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BUSINESS CYCLE AT A SECTORAL LEVEL: THE PORTUGUESE CASE

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Business Cycle at a sectoral level: the Portuguese case*

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Abstract

The existence of comovement across different sectors is an important feature of the business cycle definition. The purpose of this work is to characterise the Portuguese sectoral business cycle, with particular emphasis on the comovement phenomenon, for the years 1953-2003 in terms of both GVA and employment. In the last fifty years substantial structural changes were observed in the Portuguese economy. These changes mean that some sectors, notably the service sectors, are growing in relative terms. Despite the existing differences in characteristics, such as trend and volatility, there is evidence for the presence of comovement among Portuguese activity sectors. A discussion on the causes of such phenomenon, such as the input-output linkages, in light of the Portuguese economy is done.

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1 Introduction

The existence of comovement across different sectors is an important characteristic of the business cycle definition. According to Burns and Mitchell (1946),

"... a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions ..."

and according to Lucas (1977),

"... Output movements across broadly defined sectors move together..."

The NBER defines recession in a similar way,

" a recession is a period of decline in total output, income, employment, and trade, usually lasting from six months to a year, and marked by widespread contractions in many sectors of the economy".

Many papers have studied the sectoral business cycle, namely for the case of the United States' (U.S.) economy, showing strong evidence of sectoral comovement. Some recent examples are Christiano and Fitzgerald (1998), Hornstein (2000) and Shea (2002).[1] The purpose of this work is to characterise the Portuguese sectoral business cycle, in particular volatility and the comovement phenomenon, i.e. when sectors expand and contract simultaneously, for the years 1953-2003.

In the last decades substantial structural changes were observed in the Portuguese economy, in terms of both Gross Value Added (GVA) and employment. These changes were characterised by the increased importance of the service sectors in relation to other more volatile sectors, as durable manufacturing and agriculture. These developments are in line with the ones observed in the U.S. and other developed countries. Such characterisation is important since sectoral composition may influence the features of an economy's business cycle.

Differences in volatility across sectors are a distinctive element of aggregate business cycles. The analysis of the sectoral sources of aggregate fluctuations provides important information about the driving forces for the business cycles. Additionally, in light of the observed sectoral changes that have occurred over the last fifty years, their impact on the change of the Portuguese aggregate volatility is acknowledged.

The main result of this work is that despite the existing differences in characteristics, such as trend and volatility, there is evidence for the presence of comovement among Portuguese activity sectors.

In a context of increased importance of globalisation of the link across economies, in particular in the European Union, the characterisation of the business cycle at a sectoral

[1] Another important studies in this field includes Long and Plosser (1983,1987), Hornstein and Prashnick (1997) and Horvath (1998,2000).

level is important to better understand some issues at an aggregate level. In fact, earlier analyses confirmed that in the European Union countries, business cycle synchronisation increased over time. In particular, Portugal is one of the set of countries with the highest degree of association with the euro area business cycle (Belo (2001)).

At the present time, in theoretical terms, there seems to be no total agreement on what's behind business cycle, in particular the reasons for the existence of comovement, especially in employment across sectors. Rebelo (2005) argues that "the comovement patterns are likely to contain important clues about the shocks and mechanisms that generate business cycles. Exploring the comovement properties of business cycle models is an important, but under-researched topic in macroeconomics".

In the last two decades many economists tried to solve the comovement puzzle with extensions of the standard RBC models. Some factors were pointed out as possible explanations for sectors to move up and down together over the business cycle. A group of papers relies on a input-output structure on a multi-sector framework, while others use mainly a two-sector model framework. Moreover, we discuss the relevance of such factors in light of the Portuguese economy.

The work is organized in the following way. Section 2 describes the dataset used. Next, Section 3 overviews the structure of the Portuguese economy and characterises the cyclical behaviour at a sectoral level, in particular volatility and comovement. Section 4 briefly reviews the Business Cycle literature on the causes of the comovement phenomenon and discusses those factors such as the input-output linkages in light of the Portuguese economy. Finally, section 5 concludes.

