ..., a'_{k,j,t}, ..., a'_{J,i,t})$ as defined by this stochastic process, is introduced in the production function if the potential unitary cost is lower then the actual unitary cost:

$$(a_{1,j,t+1}, ..., a_{J,j,t+1}) = \begin{cases} (a'_{1,j,t}, ..., a'_{k,j,t}, ..., a'_{J,i,t}) & \text{If } \sum_{k=1}^{J} a'_{k,j,i,t} p_{k,t} < \sum_{k=1}^{J} a_{k,j,i,t} p_{k,t} \\ (a_{1,j,t}, ..., a_{k,j,t}, ..., a_{J,i,t}) & \text{Otherwise} \end{cases} \quad (22)$$

A firm exits the market if its market share is below $\bar{z}$. It is immediately replaced by a firm whose characteristics correspond to the average values characteristics of the sector.

The dynamic functioning of the model is therefore based on the following mechanisms, across different levels of analysis:

1. An (exogenous) technological shock (i.e. driven by the adoption of ICTs) translates, at the firm level, into lower input costs and prices, which augment firms' market share. The Kaldor-Verdoorn mechanism assures that a virtuous circle between firm's output growth pulled by demand, positive labour productivity dynamics, and further lowering prices and higher demand occurs.

2. At the sectoral level, the (diverse) higher sectoral market share affects the structure of intermediate coefficients, which in turn explains different patterns of structural change of the economy, driven by both technological shocks at the firm level and by changes in the intermediate demand.

3. The aggregate outcome in terms of (output) growth is therefore a function of both the single firms' absorption of technological shock (via lowered prices, higher final demand and output growth, i.e. Kaldor-Verdoorn-like) and the meso-level adjustments in terms of changed intermediate coefficients, the main responsible for the evolution of the structure of the economy.

3 Demand, Technology and Structural Change: Simulation Results

3.1 Simulation Procedure

We conduct numerical simulations on the model developed in Section 2, in order to investigate the sources of the changes in demand and their effect on the sectoral structure of the economies. The simulations are conducted as follows:

- The country specification contains 13 sectors, corresponding to the 13 sectors used in the Input–Ouput Structural Decomposition Analysis carried out in Savona and Lorentz (2006) and reported for convenience in Table 2 in the Appendix.

- Each of the sectors contains 20 firms.

- The results presented are the average outcome of a minimum of 50 replications of the simulation setting. Each simulation runs over 250 steps.

In order to reduce the spectrum of the parameters to be studied, we set the initial structure of the simulation parameters on the basis of the data used in Savona and Lorentz (2006), focusing on the German case. The simulations are carried out on the basis of the actual OECD STAN (1970–1999) and I–O data at the first time step for the following variables and parameters:

- Sectoral intermediate I–O coefficients ($a_{j,k,t}$). Table 3 in the Appendix reports the initial simulation step structure of the intermediate coefficients, as drawn from the German Input–Output tables for 1978.

- Sectoral exports ($X_{j,t}$). These figures are drawn from the I–O tables for Germany 1978, and reported in Table 4 in the Appendix.

- Sectoral shares of final consumption ($c_{j,t}$). These are computed as the ratio between the sector's consumption and total consumption using the 1978 German I–O table. The figures are reported in Table 4 in the Appendix.

- Sectoral shares of import ($m_{j,t}$). These are computed as the ratio between sector's foreign demand and sector's total demand (final and intermediate) using once again the 1978 German I–O table. Also these figures are detailed in Table 4 (Appendix).

- Sectoral Kaldor–Verdoorn parameters (β_j and λ_j). These figures have been estimated using the OECD STAN (1970–1999) data base, and are also reported in Table 4.

We identified four scenarios leading to structural change and analyse the effect of these scenarios in the case of a simulation specification based on the German data. The scenarios are detailed in the next section. It is useful to bear in mind that we do not aim to carry out a proper calibration exercise, as we do not aim to reproduce the trend observed in the data. Rather, we aim to investigate whether the results emerging from the various simulation scenarios are plausible with respect to the empirical findings.

We measure the effect of the different scenarios on the structure of the economy through two different dimensions:

1. The degree of concentration, in income (nominal product), real output and employment. This degree is measured using an inverse Herfindahl index. The index is intended to measure the unevenness of labour and resources allocation among sectors, as well as the changes in these latter due to the mechanisms involved by the various scenarios.

2. The sectoral composition of the economy, in terms of real output and employment. This dimension allows us to detail the changes occurring according to the various scenarios.

3.2 Simulation Scenarios

Drawing upon the stylised facts found in Savona and Lorentz (2006) and some preliminary simulations, we identified four main scenarios driving structural change. Three of these lead to changes in intermediate demand and the fourth to changes in the structure of final consumption. Each of these four scenarios corresponds to a specific setting of a selected number of key parameters. The four scenarios can be described as follows:

1. The *"Baumol disease"* scenario: In this case, the structural change of the employment (and output) composition of the economy follows a re-allocation of workers toward the least productive sectors. In our model, this scenario emerges as a result of *a priori* differences in cross-sector productivity levels, holding final and intermediate demand constant. The differences in productivity levels among sectors mechanically lead to higher shares of employment in the least productive sectors. The differences in productivity levels are linked to the differences in the values of the Kaldor-Verdoorn parameters among sectors. In other words, the dynamics emerging in this scenario are defined by the initial conditions. In this case, the parameters are set as follows:
   (a) The selection mechanism occurs ($\phi = 1$).
   (b) The changes in intermediate coefficients are neutralised ($\sigma = 0$).
   (c) The structure of final demand remains constant (All $c_{j,t} = c_j$).

2. The *"Schumpeterian"* scenario: In this case structural change is driven by changes in the intermediate coefficients. The changes in the macro-structure of the economy is only due to technological shocks. These latter diffuse in the economy *via* the selection mechanisms. The structural change favouring a small number of sectors is therefore only due to the characteristics of the stochastic processes defining changes in the intermediate coefficients. The parameters are set as follows:

   (a) The selection mechanism occurs ($\phi = 1$).

   (b) The sectoral wage growth rates are perfectly correlated with the sector productivity growth rate ($\nu = 0$).

   (c) The structure of final demand remains constant (All $c_{j,t} = c_j$).

   (d) The changes in intermediate coefficient occur ($\sigma \neq 0$).

