Testing for Linkages in Sectoral Development: An SVAR-Approach to South Africa

Michael Wild*, Oliver Schwank
Vienna University of Economics and Business Administration

October 2008

Abstract

South Africa has a peculiar industrial structure given its factor endowments: production is capital intensive in sectors and concentrated in capital intensive sectors despite an abundance of unskilled labour. Part of the reason for this phenomenon lies in the development process of South African industry: it grew around the mining sector and its core sectors remain close to the minerals endowment up until today.

A possible explanation for this path dependent development is the existence of forward and backward linkages between sectors that drive industrial development. We use an SVAR approach with realistic identification assumptions from input-output relations—following a paper by Abeysinghe and Forbes (2005)—to estimate the effect of linkages between sectors on sectoral growth performance.

1 Introduction

South Africa's economy was historically dominated by a strong mining and quarrying sector which was largely responsible for its overall economic performance. At least since the 1970s, the mining sector is in decline however, and now only contributes about 6% of total value added in South Africa. Nevertheless it is often argued that due to strong linkage effects, mining remains hugely influential for the South African economy and determines its growth path. The peculiar form of sectoral development in South Africa—a strong performance of capital-intensive industries and disappointing growth in labour-intensive manufacturing despite an abundance of unemployed unskilled labour—certainly requires explanation, and the country's mineral endowment and its heavy use in a number of capital-intensive sectors might provide just that.

In this paper we seek to investigate whether these linkages are present and how large their contribution to individual sectoral development is. Methodologically we try to solve this puzzle by using an SVAR approach (using an approach

*Corresponding author: Vienna University of Economics and Business Administration, Augasse 2-6, 1090 Wien; email: michael.wild@wu-wien.ac.at; Tel: +43-1-31336-5016

developed by Abeysinghe and Forbes 2005) which not only allows us to consider the direct input-output linkages between individual sectors, but also indirect effects that are not captured in IO-tables. We proceed as follows: after a short theoretical overview and description of historical sectoral development in South Africa, we introduce the econometric model in section 4. This is followed by a short discussion of the data and the presentation of results. Lastly, we carried out impulse-response analysis (7) to isolate the impacts of sectoral shocks on the rest of the economy.

2 Linkages in Economic Theory

The sectoral composition of output, the linkages between the different sectors and their combined impact on growth and development have been of interest to a variety of theoretical approaches to economic growth. We limit ourselves to those that stress linkages (for a more complete overview see Tregenna 2007).

German economist Friedrich List may be better known for his arguments on infant industry protection, yet the underlying idea presented by him is equally interesting: in his main work, first published in 1841, he stresses the importance of productive capabilities that are built up in the development process, and how the pursuit of certain industrial activities calls forth production and is productivity enhancing in other sectors of the economy (List, 1950). For him, there is an important difference between a nation using its resources in agricultural production, and one that focuses on manufacturing. The latter is preferable since manufacturing activities lead to productivity increases in all other sectors. Moreover, they trigger processes of institutional, infrastructural and political progress (ibid., 230). However, diversification and the emergence of new industries is not a 'natural' phenomenon that can be relied on happening in a market economy. He argues that protective tariffs are necessary to protect 'infant industries' from competition—the underlying argument being that productivity increases over time and with scale (ibid., 415ff.).

After 1945, the impending independence of colonies sparked an interest in questions of development that was answered by the nascent discipline of development economics. Often, the concept of linkages was at the very core of these works. In addressing challenges of industrialisation in the European periphery, Rosenstein-Rodan argues for a "large scale planned industrialization" (Rosenstein-Rodan, 1943, 205) in order to enable the exploitation of complementarity of industries. He explicitly refers to external economies as introduced by Marshall (1938) here: the social marginal product of an activity exceeds the private marginal product since it creates linkages—both directly by pushing suppliers of inputs over a certain profitability threshold, and indirectly by raising aggregate demand due to the employment of formerly idle manpower.

Albert O. Hirschman then went on to explicitly define backward and forward linkages, the former inducing local production of inputs once demand for these inputs reaches a critical scale, the latter providing inputs locally for downstream producers (Hirschman, 1966). He also enriched the concept by stressing two necessary conditions for linkages to work: scale effects—without economies of scale the concept of linkages would be meaningless since every economic activity is linked to many others—and private entrepreneurial or public responsiveness to incentives. Linkages can also be understood as providing investment opportunities and therefore act as guidance for private and state investment (Hirschman, 1981). Here, Hirschman comes very close to ideas of 'unbalanced growth' (see for example Streeten, 1959). Recently, backward and forward linkages have been formalized in models of the New Economic Geography type (see for example Krugman and Venables, 1995; Venables, 1996).

The importance of structural dynamics within developing countries has also resurfaced in recent debates. Ocampo (2005) stresses the importance of a dynamic production structure capable of constantly generating new activities. The importance of sectoral diversification in the long-run development process has also recently been empirically shown in an important paper by Imbs and Wacziarg (2003). Rodrik (2007), in a related effort, then goes on to deduce the necessity of industrial policy to support entrepreneurs, since innovators usually do not reap the full benefits of their risky investments in developing countries.

Linkages thus play a crucial part in the industrialisation path a country is taking. They provide opportunities for further activities—in the case of a minerals economy such as South Africa these opportunities naturally appear around the resource endowments. This corresponds to the actual development experience of South Africa.

3 South African Industrial Development

South Africa's economy was built up around the mining sector, and many of the structural features characterizing South Africa today can be traced back to the 'mineral revolution' of the 1870s when gold was first discovered in the region. Due to the depth of the mines, the exploitation of minerals was a very capital intensive undertaking, requiring expensive exploration operations and elaborate and energy-intensive physical and chemical processes. This resulted in an early consolidation of ownership in the industry, while backward linkages fostered growth in coal mining and electricity generation, chemicals (explosives) and a range of other industries (Feinstein, 2005, 101ff.).

The evolution of the South African economy around the mining sector has inspired Fine and Rustomjee (1996) to coin the term 'Minerals-Energy Complex' or MEC. By MEC they mean the mining sector and the tightly integrated sectors built up around it: "Coal, gold, diamond and other mining activities; electricity; non-metallic mineral products; iron and steel basic industries; non-ferrous metals basic industries; and fertilisers, pesticides, synthetic resins, plastics, other chemicals, basic chemicals and petroleum." (ibid.: 79). They interpret the MEC as a system of accumulation that can explain the structure of South African industrialisation. This system is central, not only due to its input-output linkages, but because of its specific ownership structure and its relation to the financial sector and state. In mining, ownership was highly concentrated,