2 Data

There are different ways to measure economic activity in a given sector. We can look to the production itself or to the quantity of inputs used in each sector. In this work, annual data for the GVA[2] and total employment are used as measures of economic activity, in order to characterise the sectoral business cycle in the period 1953-2003. The choice of annual data was determined by the need to get series as long as possible for a large number of sectors in order to include the maximum possible number of complete business cycles (approximately 5). The data include sectors approximately arranged according to the two digits NACE rev2 disaggregation level, comprising a total of 22 sectors (appendix A). This breakdown level gives an important and sufficient degree of sectoral heterogeneity and allows some international comparisons. Moreover, given the available sources, the breakdown level used for the business cycle analysis defines the highest possible level of disaggregation.

[2]This measure is approximately the Gross Domestic Product (GDP). There is an important difference between GDP and GVA: GVA is measured net of taxes (for instance VAT) and subsidies on products.

The database has been constructed in the following way: For the 1995-2001 period we used National Accounts released by *Instituto Nacional de Estatística (INE)*. For the period 1953-1995, we used *Banco de Portugal Series Longas*. For the last two years of the database, 2002 and 2003, GVA and total employment series were forwarded with *Banco de Portugal* estimates and *INE's* Employment Survey, respectively.[3]

3 Empirical results

In the last decades Portugal was characterised by substantial structural changes, in terms of both GVA and employment. Therefore, a quantitative assessment of the production structures in Portugal and their dynamics over the last fifty years is provided in subsection 3.1. This characterisation is important since sectoral composition may influence the characteristics of an economy's business cycle and may also have an effect on the transmission of shocks. Hence, in subsection 3.2 the cyclical behaviour at a sectoral level is studied, in particular in terms of volatility and comovement.

A defining feature of the business cycle definition is the existence of comovement. Sectoral comovement means that the movement of level of activity over the business cycle is quite similar across sectors, such that it increases and decreases together. Three different measures are used in order to study and characterise the degree of comovement. The first and most commonly used in the business cycle literature consists in the correlation coefficient of each sector with the aggregate. Since an aggregate is the sum of sectoral series, even if they are independent of each other, we would observe that each individual series is positively correlated with the aggregate since it is perfectly correlated with its own contribution to the aggregate.This problem is mitigated when the number of sectors increase. Here, a total of 22 sectors is sufficient to prevent biased interpretations. In fact, the correlations between each sector and is complement present very similar results. The second measure relies on cross-pairwise correlations - correlations between all the sectors. Finally, the percentage of the aggregate volatility that is due to intersectoral comovement can also be used. The variance of each aggregate is calculated and decomposed into variance component and a comovement term due to the covariance elements. Given the importance of the comovement to aggregate volatility, a brief characterisation of the differences in volatility across sectors is also provided. In fact, differences in volatility across sectors are a distinctive element of aggregate business cycles. The analysis of the sectoral sources of aggregate fluctuations can provide important information about the driving forces for the business cycles. Additionally, in the light of the sectoral changes observed over the last fifty years, their impact on the change of the Portuguese aggregate volatility is also acknowledged.

[3]Data was chained forward and backward using the growth rates of each sector.

3.1 Structure of the economy

In the last fifty years substantial structural changes were observed in the Portuguese economy. Such changes mean that, over time and in relative terms, production and use of resources in some sectors grew more than in others. Table 1 describes the structure of the Portuguese economy over the periods 1953-1974 and 1975-2003, in terms of GVA at current prices and employment, for the main aggregate sectors. These sub-periods compare two different episodes of the Portuguese economy that have completely different characteristics, in particular at the economic level. In fact, there is evidence that only from mid-seventies economic cycles are reasonably long and regular, when compared to the less regular pattern oberved in the fifties and sixties[4].