3. The *"cost reduction"* scenario: In this case structural change is driven by the changes in the cost structure at the level of the firm, simultaneously due to the changes in the intermediate coefficients and to differences in productivity levels among sectors. Wages are perfectly correlated to the aggregate productivity dynamics ($\nu = 1$). In this case, wages do not absorb the sectoral differences in productivity growth rates. These latter therefore directly affect the production costs and prices of firms. Selection occurs on the basis of price competitiveness. In a given sector, firms that are more likely to survive are therefore those who are able to use the cheapest combination of the others sectors' (intermediate) inputs. This affects the structure of the intermediate demand and therefore the structure of the economy. In this case parameters are set as follows:

   (a) The selection mechanisms occur ($\phi = 1$).

   (b) The changes in intermediate coefficient occur ($\sigma \neq 0$).

   (c) The sector wage growth rates are perfectly correlated with the aggregate productivity growth rate ($\nu = 1$).

   (d) The structure of final demand remains constant (All $c_{j,t} = c_j$).

4. The *"final demand driven"* scenario: In this case structural change is only driven by changes in the sectoral consumption shares. Sectoral shares of consumption change independently from each other. There is no changes in the sectoral interdependencies. Structural change is driven by the differences in income elasticities of final demand. In this scenario, parameters are set as follows:

(a) The changes in intermediate coefficient are neutralised ($\sigma = 0$).

(b) The share of a sector in final consumption is function of income elasticity (All $c_{j,t} = \frac{Y_{t-1}^{\varepsilon_j}}{Y_{t-1}}$).

(c) There exist differences in the income elasticity levels among sectors ($\varepsilon_j \neq \varepsilon_k$ for $j \neq k$)

The scenarios rely on a limited number of parameter changes. Modifying the values for σ and ν allows us to consider three different sets of causalities leading to changes in the structure of intermediate demand, i.e. supply– and intermediate demand–led structural changes. The last scenario is based only on changes in the structure of final consumption. The relationship between the various parameter settings and the scenarios is summarised in Table 1:

Table 1: *Simulation scenarios*

	$\nu = 0$		$\nu \to 1$
	$\varepsilon_j = \varepsilon_k$	$\varepsilon_j \neq \varepsilon_k$	
$\sigma = 0$	"Neutral" case	*"Final demand driven"* scenario	*"Baumol disease"* scenario:
$\sigma \neq 0$	*"Schumpeterian"* scenario		*"Cost reduction"* scenario

3.3 Simulation results: the case of Germany

This section presents the results obtained from the numerical simulation carried out for Germany. We applied the parameter configurations corresponding to the three scenarios affecting intermediate demand (Scenarios 1, 2, and 3 as illustrated in the previous Section) to the model set using the I–O data for Germany. Note that we did not consider the fourth scenario for Germany as the data do not show any significant change in the structure of final consumption.

The empirical evidence for Germany, as emerging in Savona and Lorentz (2006), shows an increase in the degree of concentration of output, between 1978 and 1995. In other words aggregate output has been growing but confined to a small number of sectors.

Figures 1 to 2 respectively present the degree of concentration measured for income, employment and real output. The figures have been obtained for various specifications of the parameters σ and ν, in such a way that they emerge as the effects of the dynamics consequent to the three different scenarios. In particular:

- Keeping σ null and moving along the y-axis corresponds to the emergence of a "Baumol disease" type of dynamics;
- Keeping ν null and moving along the x-axis corresponds to "Schumpeterian" types of dynamics of structural change;
- Modifying simultaneously ν and σ generates "Cost reduction" type of structural change.

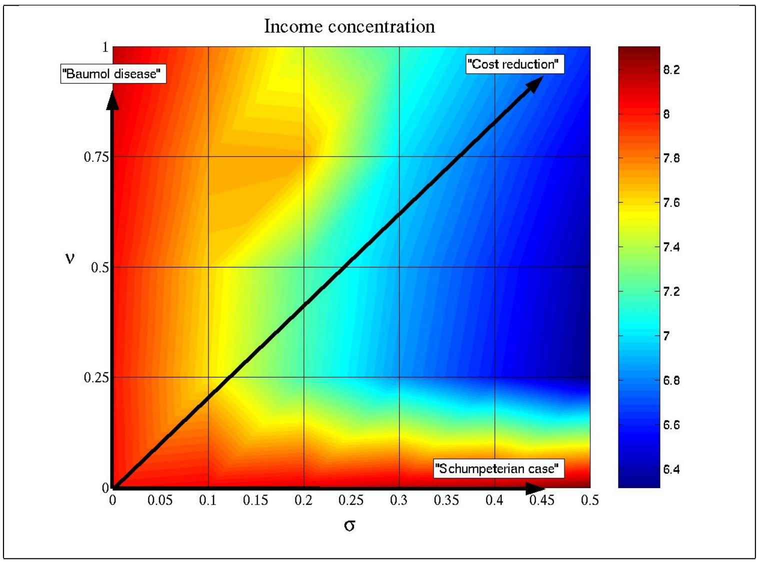

Figure 1: Income sectoral concentration (Inverse Herfindahl index)

As illustrated by Figure 1, in the two extreme cases, the "Baumol disease" and the "Schumpeterian" cases, the dynamics lead to lower degrees of concentration in income than the "Cost Reduction" or intermediate case. A similar pattern emerges when considering the concentration in employment (see Figure 2).

Figure 3 presents the concentration levels in terms of output, measured for the various specifications of the parameter ν and σ. A drastic difference appears with respect to income and employment. As the wage dynamics tend to be more centralised, when keeping the probability of technological shocks to zero, the output concentration, measured at the end of the simulations, appear higher. In other words, in the case of the "Baumol disease" scenario,

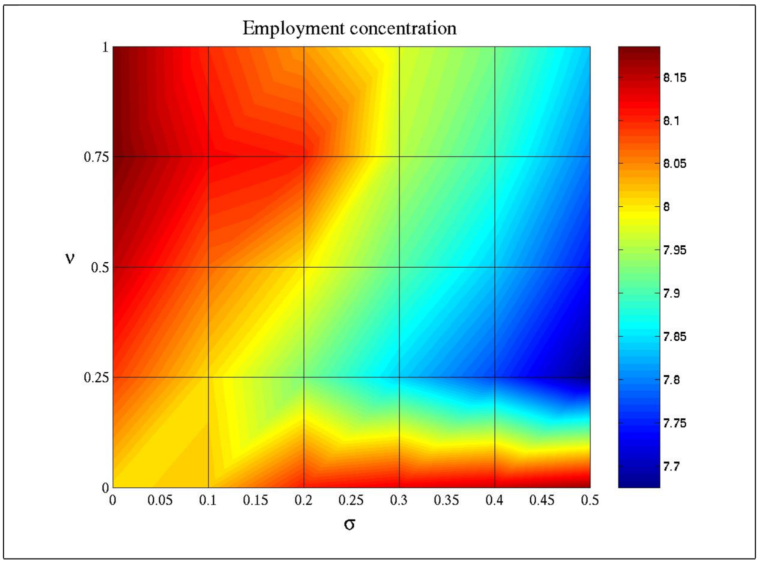

Figure 2: Employment concentration (Inverse Herfindahl index)