	Value Added, Ann Gr		Sectoral Shares in Total VA			Investment, Ann Gr		EX/Output
	1970-2006	1990-2006	1970	1990	2006	1970-2006	1990-2006	2005
Agriculture, forestry and fishing	1,62	-0,06	0,03	0,04	0,02	-0,80	0,46	22,56
Mining and quarrying	-0,34	0,31	0,19	0,09	0,06	3,19	-0,78	62,48
Manufacturing	2,67	1,99	0,18	0,20	0,18	3,49	3,96	18,36
Food, beverages and tobacco	2,21	0,57	0,03	0,04	0,03	3,46	3,86	6,54
Textiles, clothing and leather	1,17	0,32	0,01	0,01	0,01	-0,22	1,34	8,35
Wood and paper; publishing and printing	2,14	1,79	0,02	0,02	0,02	3,97	8,44	9,88
Petroleum products, chemicals, rubber and plastic	4,95	3,92	0,02	0,03	0,04	4,53	0,99	14,86
Other non-metallic mineral products	1,05	0,44	0,01	0,01	0,01	2,55	8,58	7,45
Metals, metal products, machinery and equipment	1,90	2,19	0,05	0,04	0,04	1,23	3,08	38,48
Electrical machinery and apparatus	3,87	1,95	0,00	0,01	0,01	1,15	3,35	8,04
Radio, TV, instruments, watches and clocks	2,49	-0,50	0,00	0,00	0,00	2,69	7,92	33,63
Transport equipment	2,42	2,52	0,02	0,02	0,02	5,14	11,18	21,77
Furniture and other manufacturing	4,45	1,59	0,01	0,02	0,02	8,07	9,91	19,11
Electricity, gas and water	4,17	2,16	0,01	0,03	0,02	1,64	1,00	0,68
Construction (contractors)	1,63	2,71	0,05	0,03	0,03	4,09	6,85	0,05
Trade, catering and accommodation services	3,12	3,43	0,13	0,14	0,15	2,76	6,34	6,04
Transport, storage and communication	4,33	5,36	0,06	0,07	0,11	3,65	9,46	8,09
Financial intermediation, insurance, RE, BS	3,73	4,47	0,15	0,16	0,22	2,91	5,01	3,37
Community, social and personal services	2,63	1,60	0,20	0,24	0,20	1,84	3,81	0,58
All Industries	2,65	2,71				2,68	4,20	12,08

Figure 1: Sectoral Development of the South African Economy

Source: Quantec, own calculations

but the mining conglomerates' economic control also extended to manufacturing and—crucially—the financial sector, leading to oligopolistic or monopolistic structures in many sub-sectors, as well as an extremely high overall ownership concentration.

The South African state reinforced these developments by establishing state-owned corporations such as Eskom (electricity, founded in 1923), Iscor (steel, 1928) and Sasol (petrochemicals, 1950), and by encouraging joint ventures with the private sector. State investment and support was mostly concentrated in capital intensive sectors linked to the MEC, where skilled and highly paid white workers would find jobs (Black, 1991, 159ff.). The massive expansion of Sasol's capacity to produce oil from coal in the late 1970s—when talk of economic sanctions grew louder—was certainly motivated by concerns over energy supply as well. While attempts were made to support manufacturing sectors such as textiles by means of a tariff policy, these measures lacked coherence and proved far less effective and important than support for the MEC (Fine and Rustomjee, 1996, 191). The problem, of course, was that the MEC was capital intensive, and this led to a 'paradoxical' production structure in a country with an abundant supply of unskilled labour.

After the change in government in 1994, industrial development was shaped by the restrictive macroeconomic framework conditions and growth rates were thus disappointing. Yet, there were significant sectoral variations, and they corresponded to the pattern observed in previous periods.

Mining's share in output declined since 1990 but this decline does not adequately reflect the job losses in the sector. While in 1987 more than 760.000 people worked on the mines, this number was down to just above 402.000 in 2002 (Seidman Makgetla, 2004, 273). A major reason for this development is the relative shift from gold exports to platinum. Platinum mining is far less labour intensive than gold mining.

Turning to manufacturing, the overall performance of the sector remained weak. Its share in the economy declined slightly and growth rates have been disappointing. In addition, labour intensive branches have grown even slower than the average. This includes food and beverages, textiles, clothing and footwear. “Low rates of growth in the labour intensive sectors have combined with overall rising capital intensity resulting in consistent declines in manufacturing employment.” (Kaplan, 2003, 10) Edwards’ (2001) decomposition shows that ultra-labour intensive sectors such as wearing apparel and leather products are particularly affected by both weak export performance and growing import penetration.

The MEC concept thus continues to be relevant for South Africa. In terms of value added, expansion is clearly concentrated in a small number of sectors close to mining—coke and petroleum, chemicals, and basic metals. Overall, MEC sectors grew at 1,92% annually between 1990 and 2006, while non-MEC manufacturing sectors grew significantly less at 1,11% annually (own calculations). The notable exception to this trend is transport equipment. Positive results in this sub-sector are driven by the automotive industry which was supported by the Motor Industry Development Programme—the industrial policy sector program that was deemed to be the most successful of all interventions by the government.

Briefly looking at the rest of the sectors we observe that construction lost in importance, most probably due to the slump in state investment in construction (Seidman Makgetla, 2004, 274) and that overall, services became more important. Overall, one observes a—in all likelihood premature—trend toward a de-industrialisation of the economy (Rodrik, 2006, 6).

4 The Econometric Model

The model is based on a structural VAR model developed by Abeysinghe and Forbes (2005), which they used for the analysis of trade linkages and output multiplier effects between countries. In our model the trade linkages are replaced by the linkages between sectors—stemming from intermediate inputs used in a sector that come from the rest of the economy. The reduced form representation of the output linkages is derived as follows.

Let Y be an individual sector’s production, which is a composite of

$$Y = IM + A \tag{1}$$

where IM is the sector’s output used as input in other sectors (intermediate output) and A is the part of output that is going to final consumption, exports and that is used in its own production. Rewriting equation (1) in a way where IM represents the sum of all the intermediate output going to the other (n-1) sectors gives

$$Y = \sum_{j=1}^{n-1} IM_j + A \tag{2}$$

We rewrite equation (2) in terms of growth rates to get

$$dY/Y = 1/Y \left[\sum_{j=1}^{n-1} dIM_j + dA \right] \tag{3}$$

In a next step, we assume that the intermediate output to sector j can be formulated as a function of total output in sector j.

$$IM_j = IM_j(Y_j) \tag{4}$$

Differentiating (4) with respect to Y_j gives

$$dIM_j = (\partial IM_j/\partial Y_j)dY_j \tag{5}$$

By inserting (5) into (3) we finally get

$$dY/Y = IM/Y \sum_{j=1}^{n-1} \left[\eta_j(IM_j/IM)(dY_j/Y_j)\right] + dA/Y \tag{6}$$

where $\eta_j = (\partial IM_j/\partial Y_j)(Y_j/IM_j)$ represents the elasticity of intermediate inputs flowing from the sector under scrutiny to sector j with respect to sector j's production. It is thus a measure of how strongly the intermediate output flowing to a specific sector will react to this sector's growth. By assuming now that this elasticity is the same across sectors and adding time and industry subscripts we can then rewrite and simplify equation 6 as

$$y_{it} = \alpha_i y_{it}^{im} + u_{it} \tag{7}$$

where $\alpha = (IM/Y)\eta$ and $y^{im} = \sum(IM_j/IM)y_j$. The elasticity η, assumed to be the same across sectors, can be taken out of the sum, which leaves other sectors's growth rates weighted by their contribution to the total intermediate output of the sector under scrutiny. The error term u_{it} captures omitted variables.