In terms of GVA, from the analysis of the main sectors it is observed a significant decline of the importance of the primary sector (from more than 15 per cent in 1953-1974 to more than 5 per cent in 1975-2003) and a substantial increase of the share of the services sector in the total economy, reaching almost 60 per cent in the last thirty years (more than 45 per cent in the 1953-1974 period). The importance of manufacturing sector is broadly stable over the two periods. These developments are in line with the pattern observed in terms of employment and to what is observed in other countries.[5] It should be noted that, in the last decades, notably following the accession of Portugal to the European Economic Community (EEC) in 1986, a more competitive regulatory framework was progressively introduced, leading to more competition in domestic market. Moreover, Portuguese economy experienced a period of progressive liberalisation of the goods and services trade and of the circulation of capital at the international level, associated with the European integration.

Although there is a virtual stability of the share of the manufacturing sector in the total economy, within this sector important changes were observed. In terms of GVA, Figure 1 shows a decline of the "Chemical, rubber, plastics and fuel products" and of some traditional sectors as the "Wood and products of wood and cork" and "Textiles and textile products". In contrast, sectors like "Machinery and equipment" and "Transport equipment" increase their relative importance in the total manufacturing, reaching values around 9 and 8 per cent, respectively.[6] Nevertheless, it should be noted that the traditional sectors, in particular "Textiles and textile products", is still the major sub-sector within manufacturing industry, reaching around 20 per cent of total manufacturing in the last thirty years. "Food products, beverages and tobacco" are also an important manufacturing sub-sector with more than 15 per cent of total manufacturing in the 1975-2003 period. In terms of employment, the developments are quite similar to the ones presented to GVA, as displayed in Figure 2.

[4] For further details see Bonfim and Neves (2002).

[5] See for example Kongsumat, Rebelo and Xie (2001).

[6] This behaviour is mainly due to the foreign direct investment projects.

In what concerns the service sub-sectors it should be noted the increased importance of the "Community social and personal services"(from more than 25 per cent in 1953-1974 to almost 35 per cent in 1975-2003 of total GVA services), mainly comprising public services, and "Financial intermediation" (from around 5 per cent in 1953-1974 to around 10 per cent in 1975-2003 of total GVA services) and the still high share of the "Wholesale and retail trade and repairs" (around 25 per cent of total GVA services in the 1975-2003 period), despite the slight decline of the relative importance of this sector (Figure 3).

Figure 4 illustrates that, in terms of employment, despite their decline of the relative importance, "Community social and personal services" and "Wholesale and retail trade and repairs" are the most important sectors (more than 45 and 25 per cent of total services in the last thirty years, respectively). Finally, it should be noted the increased importance of the "Financial intermediation" sector, as observed in terms of GVA, despite less pronounced.

3.2 Business cycle

To analyse the cyclical evolution of the different sectors we must first provide an operational definition for business cycles. In this study we follow Lucas (1977) in defining business cycles as deviations from trend. This is called "growth definition" and it is the one most often employed in the empirical literature on business cycles. To remove the trend component we used the Christiano and Fitzgerald (2003) band pass filter, which is capable of retaining the component of a specified range while discarding all the others.[7] In this case, business cycle periodicities was set to be between 2 and 10 years. Note that, in contrast to what is observed in the United States, Agresti and Mojon (2001) argue that European business cycles tend to last longer (8 years is too low for the upper band). In fact, Rua (2004) supports this argument for the Portuguese case, estimating a duration of around 10 years for the Portuguese business cycle.

Figure 5 displays the business cycle component of the two economic activity measures chosen to characterise the Portuguese business cycle.[8] We observe some well known stylised facts, which are also present for the majority of market economies:[9]

Result 1. (i) GVA is much more volatile than total employment (GVA exhibits a standard deviation of 0.028, while total employment stands only up to 0.012) and (ii) these series are strongly contemporaneously correlated (the contemporaneous correlation coefficient is 0.83).

[7] In order to get a complete description of band pass filters, see Christiano and Fitzgerald (1998) and (2003) or Baxter and King (1999). The results are qualitatively very similar to the ones observed with the HP filter.

[8] In the remaining sections, GVA is measured at constant prices.

[9] See for example Stock and Watson (1999).