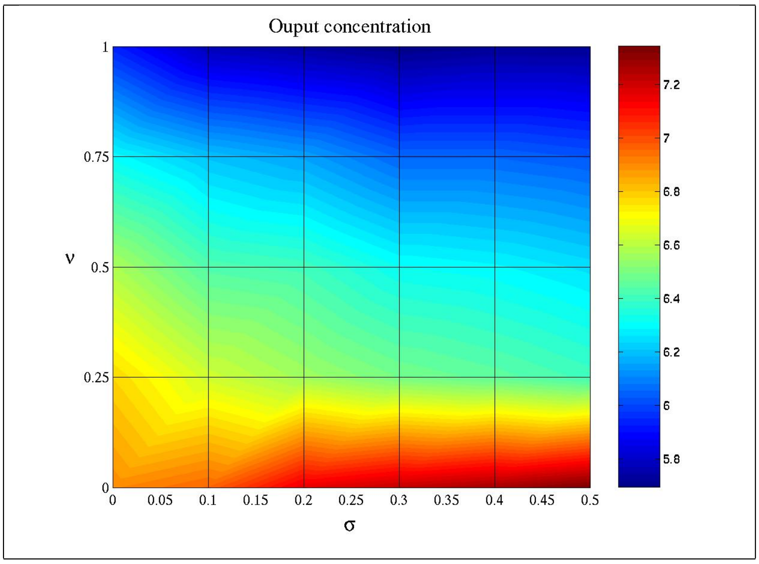

Figure 3: Real output concentration (Inverse Herfindahl index)

the output structure concentrates in a smaller number of sectors. On the contrary, the dynamics considered in the "Schumpeterian" scenario lead to a lower level of concentration (higher dispersion).

These results are confirmed by Figures 4 and 5 that reports the evolution of the measure of concentration of output along the simulations for the

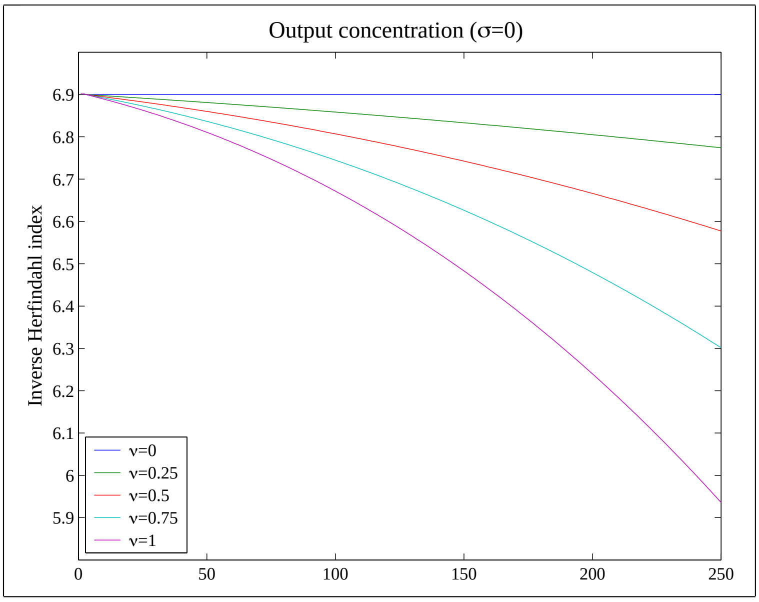

Figure 4: Real output concentration ("Baumol disease")

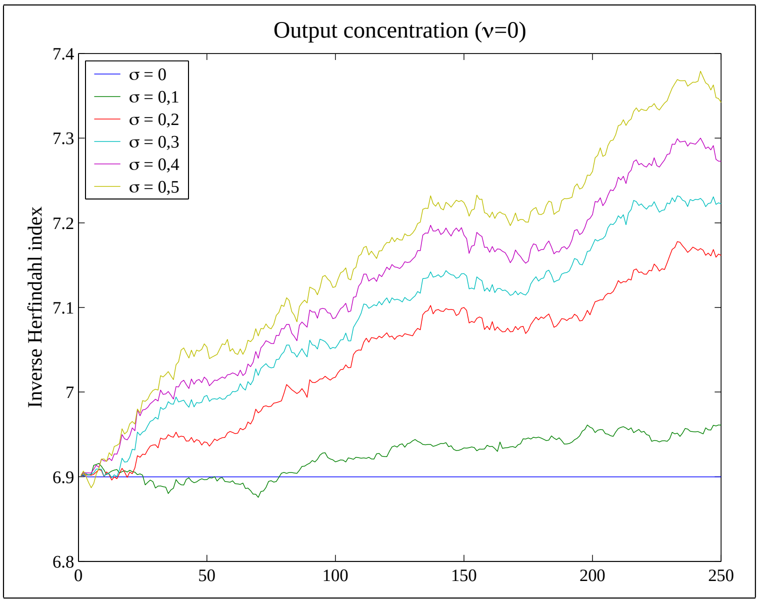

Figure 5: Real output concentration ("Schumpeterian Case")

two extreme scenarios. Figure 4 clearly shows that, in the "Baumol disease" case, output concentrates in a small number of sectors over time. This process is accelerated as wages are more centralised ($\nu \to 1$). In the case of a "Schumpetarian"-like structural change (Figure 5), the emergence of technological shocks dramatically reduces the concentration index. The more likely are the technological shocks, the faster and more significant the reduction of the concentration index.