The core proposition of this formulation is that sectoral growth depends on the growth performance of other sectors in the economy. The extent of direct influence is determined by the intermediate output linkage IM_j. Yet, the model also captures indirect effects. For example, if output growth in the furniture manufacturing sector slows down, this obviously has a direct effect on the demand for machinery. There is also an indirect effect as the demand for transportation also diminishes, and thus transportation's demand of machinery. All the other determinants of sectoral growth will show up in the error term.

In a next step, and to amend our equations to econometric estimation, we transform the model and rewrite it as a structural vector autoregression. We thus assume that sectoral output performance can be explained by its own past output performance and the past output performance of all the other sectors in the economy. The latter enter weighted according to the linkage strength. This representation closely matches equation 7 where sectoral growth is explained by growth in the rest of the economy, weighted by the respective linkage strength. The transformation to an autoregressive process requires the assumption that the error terms u_{it} are correlated over time and across equations and that they follow a vector ARMA process as described in Abeysinghe and Forbes (2005, 359). Formally,

$$y_{it} = \lambda_i + \sum_{j=1}^{p} \phi_{ji} y_{it-j} + \sum_{j=0}^{p} \beta_{ji} y^f_{it-j} + \epsilon_i t \tag{8}$$

where λ_i is a vector of constants, the first sum captures all sectors' own lagged values and the second present and past values of the other sectors weighted by linkages. More precisely,

$$y^f_{it} = \sum_{j=1}^{n} w_{ij} y_{jt}$$

w_{ij}, the elements of the weighting matrix, are the shares of total intermediate output of sector i that go to the other sectors j (IM_j/IM). $i \neq j$. The sum of all shares of sector i's output to the other sectors must equal one. Equation (8) can be estimated separately for each sector of the economy. However, they can also be written as an SVAR system of equations. To illustrate, assume that there are three sectors in the economy, and the estimation takes only one lag into consideration. Then, the SVAR system of equations equals

$$\begin{bmatrix} 1 & -\beta_{01}w_{12} & -\beta_{01}w_{13} \\ -\beta_{02}w_{21} & 1 & -\beta_{02}w_{23} \\ -\beta_{03}w_{31} & -\beta_{03}w_{32} & 1 \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \end{bmatrix} + \\ + \begin{bmatrix} \phi_{11} & \beta_{11}w_{12} & \beta_{11}w_{13} \\ \beta_{12}w_{21} & \phi_{22} & \beta_{12}w_{23} \\ \beta_{13}w_{31} & \beta_{13}w_{32} & \phi_{33} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ y_{3t-1} \end{bmatrix} + \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \end{bmatrix}$$

or, in a compact form,

$$(B_0 \cdot W)y_t = \lambda + (B_1 \cdot W)y_{t-1} + \epsilon_t \tag{9}$$

where $(\cdot)$ stands for the element-products of the matrices. The matrix on the left hand side captures contemporaneous effects of the time series on each other, the 3x3 matrix on the right hand side captures the effect of own lagged values (ϕ_{ii}) and lagged values of the time series on each other (β_{1i}). The major difference of this approach to other SVAR works as stressed by Abeysinghe and Forbes (2005, 360) is that the model is overidentified as the elements of the weighting matrix w_{ij} are known, and that we do not have to assume that the error terms ϵ_{it} are uncorrelated as is usually the case, but can explicitly test for it.

5 Data Description

The model is applied to a number of settings at different levels of aggregation. A list of these sectors and the abbreviations used henceforth can be found in Table 9 in the appendix.

Our data set stems from the Quantec database, a commercial database which collects economic data for South Africa from different sources. The time period covered is 1970 to 2007, so we have 37 observations per time series. A highly aggregated sector composition—we look at the development of output in agriculture, mining, the secondary and the tertiary sector—constitutes our first layer of analysis. Unit roots tests confirm their presence, thus output enters in log first differences in the estimation. In order to assess the relevance of the MEC concept for sectoral development, we use two specifications, where the second divides the secondary sector in MEC activities (excluding mining) and non-MEC manufacturing. Figure 5 in the appendix shows the development of total output in these 5 sectors.

The corresponding weighting matrices that we need in the VAR are calculated by using data on the intermediate input used in each sector stemming from the rest of the economy. Crucially, we only consider domestic intermediate inputs, because only they will induce a backward linkage locally. This differentiation between domestic and total linkage effects is not always made in related analysis, perhaps due to a lack of data. Again, the Quantec database provides this information. Although we could have used only one weighting matrix for the whole period, we decided taking the accurate weighting matrix for each year, as this captures the change in input linkages over time. An exemplary matrix that indicates linkages between sectors is presented in Section (6)—note that, in line with the model specification, the intermediate input stemming from the sector itself has been set to zero. Upon inspection, we see that the secondary sector is a large consumer of intermediate goods from other sectors, thus potentially and not surprisingly the sector with the most pulling power in the economy.

The second data set consists of a sample of output development and input linkages from 1970 to 2007 for the nine 2-digit sectors of the economy and is also taken from the Quantec database. Figure 6 in the appendix shows the individual sector's development over the whole period in absolute values. Again, we performed a unit root test in the level values and unsurprisingly detected it in almost every sector. Due to this and also to reflect the model's formulation in growth rates, the data is transformed into log first differences as well.

Lastly, we look at 10 manufacturing subsectors, applying the same procedure. Figure (7) in the appendix displays their output performance over the period under scrutiny. The outlier in sectoral development is the Petroleum, Chemicals and Plastics sector. It performed strongly throughout the last 37 years and did particularly well in the second half of the 1990s. Another important sector that grew strongly since the democratic opening is the Transport Equipment sector, reflecting the success of the industrial policy intervention in this specific area, the Motor Industry Development Programme.

In terms of linkages, there is no one sector within manufacturing that possesses a dominance equivalent to the manufacturing sector as a whole on a higher level. Overall, Transport Equipment draws the largest amount of inputs from other sectors—in accordance with the common understanding that automotive production is desirable because of its widespread linkages and thus justifying the support the sector receives.

6 Estimation Results

The estimation follows the approach by Zellner and Palm (1974) which estimates the model in the tradition of a seemingly unrelated regressions (SUR) model instead of using the standard SVAR approach. Thus, equation (8) is estimated for each sector separately. It can then be rewritten and expressed as a SVAR system so that impulse responses can be calculated.