Therefore, both variables are used in the following two sub-sections to document sectoral business cycle volatility and comovement. The characterisation of the business cycle at a sectoral level is also important to better understand some issues at an aggregate level.

3.2.1 Volatility

Differences in volatility across sectors are a distinctive element of aggregate business cycles. Table 2 reports the standard deviation of the business cycle component of each variable and in relative terms (divided by the standard deviation of the aggregate). These figures confirm some well known stylised facts:

Result 2. Higher volatility of the goods-producing industries when compared to the service-producing ones.

In fact, in terms of main aggregates, the relative volatility of the construction and the mining sector is significantly high, being followed by the agriculture and total manufacturing. All these aggregates exhibit higher volatility than the total of the economy. At a more disaggregated level it is observed that the manufacturing industries tend to be more volatile than the service ones, in particular the durable industries. In fact, as expected, within manufacturing, durable sectors are more volatile than non-durable ones. In what concerns services, it should be noted that "Community social and personal services" bear the responsibility for the reduced level of services volatility. In general, despite some minor differences, these facts are similar in terms of both aggregates, GVA and employment, and between the two sub-periods in analysis.[10]

Another interesting feature related with volatility is to examine to what extent each sector contributes to the total economy volatility. This is a difficult task but a simple exercise has been done in order to get a proxy of what can be the importance of each sector to the volatility of the economy as a whole.

The variance of a sum can be written as the sum of the covariances between each element and the aggregate. In fact, with two terms we have:

$$\begin{aligned} Cov(x+y, x+y) &= E((x+y)(x+y)) \\ &= E(x^2 + 2xy + y^2) \\ &= E(x(x+y) + y(x+y)) \\ &= cov(x+y, x) + cov(x+y, y) \end{aligned} \tag{1}$$

[10]Real estate, renting and business activities sector seems to be an exception. It presents a reduced relative volatility in terms of GVA, while is one of the most volatile sectors in terms of employment.

Generalizing to n elements:

$$Cov(\sum_{i=1}^{n} y_i, \sum_{i=1}^{n} y_i) = \sum_{i=1}^{n} cov(y, y_i) \tag{2}$$

with $y = \sum_{i=1}^{n} y_i$.

We decompose the variance of the total economy as the sum of the covariance of each sector with the aggregate, which are displayed in Table 3. In the 1953-2003 period, the "Construction", "Wholesale and retail trade and repairs" and "Textiles and textile products" were the most important sectors, representing more than 50 per cent of the total variance. In the two sub-periods, the result is similar but somewhat less concentrated in the last thirty years, with a rising importance of some service sectors as the "Financial intermediation", "Real estate, renting and business activities" and "Community social and personal services". Hence, we have the following result:

Result 3. The contribution to aggregate volatility in both employment and GVA is concentrated in only two or three sectors.

Finally, there is evidence of a reduction of the cyclical output volatility between the two sub-samples, 1953-1974 and 1975-2003. Then, it is interesting to know what really induced this behaviour, in particular the effect of sectoral composition on the variance of the output cycle. In section 3.1 we observed that Portugal has experienced substantial structural changes, namely the increased importance of the services in relation to other more volatile sectors, as durable manufacturing and agriculture. In order to confirm whether this is an important contribution to the business cycle volatility decline, some simple calculations proposed by Stock and Watson (2003) were done. They essentially compare the variance of two different periods with counterfactual variances, implying the maintenance of the volatility of one period with the shares of the other period.[11] Table 4 reports the results for the two sub-periods. The variance of the aggregate estimated using the sectoral data was 0.00082 in the 1953-1974 period and 0.00062 in the last thirty years. If the variance of the last period is calculated with the shares of the previous one, figures similar to the first period are reached. Therefore:

Result 4. Composition effect, reflecting mainly the shift to services, seems to be important, accounting for about 70 per cent of the total variance decline since the mid-seventies.[12]

[11] For further details see Stock and Watson (2003).