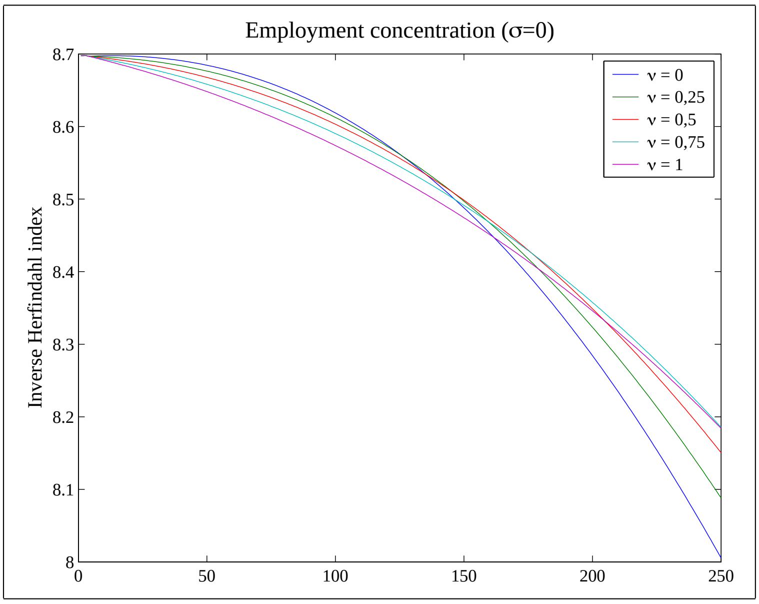

Figure 6: Employment concentration ("Baumol disease")

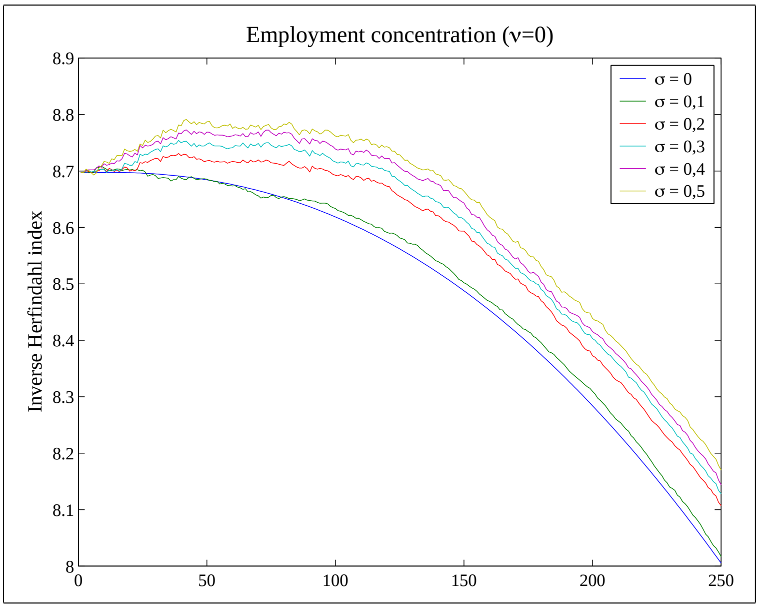

Figure 7: Employment concentration ("Schumpeterian Case")

Figures 6 and 7 present the evolution of the inverse Herfindahl index in employment shares respectively for the "Baumol disease" and the "Schumpeterian" scenarios. In both cases we observe an increase in concentration but, the closer to the extreme values (i.e respectively $\nu \to 1$ and $\sigma \to 0,5$), the slower and lower the concentration.

More precisely, as wage dynamics become more centralised, the concentration slows down over time. As the dynamics tend to the "Baumol disease" scenario, employment is less concentrated in a small number of sectors.

In the second case, the more frequent the technological shocks (while keeping wages decentralised), the slower and lower the index of concentration in the structure of employment is.

Overall, we can summarise the dynamics related to each scenarios as follows:

1. In the "Baumol disease" scenario, structural change dynamics lead to a lower degree of concentration in the income and employment structures but a higher degree of concentration in the output structure.

2. In the "Schumpeterian" case, structural change results in a lower degree of concentration for all the variables. The economic activity spreads among a larger number of sectors as compared to the initial conditions.

3. In the "Cost reduction" scenario, structural change dynamics lead to amplifying the initial heterogeneity, deepening the degree of concentration for all the indicators.

These results might be explained as follows: In the "Baumol disease" case, structural change is only driven by the differences in the productivity dynamics across sectors. As wages are centralised, these productivity differences directly affect the demand structure *via* the relative prices and the employment structure. Sectors with higher (than the average) productivity growth experience a decrease in prices over time and therefore an increase in demand. This explains the growth in the degree of concentration of real output. The high productivity sectors increase their level and share of output via reducing their prices. The low productivity sectors reduce their level of output as they experience an increase in prices. As these two effect compensate, this explains the lowering in the degree of concentration in the income structure. Similarly the loss, respectively gains, in output are partially compensated by the higher, respectively lower, gains in labour productivity, implying then a reduction, respectively increase in the sectoral shares of total employment. This would also account for the lower degree of concentration in the employment structure.

In the "Schumpeterian" case, wages are decentralised and therefore absorb the heterogeneity in productivity dynamics. The only source of structural change are the technological shocks occurring at the micro-level changing the technological coefficients in the production functions. The more frequent the shocks, the more frequent the changes in the structure of intermediate demand. However, the shocks follow similar patterns of distribution among sectors. As a consequence, technological shocks tend to reduce the differences in intermediate demand, among sectors. Therefore the more frequent the shocks the lower the degree of concentration in output. As wages absorb the changes in labour productivity, price dynamics follow the changes in the technological coefficients. At the meso-level, this implies that the less concentrated the output the less concentrated the income structure. The employment structure of the economy is a consequence, also in this scenario, of the differences in productivity dynamics among sectors, though this effect is slowed down by the technological shocks.

In the "Cost reduction" scenario, structural change is simultaneously due to the differences in the productivity dynamics among sectors and to the technological shocks. In this case, as technological shocks diffuse among the sectors and in the economy, they tend to amplify the sectoral heterogeneity in intermediate demand due to the differences in productivity. The shocks are absorbed at the micro and meso level, through the selection mechanisms, only if these reduce the production costs. The absorbed shocks are those favouring the most productive sectors. Hence, the productivity differences affect demand *via* the relative prices but also through the cost reduction linked to the adoption of technological shocks. The combination of these two mechanisms therefore reinforces the concentration dynamics in a small number of highly productive sectors. This last scenario might therefore be the most likely to explain the increase in concentration found in the empirical evidence.

The dynamics described above are illustrated in Figures 8 to 13, presenting the evolution of the sectoral composition of the economy for each scenarios.

As shown by Figure 8, in the case of a "Baumol disease" type of structural change, the manufacturing sectors, experiencing higher productivity growth, grow in terms of output, while sectors as KIBS or TRADE tend to decline. On the contrary, these latter gain importance in terms of employment shares while the manufacturing sectors employment shares decline (Figure 9).