Due to the fact that we only have yearly observations, we can include only one lag of each sector. We estimated the model in OLS, 2SLS and 3SLS. For the latter two approaches the residual correlations have been calculated and the Breusch-Pagan test on the diagonality of the residual-correlation matrix has been applied. Even though this test rejects the null of diagonality for some of the specifications (those involving 9 and 10 sectors), we decided to use the 3SLS estimates for our further analysis, as the number of significant correlation coefficients is lowest when compared to the 2SLS or OLS estimates. Tables 1, 2 and 3 display these coefficients for the three data sets, in the specification separating MEC activities from the rest of manufacturing. The other matrices are available on request, the number of significant non-zero correlations does not change, however. Those error term correlations that are significant at the 5% are printed in bold letters. For the highest level of aggregation there are no correlations significantly different from zero, indicating that the model is correctly specified. In the case of 9 (10 when one considers MEC manufacturing separately) sectors there are only 2. However, the 10 manufacturing subsectors include 9 statistically significant correlations, two of which are negative which is certainly surprising. This might be due to poor data quality or improper specification, it definitely implies that results must be interpreted very carefully for this level of aggregation because there are unresolved problems in the estimation.

	agri	min	mec	man	tert
agri	1.000				
min	-0.019	1.000			
mec	-0.184	0.204	1.000		
man	-0.209	0.047	0.256	1.000	
tert	0.170	0.291	0.216	-0.018	1.000

Table 1: Correlation for 3SLS

	Agri	Min	MEC	Man	Elec	Cons	Trade	TrSC	FinI	Comm
Agri	1.000									
Min	-0.186	1.000								
MEC	-0.085	0.025	1.000							
Man	-0.177	-0.221	0.226	1.000						
Elec	**0.390**	-0.151	0.071	-0.074	1.000					
Cons	-0.032	-0.047	-0.039	0.142	0.282	1.000				
Trade	0.186	0.064	0.136	0.073	0.157	-0.027	1.000			
TrSC	0.280	-0.150	**0.479**	-0.071	0.268	-0.091	0.012	1.000		
FinI	0.125	0.194	0.051	-0.250	-0.233	0.006	0.071	-0.033	1.000	
Comm	0.034	0.217	0.091	-0.231	0.220	-0.156	0.052	0.112	0.262	1.000

Table 2: Correlation for 3SLS, bold indicates significance at the 5 % level

	Food	Tex	Wood	Pet	NMM	Met	ElecM	Rad	Trans	Furn
Food	1.000									
Tex	-0.068	1.000								
Wood	-0.206	0.313	1.000							
Pet	**-0.367**	0.175	0.053	1.000						
NMM	-0.249	0.167	**0.410**	-0.176	1.000					
Met	0.034	**0.487**	0.083	-0.043	0.157	1.000				
ElecM	**0.420**	**0.338**	0.048	0.146	-0.293	0.123	1.000			
Rad	**0.418**	0.252	-0.007	0.024	-0.059	-0.038	**0.617**	1.000		
Trans	-0.087	**-0.384**	0.311	-0.015	0.319	-0.223	-0.194	-0.227	1.000	
Furn	0.202	-0.034	-0.094	0.119	0.141	-0.214	0.080	0.122	**0.335**	1.000

Table 3: Correlation for 3SLS, bold indicates significance at the 5 % level

7 Impulse Response Analysis

To answer the question about the direct and indirect impact of a change in one sector on the other sectors we use impulse response analysis (Hamilton, 1994). To this end we use the model estimated above and calculate the recursive relationships according to the VAR-results. This allows us to isolate the effect of a unit shock in one sector on all the other sectors in the economy. Technically, the autoregressive system has to be transformed into a moving average form. Starting with (9), by recursive replacement, we arrive at

$$y_t = \sum_{i=0}^{\infty} C_1^i u_{t-i} \tag{10}$$

where $u_{t-i} = (B_0 \cdot W)^{-1}\epsilon_{t-i}$ and $C_1 = (B_0 \cdot W)^{-1}(B_1 \cdot W)$. The impulse response matrix thus is $C_1^i(B_0 \cdot W)^{-1}$.

Looking at the overall economy at the highest level of aggregation first, the change of sectoral shares between 1970 and 2007 reveals that the tertiary sector has gained in importance, mostly at the expense of the primary sector, while the secondary sector remained roughly stable. A closer look, distinguishing between MEC and non-MEC manufacturing, reveals however that the latter declined in importance quite substantially, while MEC activities became more dominant (see Figure 2). Any statement about the declining dependence of South Africa on its mining sector must therefore be qualified.

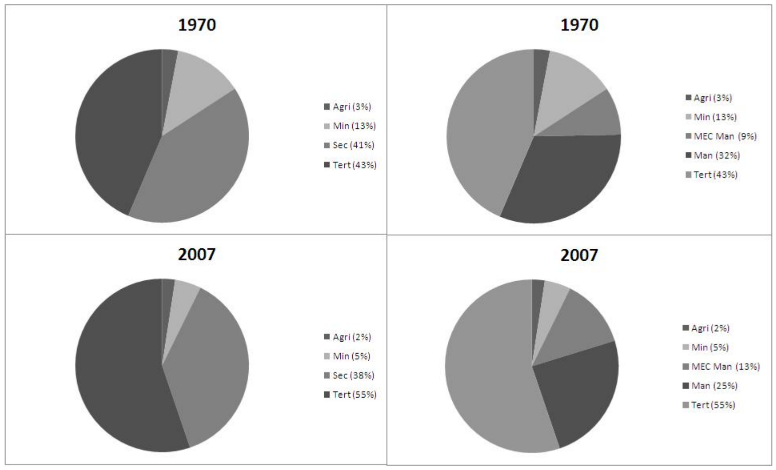

Figure 2: Share of Sectoral Output in Total Output in 1970 and 2007, Source: Quantec

On the other hand, a look at the weighting matrices used in the estimation (Table 4 shows an exemplary matrix for the year 2007) highlights the nonetheless central role of the secondary sector in the economy. The presentation of linkages is slightly unusual, so it requires explanation. Usually, the intermediate inputs used in a certain industry are displayed in rows, with each industry represented in a column. Here, the matrix has been transposed (for reasons that will hopefully become clear immediately), so each sector and the input it uses are to be found in the respective rows. The columns thus stand for the intermediate inputs domestically produced in the agricultural sector, and flowing to the rest of the economy—the intermediate input that remains within the sector has been set to zero in accordance with the theoretical model. These input flows to other sectors are reported as shares of total intermediate input goods produced in the respective sector. Therefore, they represent backward linkages—an expansion in a sector will increase its demand for intermediates, and thus induce expansion of production in upstream sectors.