[12] For other countries, Stock and Watson (2003) arrive at different conclusions for the effect of sectoral composition to the decline of the variance of the annual growth rate of the GDP for the period 1960-1996. In fact, for the United States and France the figures are below 10 per cent and for Germany around 25 per cent. The exception was the UK, where the estimated contribution was above 60 per cent. Stock and Watson highlighted another potential explanations for the decline of total volatility:

3.2.2 Comovement

As mentioned before, the comovement phenomenon is a salient characteristic of the business cycle definition. Sectoral comovement means that the behaviour over the business cycle is quite similar across sectors, such that the level of activity increases and decreases together.

In this subsection, the objective is to provide a formal, quantitative assessment of the degree of comovement among economic sectors. Three different measures are used in order to study and characterise the degree of comovement. The first one consists in the correlation coefficient of each sector with the aggregate. The second one is the correlation between all sectors (cross-pairwise correlations). Finally, the percentage of the aggregate volatility that is due to the covariance is used. These different measures support the same idea: the evidence of comovement among Portuguese activity sectors.

Comovement with the aggregate

Most of the sectors increase and decrease closely with the business cycle component of total GVA and total employment, particularly in the last thirty years. The comovement evidence is quantified in Table 5, which reports the cross-correlation of the cyclical component of each sector with the cyclical component of the aggregate (contemporaneous, once-lagged and once led correlations). The results show that in most sectors the contemporaneous correlation with their aggregate is maximal in absolute value. From this table there is also evidence of sectoral comovement with aggregate variables for both, GVA and employment.

In what concerns employment, according to the results in Figure 6,[13] it can be said that for the whole sample period, most sectoral employment tends to move together with the aggregate employment. However, this comovement is different over the two sub-periods. Sectoral comovement is substantially higher in the 1975-2003 sub-period when compared with the 1953-1974, as Figure 7 illustrates. In this figure, if a country is over the 45 degree line, it means that the correlation coefficient with the aggregate stood at the same level in both periods and if it is on the right (left) of the 45 degree line, the contemporaneous correlation has increased (decreased) between the two sub-periods. The increase in the comovement is particularly significant in most services and durables industries.

The evidence of sectoral comovement with aggregate variables is not limited to employment. Despite less pronounced we also found some evidence of comovement for the

(i) "new inventory management methods have smoothed production" and (ii) "financial innovation and deregulation has relaxed liquidity constraints and allowed consumers and businesses better to smooth shocks to their incomes".

[13] The significance levels are given by $\pm \frac{t_{\alpha/2}^{(df)}}{\sqrt{(t_{\alpha/2}^{(df)})^2+n-2}}$, with (n-2) degrees of freedom.

GVA. According to the results illustrated in Figure 8, for the whole sample period, sectors tend to move together with the aggregate. Considering the two sub-periods, and as observed in employment, we get also an increase in the degree of contemporaneous association between most sectors and the aggregate (Figure 9).

Overall, the degree of comovement measured by the correlation of each sector with the aggregate is high. Construction, manufacturing, and services contribute about 85 and 90 per cent, respectively to employment and GVA. Thus, for the majority of the Portuguese sectors, GVA and employment tend to move up or down with their aggregate. The results obtained are much in line with those of previous studies for the United States - Christiano and Fitzgerald (1998) and Hornstein (2000). See subsection 3.2.3 International Comparison.

Comovement between all sectors

As mentioned, another important feature is to find evidence that all sectors move together. For this purpose it is considered the correlation between the business cycle components of all the variables (cross-sectoral correlations). This information is reported following Christiano and Fitzgerald (1998) and Hornstein (2000), where histograms for the contemporaneous pairwise correlations, as well as quartile and average values are reported.[14]

In Figures 10 to 13 we consider the cross-sectoral correlation pattern for the economy as a whole, for the whole sample period and for the period before and after 1974, respectively. We infer that the data are consistent with the preceding statistics for the presence of comovement. Cross-sectoral correlations for employment are consistently positive with an average of 0.24, while the pattern is somewhat weaker for GVA (average