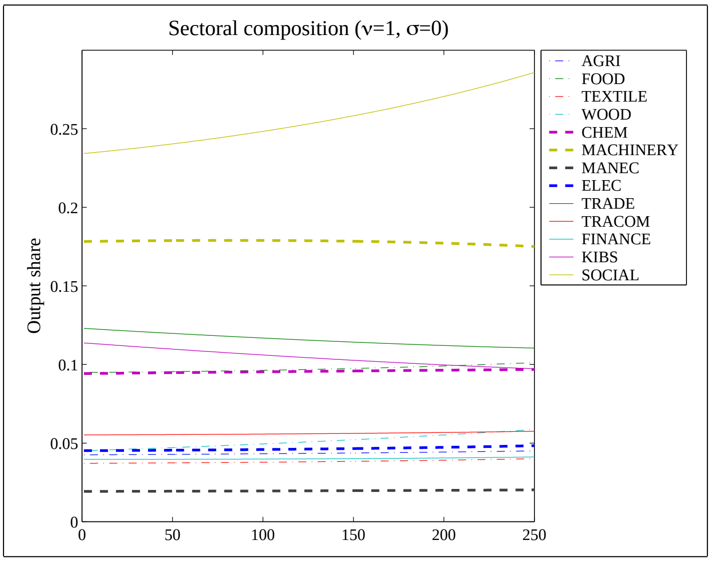

Figure 8: Sectoral composition in real output ("Baumol disease")

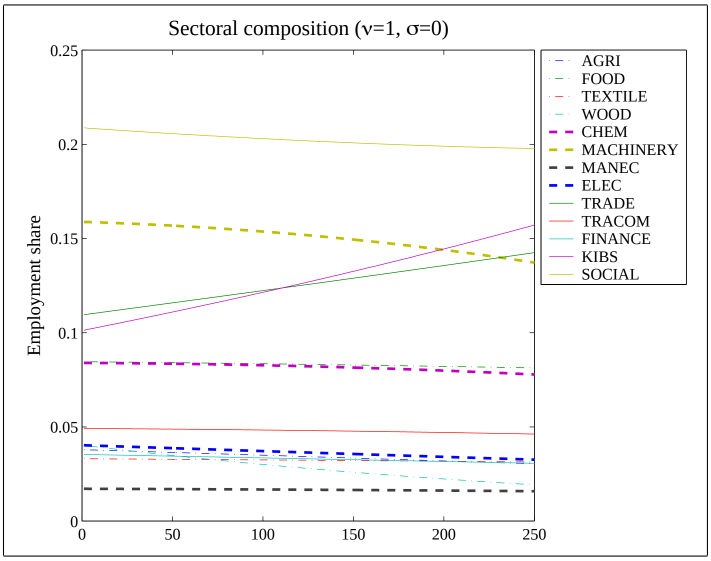

Figure 9: Employment sectoral composition ("Baumol disease")

In other words, the structural change as generated in the "Baumol disease" scenario tends to re-industrialisation and de-tertiarisation of the economy. The mechanisms behind this scenario favours high productivity manufacturing activities. This scenario is therefore unable to account for the empirical evidence found in the case of KIBS.

The structure of the economy resulting from a "Cost reduction" scenario

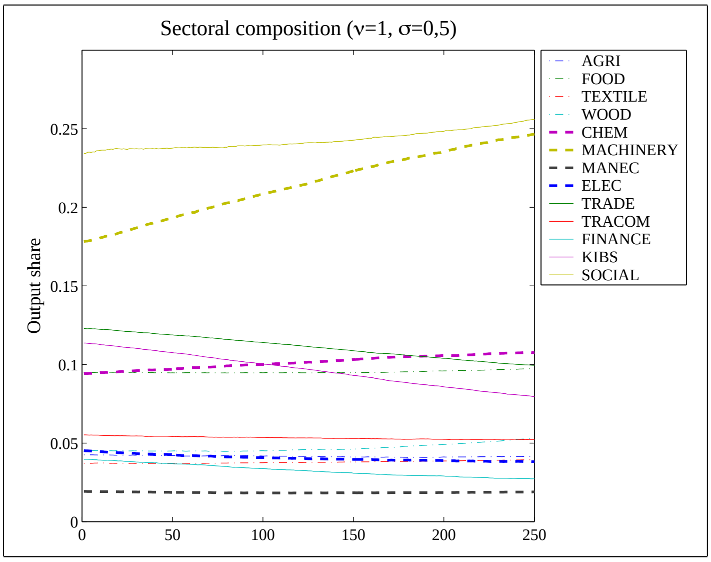

Figure 10: Sectoral composition in real output ("Cost reduction")

is similar, favouring the manufacturing activities as shown by Figures 10 and 11. The changes in the output structure are however amplified with respect to the "Baumol disease" case.

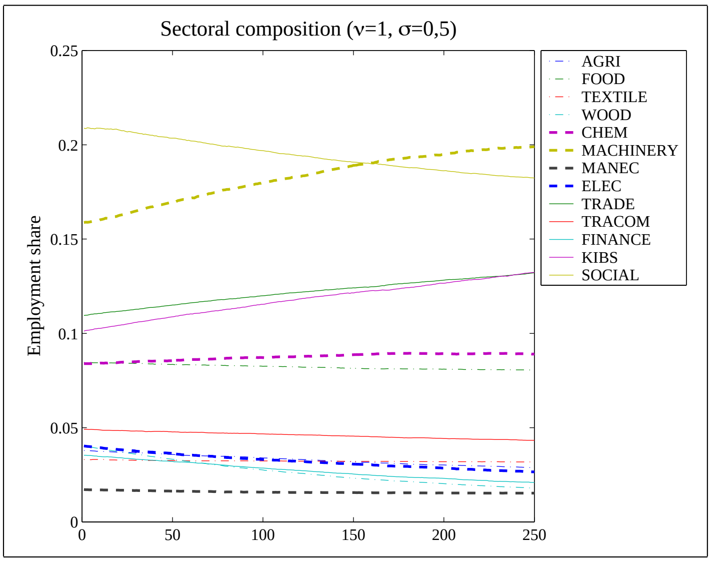

Figure 11: Employment sectoral composition ("Cost reduction")

There again the manufacturing branches benefit from the mechanisms underlying this scenario due to the fact that these sectors are characterised by higher productivity levels. However, this result might be directly linked