In terms of the sectors analysed here, the secondary sector is by far the largest consumer of intermediate inputs. For example, more than 97% of agricultural goods that are used as intermediate inputs in the rest of the economy go to the secondary sector. Albeit agriculture being the strongest case, the centrality of manufacturing is also evident for the other sectors. The introduction of the MEC as a separate sector slightly changes this picture. Overall, the secondary sector, now encompassing only non-MEC manufacturing, still is the single largest demander of intermediates. Yet, as expected, and justifying this specific aggregation, intermediate mining goods are overwhelmingly used in the MEC.

used in	Agri	Min	Sec	Tert
	Intermediates stemming from			
Agri	0.000	0.002	0.090	0.055
Min	0.000	0.000	0.094	0.150
Sec	0.974	0.962	0.000	0.795
Tert	0.025	0.037	0.816	0.000

used in	Agri	Min	MEC	Sec	Tert
	Intermediates stemming from				
Agri	0.000	0.002	0.070	0.070	0.061
Min	0.000	0.000	0.054	0.064	0.167
MEC	0.019	0.791	0.000	0.133	0.288
Sec	0.956	0.157	0.491	0.000	0.483
Tert	0.025	0.050	0.386	0.733	0.000

Table 4: Share of intermediate inputs stemming from sectors (column) used in sector (row), 2007. Source: Quantec

Impulse responses to unit shocks in all sectors reveal a strong convergence to zero after 4 years. Table 6 thus displays the cumulated effects of a one-unit shock in each of the sectors on the other sectors over a period of four years. The table must be interpreted as follows: the shock in a certain industry has an accumulated effect on all the other industries as displayed in the respective row. For example, in the 4-sector setting a one-unit shock in the secondary sector leads to a 0.338 unit increase of output in agriculture and relatively strong movements in other sectors of the economy as well—a result in line with the strong linkages detected in the manufacturing sector. The impacts of unit shocks in agriculture and mining are negligible, in the case of mining they are even negative. Lastly, spillovers from the services sector are smaller than those from manufacturing, but they are significant nonetheless, particularly when compared to agriculture and mining. Again, this is in line with linkage strength.

Shock in	Agri	Min	Sec	Tert
	Cumulated impulse response			
Agri	0.742	0.033	0.056	0.070
Min	-0.040	1.198	-0.121	-0.258
Sec	0.338	0.592	1.049	0.505
Tert	0.085	0.153	0.247	1.627

Shock in	Agri	Min	MEC	Sec	Tert
	Cumulated impulse response				
Agri	0.721	0.026	0.040	0.041	0.047
Min	-0.029	1.327	-0.070	-0.084	-0.156
MEC	0.044	0.563	1.101	0.113	0.194
Sec	0.437	0.355	0.408	1.330	0.503
Tert	0.151	0.232	0.307	0.433	1.592

Table 5: Cumulated impulse response after 4 periods

Once the MEC is considered separately, it becomes clear that the expansionary spillovers we observe from unit shocks in the secondary sector are mostly due to non-MEC manufacturing. An expansion of the MEC has a positive spillover on mining, but the effects on other sectors are comparatively small. A unit shock in MEC industries only leads to a 0.113 increase in manufacturing output in this specification, and growth spillovers to agricultural and services production are also much smaller than those observed with non-MEC manufacturing.

For a more detailed analysis, we looked at the 9 (10 when MEC is stated

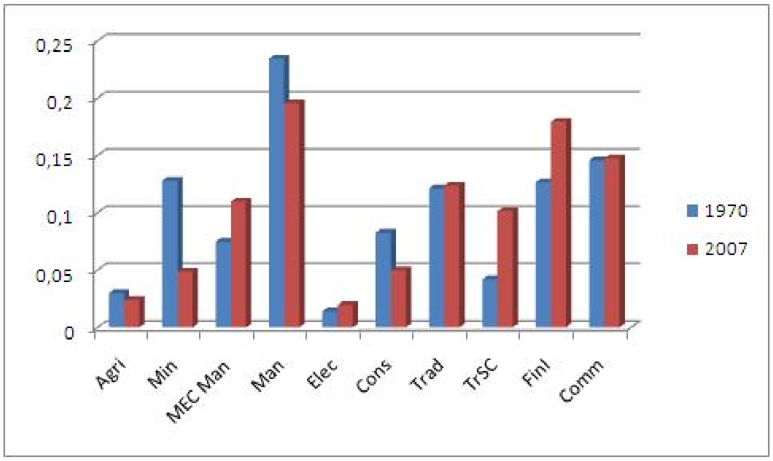

Figure 3: Share of Sectoral Output in Total Output in 1970 and 2007, Source: Quantec

	Agri	Min	Man	Elec	Cons	Trad	TrSC	FinI	Comm
Shock in				*Cumulated impulse response*					
Agri	0.736	0.022	0.034	0.036	0.023	0.034	0.026	0.041	0.053
Min	0.009	1.240	0.019	0.039	0.020	0.020	0.037	0.025	0.021
Man	0.558	0.711	1.196	0.725	0.318	0.650	0.409	0.858	0.587
Elec	0.005	0.045	0.011	1.711	0.044	0.010	0.007	0.019	0.007
Cons	0.160	0.227	0.343	0.233	2.250	0.259	0.162	0.403	0.195
Trad	0.133	0.170	0.266	0.395	0.541	1.664	0.364	0.862	0.237
TrSC	0.132	0.175	0.278	0.408	0.289	0.391	1.420	0.544	0.229
FinI	0.072	0.106	0.154	0.190	0.405	0.196	0.172	2.656	0.293
Comm	0.007	0.010	0.014	0.018	0.025	0.018	0.013	0.041	1.408

Table 6: Cumulated impulse response after 4 periods

separately) 2-digit sectors (disaggregating the secondary and the tertiary sectors). Graph 3 reestablishes the falling role of mining itself but the surge in MEC manufacturing activities. The growth in services was particularly strong in the transport, storage and communication, and in the financial intermediation, insurance and real estate sectors.

The corresponding weighting matrices are reported in the appendix (see Tables **??** and 12). With regards to the impulse responses, we can confirm the findings of the above specification at a higher level (see Tables 6 and 7). Agriculture and mining provide virtually no spillovers to the rest of the economy, while manufacturing appears to have significant pulling power. Interestingly, the construction sector has comparatively strong effects, given its size. Of the services sectors, community, social and personal services have by far the weakest effect, which is to be expected in the short run.

Once the MEC is reported separately (Table 7), we again find its pulling

	Agri	Min	MEC	Man	Elec	Cons	Trad	TrSC	FinI	Comm
Shock in					*Cumulated impulse response*					
Agri	0.737	0.031	0.037	0.040	0.049	0.039	0.043	0.032	0.062	0.056
Min	0.007	1.223	0.011	0.012	0.024	0.014	0.013	0.020	0.017	0.013
MEC	0.163	0.728	1.111	0.279	0.637	0.315	0.362	0.308	0.611	0.343
Man	0.822	0.629	0.651	1.522	0.834	0.612	0.882	0.487	1.224	0.709
Elec	0.028	0.190	0.043	0.052	1.799	0.188	0.050	0.034	0.091	0.036
Cons	0.211	0.319	0.364	0.386	0.346	2.366	0.342	0.221	0.550	0.257
Trad	0.312	0.385	0.410	0.550	0.751	0.972	1.916	0.584	1.452	0.456
TrSC	0.265	0.369	0.412	0.482	0.717	0.596	0.649	1.492	0.976	0.403
FinI	0.150	0.205	0.211	0.273	0.337	0.600	0.326	0.258	2.793	0.397
Comm	0.047	0.064	0.069	0.085	0.108	0.138	0.103	0.070	0.206	1.372

Table 7: Cumulated impulse response after 4 periods

power small in comparison to the rest of the manufacturing sector (with the obvious exception of the mining industry). This is notable also because the MEC is a significant consumer of intermediates from a number of sectors—yet this conventional backward linkage is not reflected to the same extent in the impulse response results.