[14]In statistics, there is a transformation, the hyperbolic tangent, that allows us to obtain a statistic with a known distribution for the correlation and to combine several correlation coefficients (Fisher's z-transformation - David (1949)) (see, for example, Camacho, Pérez-Quirós and Saiz (2004)). It consists on:

$$z = \tanh^{-1}(\rho) = \frac{1}{2}(\ln(1+\rho) - \ln(1-\rho)) \tag{3}$$

where $z \sim N(\rho, \frac{1}{n})$, ρ is the correlation coefficient and n is the sample size. The combination of m different correlations coefficients, it is operated in the following way:

$$z' \sim N(\frac{1}{\sum_{i=1}^{m} n_i}(\sum_{i=1}^{m} n_i \tanh^{-1}(\rho_i)), \frac{1}{\sum_{i=1}^{m} n_i}) \tag{4}$$

With the same sample size (n), it resumes to:

$$z' \sim N(\sum_{i=1}^{m} \frac{\tanh^{-1}(\rho_i)}{m}, \frac{1}{mn}) \tag{5}$$

To obtain a meaningful value, likewise a correlation coefficient, we undo the transformation (ρ = tanh(z')).

of 0.16) but still statistically different from zero.[15] Again, considering the periods before and after 1974, sectoral comovement is substantially higher in the 1975-2003 period than in the 1953-1974 period. For the late period the average of both variables increases substantially (0.35 and 0.25 for employment and GVA, respectively). Additionally, more than three-fourths of all sectors are positively correlated.

The results obtained are much in line with those of previous studies for the United States, in particular with Hornstein (2000) (See subsection 3.2.3 International comparison).

Comovement and aggregate volatility

Finally we infer the importance of intersectoral comovement to aggregate employment and GVA volatility. First, it is approximated by the business cycle of both aggregate activity measures, as a weighted average of the 22 sectoral business cycles. The variance of each aggregate is calculated and decomposed into variance component and a comovement term due to the covariance elements.

$$\begin{aligned} Var(y) &= \sum_{i=1}^{22}\sum_{j=1}^{22}(w_i w_j Cov(y_i, y_j)) \\ &= \sum_{i=1}^{22}\sum_{j=1,j=i}^{22}(w_i w_j Cov(y_i, y_j)) + \sum_{i=1}^{22}\sum_{j=1,j\neq i}^{22}(w_i w_j Cov(y_i, y_j)) \\ &= \sum_{i=1}^{22} w_i^2 Var(y_i) + \sum_{i=1}^{22}\sum_{j=1,j\neq i}^{22}(w_i w_j Cov(y_i, y_j)) \end{aligned} \tag{6}$$

Table 6 presents this decomposition for total GVA and total employment business cycle. The results suggest again that most of the aggregate volatility can be attributed to sectoral comovement. The approximate employment variance implied by the calculations is 0.00012. The variance implied by the covariance elements is 0.00007, which means that comovement accounts for almost 60 per cent of the variance of total employment. Considering the periods before and after 1974, volatility due to comovement is higher in the 1975-2003 period, accounting for 75 per cent. Qualitatively similar results hold for total GVA. The results obtained are much in line with those of Shea (2002) for the U.S. manufacturing industry (See subsection 3.2.3. International Comparison).

Hence, the three different measures support the same idea:

[15] The critical value for 1% significance level is 0.02 for the whole sample period and 0.03 for the 1975-2003 period. It should be noted that the observed negative correlations can be attributed to a small number of sectors. For employment, most of the negative correlations are accounted for by "Agriculture, forestry and fishing". For GVA, most of it are accounted for by "Electricity, gas and water".

Result 5. Strong evidence of comovement among Portuguese activity sectors in terms of GVA and employment.

3.2.3 International comparison

The evidence for sectoral comovement in the Portuguese economy is similar to the pattern observed in the United States. Next, a comparison between Portugal and the United States in terms of the cross-correlation of each sector with aggregate series and cross-sectoral correlation in all sectors is displayed. For the purpose of comparison we will discuss Hornstein (2000), which focus his analysis on United States' annual data for total economy excluding agriculture and government enterprises for the period 1950-1991.