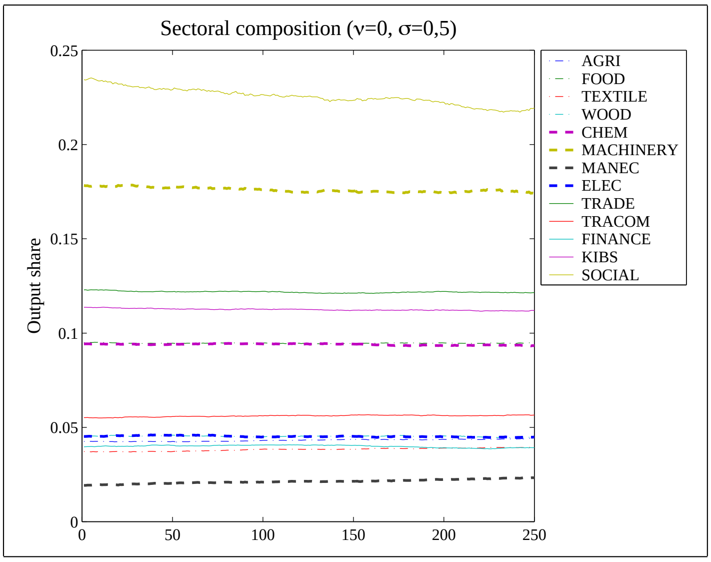

Figure 12: Sectoral composition in real output ("Schumpeterian case")

to the fact that the dynamics implied in this scenario accelerate and amplify the effects triggered by productivity differences (as in the "Baumol disease" case) or by technological shocks.

Figure 12 and 13 present the evolution of the output and the employment structure of the economy when considering a "Schumpeterian" scenario. In this last case the share of each sectors in terms of output seems to converge (Figure 12). This result is directly link to the symmetry of the technological shocks among sectors. These latter follow the same pattern of distribution regardless the sectors.

However, the structure of employment follows exactly the same scheme as in the "Baumol disease" case. Employment is structured by the productivity differences, as in the latter case. As wages are centralised, the effect of productivity differences is confined to the employment structure.

Figure 14 presents the evolution of the sectoral structure in Germany for the period 1978-1995. One can clearly observe a tendency toward tertiarisation with the rise of the shares of KIBS and SOCIAL and more generally a gain in importance of all the service sectors parallel to the relative decline of the manufacturing activities.

This structure is exactly the opposite of the one generated in both the "Baumol disease" and the "Cost reduction" scenarios. In other words, according to both these scenarios, the structural changes generated exhibit a

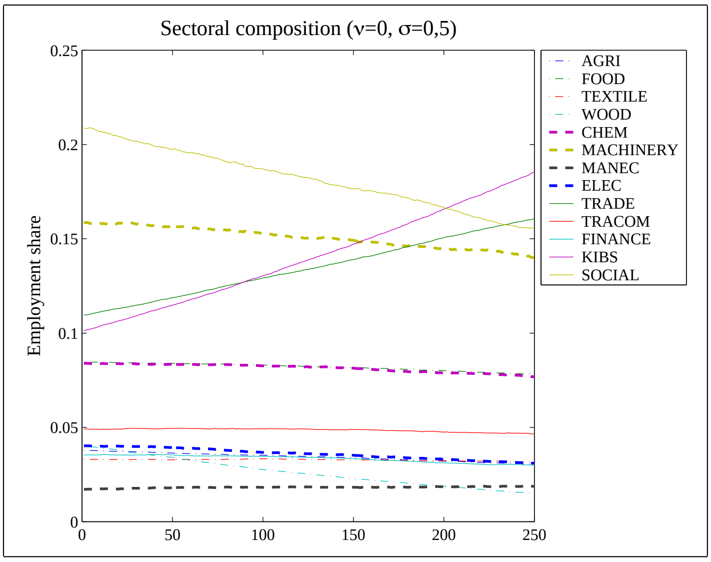

Figure 13: Employment sectoral composition ("Schumpeterian case")

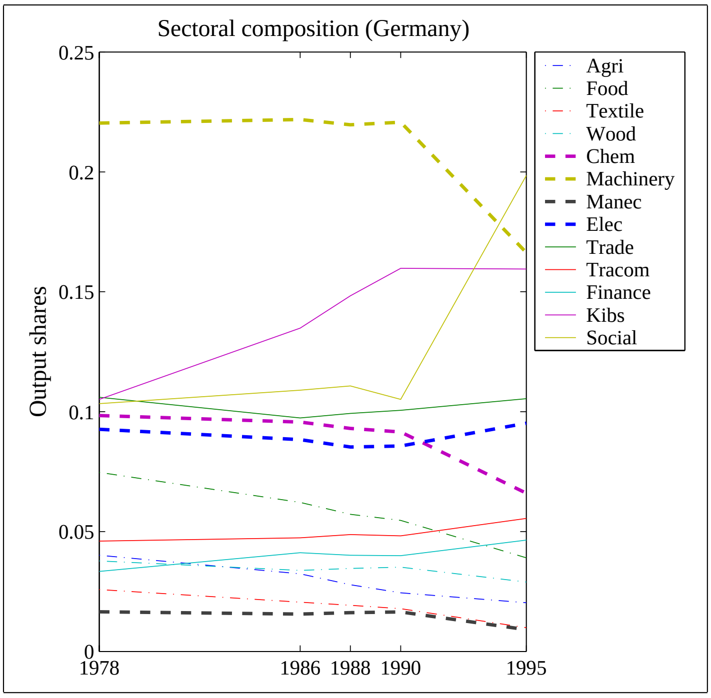

Figure 14: Sectorial composition in real output (Germany 1978-1995)

tendency towards industrialisation rather then tertiarisation observed in the German data. These two scenarios rely on the existence of productivity differences among sectors. We can therefore conclude that the growth of services in Germany cannot to be directly imputed to the structure of productivity differentials.

The simulated results obtained through the various scenarios do not seem to provide any straightforward explanation of the determinants of structural change and growth of services in Germany. However it has allowed us to reject a purely "Baumol disease" explanation. A better explanation for the structural change leading to the growth of services might be found at the micro-level of analysis, particularly in the nature of technological shocks. In this respect, the model considers symmetrical shocks whereas in reality these shocks are asymmetric and *de facto* leading to sectoral differences in the growth rates and output concentration. However, this asymmetry can hardly be introduced directly in the model, but evidences sustaining this idea might be found in micro-level empirical contributions (Savona, 2004; Cainelli, Evangelista, and Savona, 2006).

Moreover, as found in Savona and Lorentz (2006) in the case of Germany, the growth of services seems to have been complementary rather then detrimental to the growth of manufacturing sectors. Tertiarisation processes in Germany has been driven by the combination of highly productive manufacturing sectors and asymmetric technological shocks. These shocks have favoured the expansion of services following an increase in the inter–sectoral division of labour (i.e. the extension of outsourced activities by the manufacturing sectors) and an increase of the intermediate demand for service activities. A more in–depth exploration of such a scenario would require more a "history-friendly" approach. Unfortunately, the data used to set some of the initial parameters in the present work do not allow such methodological tool. This might be the subject for future developments of research.