Lastly, we have also attempted to model spillovers within the subsectors of manufacturing. As reported above, a substantial part of the error correlations in this specification are non-zero, which points to a misspecification of the model. Omitted variables are a likely cause, since we limit ourselves to a subsection of the economy here. Sectoral growth in the rest of the economy should be controlled for and we intend to do so in a follow up version of the paper. Therefore the following results have to be interpreted carefully and should be regarded as a first and tentative evaluation of the manufacturing subsectors.

Sectoral output shares in 1970 and 2007 (Figure 4) reveals the petroleum products, chemicals and plastics sector as the star performer within manufacturing over the last 37 years. Only transport equipment has gained in importance in a comparable manner—probably reflecting to an extent the efforts of the Motor Industry Development Programme. On the downside, labour-intensive sectors such as food and beverages and textiles now represent a much smaller part of total manufacturing, and the same is true for the metal, metal products and machinery sector.

The weighting matrix, printed for 2007 in the appendix (Table 10), further corroborates the positive role the transport equipment sector is playing in the economy: it is the sector with potentially the greatest pulling power, being the most important user of intermediate inputs from a variety of sectors. Other than transport equipment, food and beverages, the petroleum products and chemicals sector significantly use intermediates from the rest of manufacturing sectors.

Results of the estimation and the corresponding impulse responses (Table 8) largely confirm these results. A unit shock in the transport equipment sector induces a 0.896 unit output increase in electrical machinery production, a 0.781 increase in textiles and clothing and a 0.760 increase in the metal products and machinery sector. Other sectors are pulled along as well. In contrast to the

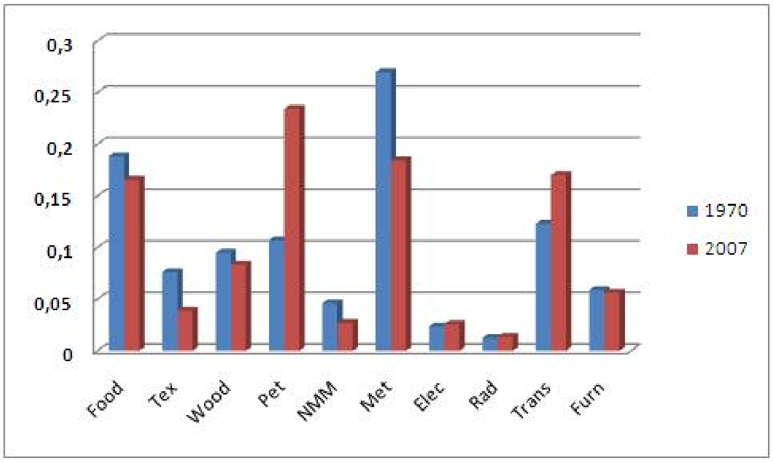

Figure 4: Share of Sectoral Output in Total Manufacturing Output in 1970 and 2007, Source: Quantec

	Food	Tex	Wood	Pet	NMM	Met	ElecM	Rad	Trans	Furn
used in					*stemming from*					
Food	1.332	0.067	0.083	0.090	0.092	0.074	0.066	0.056	0.096	0.053
Tex	0.519	1.071	0.077	0.159	0.085	0.094	0.079	0.070	0.110	0.156
Wood	0.115	0.079	0.987	0.149	0.049	0.067	0.057	0.076	0.073	0.176
Pet	0.372	0.215	0.130	1.346	0.201	0.193	0.170	0.153	0.236	0.200
NMM	0.068	0.064	0.061	0.099	1.003	0.085	0.065	0.053	0.087	0.057
Met	0.198	0.231	0.136	0.331	0.194	1.223	0.437	0.312	0.312	0.251
ElecM	0.079	0.080	0.064	0.164	0.117	0.190	1.113	0.338	0.099	0.128
Rad	0.031	0.037	0.027	0.040	0.023	0.040	0.111	0.979	0.028	0.128
Trans	0.508	0.781	0.227	0.583	0.475	0.760	0.896	0.723	1.442	0.380
Furn	0.101	0.140	0.144	0.121	0.055	0.120	0.075	0.117	0.074	1.226

Table 8: Cumulated impulse response after 4 periods

pure input linkages, the metal products and machinery sector creates stronger spillovers, particularly when compared to the petroleum products and chemicals sector. Given that the latter belongs to the MEC, these results provide a further hint (caution is due because of the specification problems) that MEC activities provide less of a spillover to the rest of the economy (in this case manufacturing) than non-MEC activities.

8 Summary and Policy Conclusions

This paper set out with a hypothesis derived from economic theory and the actual development experience of South Africa: that linkages are important in the sectoral growth process of an economy. They provide opportunities for local upstream and downstream producers and thus shape the development path of an economy. In the case of South Africa, economic development was and continues to be strongly influenced by its minerals endowment. The manufacturing industry evolved around the mining sector, initially serving its needs, and even today, within manufacturing subsectors, those activities close to the natural resources of the country still play an important role.

We tried to empirically assess the strength of these linkages by estimating an SVAR model of sectoral output growth that explicitly incorporated the linkages between the various sectors in South Africa. With regards to the overall aggregations that we looked at first, the results strongly suggest that manufacturing as a whole is the sector with the greatest 'pulling power'in the economy, thereby justifying the continued attention it receives from policy makers. This is particularly true for those manufacturing activities that are not counted among the MEC. Positive shocks in the agricultural and mining sectors (and, to a lesser extent, the MEC) lead to much smaller growth spurts in the rest of the economy, and the same is also true for tertiary sectors that are comparable in size to manufacturing.

On a higher level of disaggregation, the growth performances of the ten subsectors within manufacturing in general are less dependent on each other, reflecting the fact that linkages to sectors outside manufacturing—neglected in this setting—play an important role. Linkage effects therefore have less explanatory power. The sector that stands out is the transport equipment sector that has by far the strongest growth effects on the rest of manufacturing. Compared to simple linkage via intermediate inputs, we also observe a relatively prominent role of the metals, metal products and machinery sector, which displays stronger growth impacts on the rest of manufacturing than the petroleum products and chemicals sector.

The policy conclusions that can be drawn from this support a widely accepted stance in the literature and in policy circles: that South Africa will need to support its manufacturing sector to achieve higher overall growth rates, and that within manufacturing, more diversification and less reliance on capital-intensive sectors close to the mineral endowment such as chemicals is needed. It also vindicates support for the auto industry, given its central role within the manufacturing subsectors.