4 Conclusive remarks

The paper has aimed to add to the still on-going debate on the determinants of structural changes of the economy, particularly those leading to the growth of services. In the present work we have built upon the empirical evidence found and summarised in Section 1, in the belief that this can be interpreted in the light of both the Keynesian and the neo-Schumpeterian streams of literature. Our conjecture is that the determinants of structural change and particularly the growth of services in the advanced countries over the last decades implies the co-presence of (and most likely a virtuous circle between) a sustained growth of patterns of final demand, especially private and public domestic consumption, and radical changes in the sectoral division of labour, following technological changes and changes in the production organisation of most branches of the economy.

A growth model with evolutionary micro-founded structural change has been developed in Section 2. The model has been simulated on the basis of four different scenarios, accounting for both demand and technological determinants of structural change. The scenarios have been identified both along the main lines around which the debate over tertiarisation has revolved and on the empirical stylised facts found in our previous work (Savona and Lorentz, 2006). The simulation procedures and the characteristics of the scenarios are detailed in Section 3.1 and 3.2 respectively.

The model has been simulated on the basis of the actual (initial year) I–O intermediate coefficients at the first time-step. The results of the simulation scenarios are discussed at length in Section 3.3.

At this stage of the work, we have been able to conclude that the structural changes occurred in the case of Germany have been driven by a synthesis of the three stylised scenarios identified in this paper. In particular, and in line with the empirical evidence, the "Baumol" case cannot alone explain the actual patterns of tertiarisation occurred in Germany over the past decades. Rather, the intertwined effect of changes in the intermediate demand and technological shocks has been at work. However, more a refined account for the nature and the effects of technological shocks should be considered. The model is based on symmetrical technological shocks whereas in reality the empirical evidence is the results of asymmetrical technological shocks. To achieve this we need to revert to more disaggregated data on the mechanisms behind these shocks. This issue will be part of our future research agenda.

All in all, the present work has also aimed to start filling the fracture between Keynesian and neo-Schumpeterian 'lines of thought' (Verspagen, 2002a) in the belief that more effort should be devoted to integrating - especially in the domain of services - these two main theoretical streams, in turn driven by the idea that the growth and composition of demand might be the ultimate shapers of changes in the structural composition of advanced economies.

References

Aghion, P., and R. Griffith (2005): *Competition and Growth.* MIT Press.

Aghion, P., and P. Howitt (1992): "A Model of Growth Through Creative Destruction," *Econometrica*, 60(2), 323–351.

——— (1994): "Growth and Unemployment," *The Review of Economic Studies*, 61(3), 477–494.

Appelbaum, E., and R. Schettkat (1999): "Are Prices Unimportant? The Changing Structure of Industrialised Economies," *Journal of Post-Keynesian Economics*, 21, 387–398.

Barro, R. (1991): "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, 106(2), 407–443.

Baumol, W. (1967): "Macroeconomics of Unbalanced Growth: The Anatomy of an Urban Crisis," *American Economic Review*, 57, 415–426.

Baumol, W., and W. Bowen (1966): *Performing Arts: The Economic Dilemma.* Twentieth Century Found, New York.

Cainelli, G., R. Evangelista, and M. Savona (2006): "Innovation and economic performance in services. A firm-level analysis," *Cambridge Journal of Economics*, 30, 435–458.

Clark, C. (1940): *The Conditions of Economic Progress.* MacMillan, London.

Dosi, G., C. Freeman, R. Nelson, G. Silverberg, and L. Soete (1988): *Technical Change and Economic Theory.* Pinter, London.

Fagerberg, J. (1994): "Technology and International Differences in Growth Rates," *Journal of Economics Literature*, 32, 1147–1175.

Fuchs, V. (1968): *The Service Economy.* National Bureau of Economic Research, New York.

Kaldor, N. (1957): "A Model of Economic Growth," *Economic Journal*, December, 65–94.

——— (1966): *Causes of the Slow Rate of Growth in the United Kingdom.* Cambridge University Press, Cambridge.

Keynes, J. (1936): *The General Theory of Employment, Interest and Money*. MacMillan, London.

Leontief, W. (1951): *The Structure of American Economy 1919-1939*. Oxford University Press, New York, 2nd edn.

——— (1953): *Studies in the Structure of the American Economy*. Oxford University Press, New York.

Llerena, P., and A. Lorentz (2004a): "Co-Evolution of Macro-Dynamics and Technical Change: An Alternative View on Growth," *Revue d' Economie Industrielle*, 105, 47–70.

——— (2004b): "Cumulative Causation and Evolutionary Micro-founded Technical Change: On the Determinants of Growth Rates Differences," *Revue Economique*, 55(6), 1191–1214.

Montobbio, F. (2002): "An Evolutionary Model of Industrial Growth and Structural Change," *Structual Change and Economic Dynamics*, 13, 387–414.

Nelson, R., and S. Winter (1982): *An Evolutionary Theory of Economic Change*. Harvard University Press.

Panico, C. (2003): "Old and New Growth Theories: What Role for Aggregate Demand?," in *'Old and New Growth Theories. An Assessment'*, ed. by N. Salvadori. Edward Elgar.

Parrinello, S. (2004): "The Service Economy Revisited," *Structural Change and Economic Dynamics*, 15, 381–400.

Pasinetti, L. L. (1973): "The Notion of Vertical Integration in Economic Analysis," *Metroeconomica*, 25, 1–29.

——— (1981): *Structural Change and Economic Growth: A Theoretical Essay on the Dynamics of the Wealth of the Nations*. Cambridge University Press, Cambridge.

Pugno, M. (2006): "The Service Paradox and Endogenous Economic Growth," *Structural Change and Economic Dynamics*, 17, 99–115.

Rose, A., and S. Casler (1996): "Input-Output Structural Decomposition Analysis: A Critical Reappraisal," *Economic System Research*, 8(1), 33–62.

SAVONA, M. (2004): "Structural Change, Technology and Growth of Service," Unpublished dphil dissertation, SPRU, Science and Technology Policy Research.

SAVONA, M., AND A. LORENTZ (2006): "Demand and Technology Determinants of Structural Change and Tertiarisation: An Input-Output Structural Decomposition Analysis for Four OECD Countries," Working papers, BETA.

SCHETTKAT, R., AND L. YOCARINI (2006): "The Shift to Services Employment: A Review of the Literature," *Structural Change and Economic Dynamics*, 17, 127–147.

SCHUMPETER, J. (1934): *The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle*. Harvard University Press., Cambridge, MA.