References

Abeysinghe, Tilak and Kristin Forbes (2005): *Trade Linkages and Output-Multiplier Effects: a Structural VAR Approach with a Focus on Asia.* In: Review of International Economics 13 (2): 356-375

Black, Anthony (1991): *Manufacturing Development and the economic crisis: a reversion to primary production?* Gelb, Stephen: South Africa's Economic Crisis. Cape Town: David Philip: 156-174

Edwards, Lawrence (2001): *Globalisation and the skill bias of occupational em-*

ployment in South Africa. In: South African Journal of Economics, Vol. 69 (1): 40-71

Feinstein, Charles (2005): *An Economic History of South Africa. Conquest, Discrimination and Development.* Cambridge: Cambridge University Press

Fine, Ben and Zavareh Rustomjee (1996): *The Political Economy of South Africa.* London: Hurst & Company

Hamilton, James D. (1994): *Time Series Analysis.* New Jersey: Princton University Press

Hirschman, Albert O. (1966): *The Strategy of Economic Development.* New Haven: Yale University Press

Hirschman, Albert O. (1981): *A Generalized Linkage Approach to Development, with Special Reference to Staples.* In: Essays in Trespassing. Economics to Politics and Beyond. Cambridge: Cambridge University Press: 59-97

Imbs, Jean/ Wacziarg, Romain (2003): *Stages of Diversification.* In: American Economic Review Vol. 93 (1): 63-86

Kaplan, David (2003): *Manufacturing Performance and Policy in South Africa - A Review.* Paper prepared for the TIPS Forum 2003, http://www.tips.org.za/events/event_details/papers/forum2003/p_kaplan.pdf (31.1.2007)

Krugman, Paul/ Venables, Anthony (1995): *Globalization and the Inequality of Nations.* In: The Quarterly Journal of Economics, Vol. CX (4): 857-880

Lewis, Jeffrey D. (2001): *Reform and Opportunity: The Changing Role and Patterns of Trade in South Africa and SADC.* World Bank: Africa Region Working Paper Series Nr. 14

List, Friedrich (1950): *Das nationale System der Politischen Ökonomie.* Sechste Auflage. Jena: Gustav Fischer

Machaka, Johannes/ Roberts, Simon (2003): *The DTI's new 'Integrated Manufacturing Strategy'? Comparative Industrial Performance, Linkages and Technology.* In: South African Journal of Economics, Vol. 71 (4): 679-704

Marshall, Alfred (1938): *Principles of Economics.* London: Macmillan

Nattrass, Nicoli (1998): *Globalisation and the South African Labour Market.* In: Trade and Industry Monitor, Volume 6 (July): 18-20

Ocampo, José Antonio (2005): *The Quest for Dynamic Efficiency: Structural Dynamics and Economic Growth in Developing Countries.* In: Ocampo, José Antonio (ed.): Beyond Reforms—Structural Dynamics and Macroeconomic Vulnerability. Palo Alto: Stanford University Press: 3-43

Roberts, Simon (2006): *Encouraging Downstream Value-Added and Labour-Intensive Growth? The Case to the Metal Products Sector.* In: Sustainable Manufacturing? The Case of South Africa and Ekurhuleni. Cape Town: Juta: 159-181

Rodrik, Dani (2006): *Understanding South Africa's Economic Puzzles.* CID Working Paper No. 130. Harvard University

Rodrik, Dani (2007): *One Economics, Many Recipes.* Princeton: Princeton University Press

Rosenstein-Rodan, Paul (1943): *Problems of Industrialisation of Eastern and South-Eastern Europe.* In: The Economic Journal, Vol. 53: 202-211

Seidman Makgetla, Neva (2004): *The Post-apartheid Economy.* In: Review of African Political Economy 100: 263-281

Streeten, Paul (1959): *Unbalanced Growth.* In: Oxford Economic Papers XI (June): 167-190

Tregenna, Fiona (2007): *Which Sectors Can Be Engines of Growth and Employment in South Africa?* Paper presented at HSRC Roundtable, 21 May 2007

Venables, Anthony (1996): *Equilibrium Locations of Vertically Linked Industries.* In: International Economic Review, Vol. 37 (2): 341-359

Zellner, Arnold and Palm Franz C. (1974): *Time Series Analysis and Simultaneous Equation Econometric Models.* In: Journal of Econometrics 2 (1974): 17-54

A Appendix

Sectoral Abbreviations	
	1-digit Sectors
Agri	Agriculture, forestry and fishing
Min	Mining and quarrying
MEC	Pet, NMM, Basic Metals, Electricity
Sec	Secondary Sector (Man, Elec, Cons)*
Tert	All Services
	2-digit Sectors
Agri	Agriculture, forestry and fishing
Min	Mining and quarrying
Man	Manufacturing
Elec	Electricity, gas and water
Cons	Construction
Trad	Trade, catering and accommodation services
TrSC	Transport, storage and communication
FinI	Financial intermediation, insurance, real estate
Comm	Community, social and personal services
	3-digit sectors
Food	Food, beverages and tobacco
Tex	Textiles, clothing and leather
Wood	Wood and paper; publishing and printing
Pet	Petroleum products, chemicals, rubber and plastic
NMM	Other non-metallic mineral products
Met	Metals, metal products, machinery and equipment
ElM	Electrical machinery and apparatus
Rad	Radio, TV, instruments, watches and clocks
Trans	Transport equipment
Furn	Furniture and other manufacturing

Table 9: Sectoral abbreviations, *when MEC is included, Sec and Man represent non-MEC manufacturing

used in	Agri	Min	Man	Elec	Cons	Trad	TrSC	FinI	Comm
					stemming from				
Agri	0.000	0.002	0.085	0.022	0.012	0.029	0.031	0.011	0.088
Min	0.000	0.000	0.070	0.115	0.037	0.025	0.187	0.018	0.059
Man	0.974	0.696	0.000	0.405	0.001	0.461	0.237	0.273	0.401
Elec	0.000	0.247	0.018	0.000	0.143	0.010	0.007	0.020	0.001
Cons	0.000	0.019	0.184	0.011	0.000	0.036	0.017	0.050	0.010
Trad	0.017	0.001	0.140	0.131	0.216	0.000	0.242	0.312	0.035
TrSC	0.000	0.002	0.193	0.132	0.058	0.169	0.000	0.112	0.046
FinI	0.001	0.023	0.134	0.100	0.382	0.143	0.181	0.000	0.358
Comm	0.007	0.010	0.177	0.084	0.152	0.127	0.098	0.204	0.000

Table 10: Weighting matrix for 9 two-digit sectors, 2007

used in	Agri	Min	MEC	Man	Elec	Cons	Trad	TrSC	FinI	Comm
					stemming from					
Agri	0.000	0.002	0.060	0.059	0.022	0.012	0.029	0.031	0.011	0.088
Min	0.000	0.000	0.046	0.054	0.115	0.037	0.025	0.187	0.018	0.059
MEC	0.019	0.581	0.000	0.113	0.269	0.000	0.107	0.154	0.099	0.147
Man	0.955	0.115	0.424	0.000	0.136	0.001	0.355	0.083	0.175	0.254
Elec	0.000	0.247	0.007	0.020	0.000	0.143	0.010	0.007	0.020	0.001
Cons	0.000	0.019	0.129	0.132	0.011	0.000	0.036	0.017	0.050	0.010
Trad	0.017	0.001	0.052	0.163	0.131	0.216	0.000	0.242	0.312	0.035
TrSC	0.000	0.002	0.126	0.151	0.132	0.058	0.169	0.000	0.112	0.046
FinI	0.001	0.023	0.055	0.150	0.100	0.382	0.143	0.181	0.000	0.358
Comm	0.007	0.010	0.101	0.158	0.084	0.152	0.127	0.098	0.204	0.000

Table 11: Weighting matrix for 9 2-digit sectors including separated MEC, 2007

	Food	Tex	Wood	Pet	NMM	Met	ElecM	Rad	Trans	Furn
used in					*stemming from*					
Food	0.000	0.050	0.412	0.188	0.364	0.102	0.002	0.002	0.343	0.048
Tex	0.525	0.000	0.026	0.100	0.023	0.022	0.001	0.000	0.050	0.129
Wood	0.078	0.042	0.000	0.177	0.017	0.022	0.002	0.055	0.054	0.248
Pet	0.350	0.130	0.111	0.000	0.198	0.088	0.009	0.028	0.236	0.162
NMM	0.012	0.009	0.041	0.041	0.000	0.034	0.001	0.000	0.044	0.013
Met	0.012	0.037	0.055	0.144	0.061	0.000	0.254	0.095	0.194	0.103
ElecM	0.001	0.004	0.025	0.085	0.079	0.145	0.000	0.349	0.027	0.037
Rad	0.008	0.025	0.013	0.015	0.005	0.014	0.230	0.000	0.016	0.243
Trans	0.007	0.506	0.044	0.157	0.227	0.421	0.493	0.322	0.000	0.017
Furn	0.007	0.197	0.275	0.094	0.026	0.152	0.008	0.149	0.037	0.000

Table 12: Weighting matrix for 10 3-digit sectors, 2007

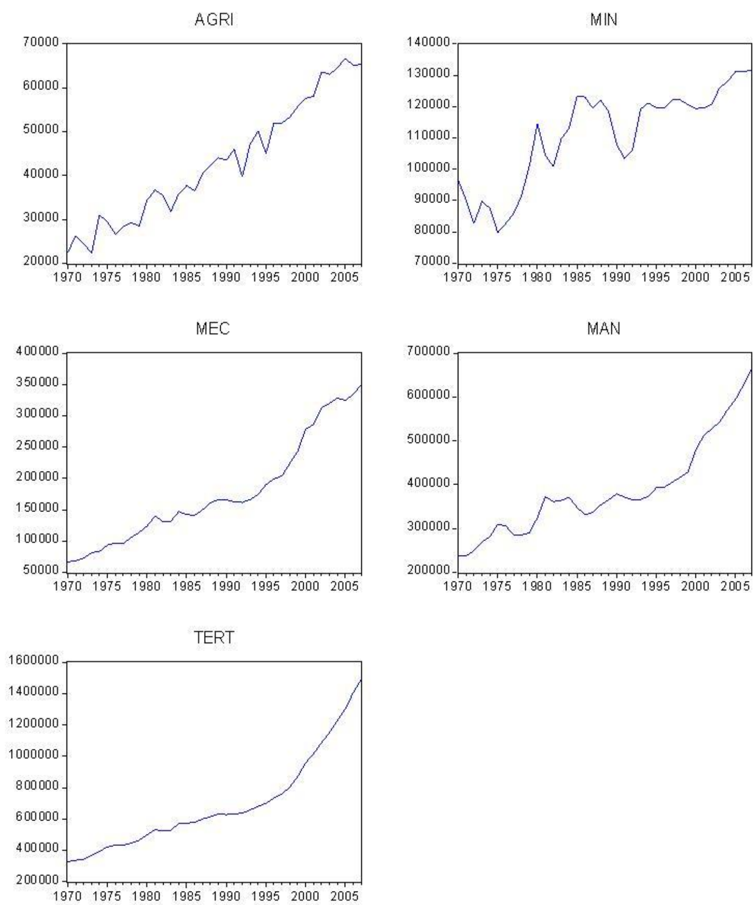

Figure 5: Development of output for 5 sectors

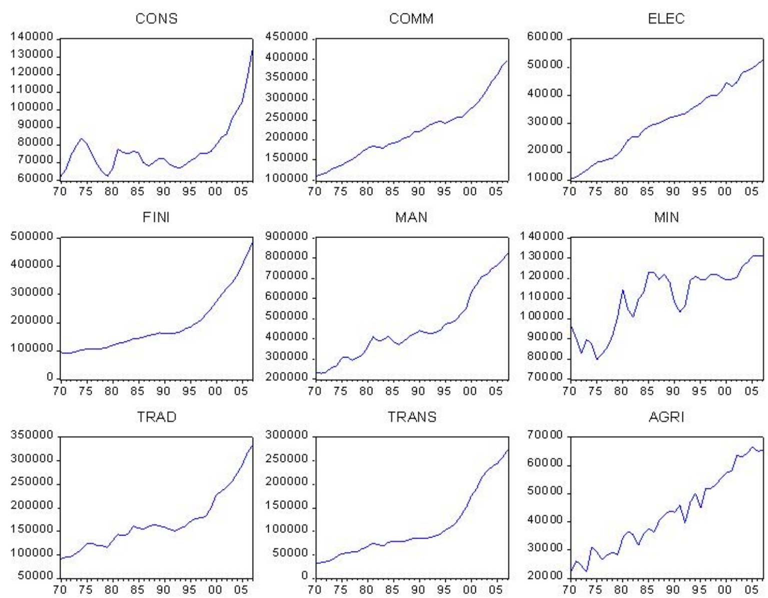

Figure 6: Development of output for the 9 2-digit sectors

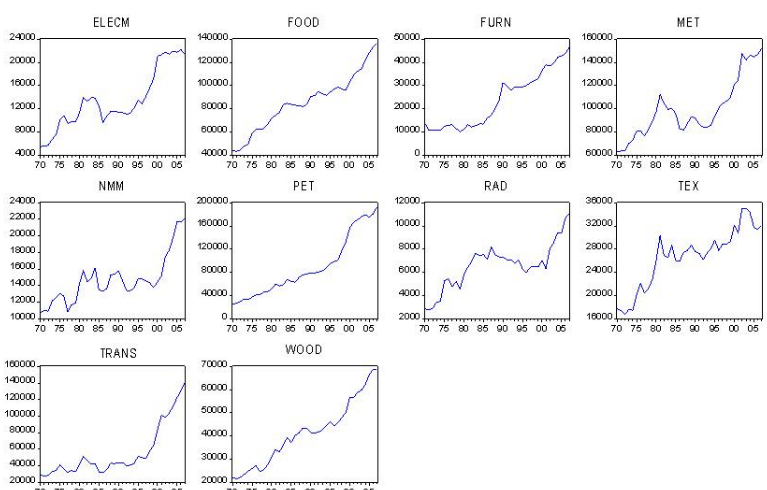

Figure 7: Development of output for the 10 3-digit sectors