SILVERBERG, G., AND B. VERSPAGEN (1995): "Evolutionary Theorizing on Economic Growth," Working paper, MERIT, Maastricht.

TEN RAA, T., AND R. SCHETTKAT (2001): *The Growth of Service Industries. The paradox of exploding costs and persistent demand*. Edward Elgar, Cheltenham.

THIRLWALL, A. P. (2002): *The Nature of Economic Growth. An Alternative Framework for Understanding the Performance of Nations*. Edward Elgar, Cheltenham, UK and Cambridge, Mass.

——— (2003): "'Old' thoughts on 'New' Growth Theory," in *'Old and New Growth Theories. An Assessment'*, ed. by N. Salvadori. Edward Elgar.

VERDOORN, P. (1949): "Fattori che Regolano lo Svilluppo della Produttivitá del Lavoro," *L' Industria*, 1, 45–53.

VERSPAGEN, B. (1993): *Uneven Growth Between Interdependent Economies: Evolutionary Views on Technology Gaps, Trade and Growth*. Avenbury.

——— (2000): "Growth and Structural Change: Trends, Patterns and Policy Options," in *'The Future of Innovation Studies', Eindhoven University*.

——— (2002a): "Evolutionary Macroeconomics: A synthesis between neo-Schumpeterian and post-Keynesian line of thought," *The Electronic Journal of Evolutionary Modeling and Economic Dynamics*, n. 1007(http://www.e-jemed.org/1007/index.php).

——— (2002b): "Structural Change and Technology. A Long View," in *DRUID Summer Conference*, Copenhagen - June 2002.

Appendix

Table 2: Sectors Included in the analysis

ISIC Rev.3	**Acronym**	**Industry**
1-14	AGRI	Agriculture, hunting, forestry, fishing, mining, and quarrying
15-16	FOOD	Food products, beverage and tabacco
17-19	TEXTILE	Textiles, textile products, leather and footwear
20-22	WOOD	Wood, wood products, cork, pulp, paper, paper products, printing and publishing
23-26	CHEM	Chemical, rubber, plastic, fuel products, and other non-metallic mineral products
27-35	MACHINERY	Basic and fabricated metal prod., machinery and equipments
36-37	MANEC	Manufacturing n.e.c.
40-45	ELEC	Electricity, Gas, Water and Construction
50-55	TRADE	Wholesale and retail trade; Hotels and restaurants
60-64	TRACOM	Transports, storage and communications
65-67	FINANCE	Financial Intermediation
70-74	KIBS	Real estate; Renting of machinery and equipment; computer and related; R&D; business services**
75-99	SOCIAL	Community; social; personal and other government services

**Business services (74) includes: Legal and Accounting; Engineering; Technical Consultancy; Marketing; Training; Cleaning; Security

Table 3: Initial I–O coefficients (Germany 1978)

	AGRI	FOOD	TEXTILE	WOOD	CHEM	MACHINERY	MANEC	ELEC	TRADE	TRACOM	FINANCE	KIBS	SOCIAL
AGRI	0.16157	0.30250	0.03098	0.03728	0.09699	0.01651	0.00096	0.05997	0.01367	0.00022	0.00078	0.00940	0.00316
FOOD	0.08889	0.21821	0.00028	0.00039	0.00501	0.00052	0.00054	0.00028	0.05911	0.00636	0.00152	0.00989	0.01127
TEXTILE	0.00154	0.00074	0.32907	0.01668	0.00365	0.00210	0.00558	0.00174	0.00298	0.00209	0.00158	0.00272	0.00311
WOOD	0.00956	0.01792	0.00723	0.24626	0.01663	0.00907	0.02665	0.03156	0.02798	0.01101	0.01742	0.00856	0.04735
CHEM	0.07711	0.03023	0.07225	0.08083	0.30363	0.04622	0.06617	0.14025	0.02236	0.05728	0.00493	0.01865	0.01683
MACHINERY	0.05907	0.00934	0.01398	0.02796	0.02574	0.39281	0.24025	0.06671	0.01303	0.04702	0.01043	0.01469	0.01679
MANEC	0.00331	0.00999	0.00689	0.01628	0.00807	0.01221	0.03808	0.01543	0.00299	0.00289	0.00218	0.00187	0.00087
ELEC	0.04959	0.01182	0.01588	0.02187	0.03627	0.01703	0.01456	0.04710	0.02241	0.02219	0.01027	0.05487	0.00372
TRADE	0.02703	0.03541	0.05260	0.05086	0.03959	0.04836	0.05346	0.03270	0.05125	0.04373	0.01476	0.01319	0.00900
TRACOM	0.02351	0.02725	0.01842	0.03524	0.03109	0.01945	0.02294	0.02553	0.03468	0.10062	0.02985	0.00850	0.00941
FINANCE	0.02761	0.01138	0.02065	0.02163	0.01560	0.01923	0.02374	0.02835	0.03831	0.04751	0.02313	0.04680	0.01007
KIBS	0.01751	0.02474	0.03949	0.03580	0.04762	0.03701	0.04228	0.03706	0.10449	0.02585	0.14282	0.06973	0.01763
SOCIAL	0.00882	0.00211	0.00278	0.00272	0.00241	0.00239	0.00311	0.00127	0.00688	0.00214	0.00898	0.01306	0.00971

Source: OECD Input Output Tables, own calculation

Table 4: Initial values for selected coefficients (Germany 1978)

	Exports	Consumption shares	Import shares	K–V coefficients	
	$X_{j,t}$*	$c_{j,t}$*	$m_{j,t}$*	λ_j**	β_j**
AGRI	9768.69818	0.00801	0.39532	0.872	-0.002
FOOD	14510.06581	0.04785	0.11404	0.862	-0.001
TEXTILE	16484.99734	0.01964	0.35369	0.475	0.034
WOOD	10152.96088	0.00863	0.13128	0.715	-0.002
CHEM	65014.43969	0.02415	0.21723	0.851	-0.001
MACHINERY	204944.78578	0.03033	0.17266	0.582	-0.001
MANEC	12873.43864	0.00520	0.22848	0.612	0.005
ELEC	3117.50666	0.01261	0.00509	0.469	-0.021
TRADE	13869.20244	0.06247	0.01892	0.717	-0.002
TRACOM	23830.67028	0.01489	0.08088	0.902	0.001
FINANCE	366.39001	0.00828	0.00449	0.928	-0.03
KIBS	7777.17059	0.0541	0.03043	0.217	0.004
SOCIAL	3263.04137	0.09851	0.01350	0.812	-0.011

Source: *OECD Input Output Tables, own calculation
**OECD STAN, own calculation