Broadly speaking, in both countries most sectors move contemporaneously with their aggregate counterpart (Table 7). The presence of sectoral comovement with aggregate variables is observed for almost all sectors. In fact, in both countries, correlation of employment in all the manufacturing sectors is positive and mostly higher than 0.4. Despite less pronounced we also found some evidence of comovement for the service sectors. In terms of GVA, results do not differ much, albeit with a lesser degree of comovement, in particular for the Portuguese economy.

Table 8 displays a comparison of the quartile and average values for the pairwise correlations. Once again, figures are very similar in both countries, in particular for total employment, where the average correlation coefficient is around 0.35. The pattern for GVA is weaker, in particular in the Portuguese case. The average cross-sectoral correlation coefficient for GVA is 0.24 for the United States and 0.16 for Portugal. Overall, the presence of sectoral comovement in Portugal is in line with the one observed in the United States, although less pronounced.

The previous section confirms that intersectoral comovement is important to explain aggregate GVA and employment volatility. In fact, in the 1953-2003 period, comovement accounts for almost 60 per cent of the variance of total employment and around 75 per cent in the 1975-2003 period. In terms of GVA, in both periods, comovement accounts for around 75 per cent of total economy volatility.

Shea (2002) shows that in the U.S. manufacturing industries most of the aggregate volatility can be due to intersectoral comovement in the 1960-1986 period. The results suggest that this pattern is even higher than the one observed in the Portuguese economy. For the U.S., comovement accounts for almost 95 per cent of the variance of manufacturing employment and around 80 per cent of the manufacturing GVA volatility. Therefore, the importance of sectoral comovement to aggregate GVA and employment volatility in Portugal seems to be in line with the one observed in the US, although less pronounced.

4 What's behind business cycle comovement ?

Economists argue that, over the business cycle, most sectors expand and contract simultaneously. In theory, intersectoral comovement could be entirely due to the direct effects of common shocks or to complementarities that propagate them across sectors. Lucas (1977) argues that this behaviour is due to the so-called aggregate shock, a phenomenon that hits all sectors of the economy. However, a different line of research has suggested other possibilities, basically related with the presence of intersectoral complementarities.[16] For example, in the presence of input-output linkages, Long and Plosser (1983, 1987) and Horvath (2000) show that individual shocks, even uncorrelated ones, may have significant aggregate effects and could result in comovement. Moreover, in the context of a multi-sectoral model, Horvath (2000) concludes that "one-sector models are not such a bad approximation to reality, so long as economists do not interpret the one-sector shocks as real aggregate shocks. When one aggregates to the one-sector level, real sectoral shocks get aggregated into the appearance of aggregate shocks".

In the last two decades many economists tried to solve the comovement puzzle with extensions of the standard RBC models, pointing out different factors as possible causes for sectors to move up and down together over the business cycle. A group of papers relies on a input-output structure in a multi-sector framework, while others use mainly a two-sector model framework.

A brief overview of these factors will be carried out in the following subsection.

4.1 Multi-sector models framework

As mentioned, the presence of comovement may be due to complementarities that propagate shocks across sectors. In a multi-sector model framework, Long and Plosser (1983) and Horvath (2000) suggest input-output linkages as one important possibility of intersectoral complementarity. Long and Plosser (1983) were the first authors emphasising the importance of such channel in the explanation of some features of economic activity. Although they used some strong assumptions in order to solve their multi-sector model analytically, they found that input-output linkages produced the large positive cross-sector correlations in investment, labour supply and consequently in output. At the same time, this channel produced significant internal propagation. In a similar but less restrictive framework, Horvath (2000) gets similar conclusions.[17]

The input-output matrices may have an important role on the explanation of sectoral comovement of aggregate cyclical fluctuations. Horvath (1998) shows that U.S. input-output matrices are characterised by sparse columns and few full rows. The fullness in the

[16] For further details on the role of complementarities see Shea (2002) and Cooper and Haltinwanger (1996).

[17] Hornstein and Praschnik (1997) also explores this extension in a two-sector model.

rows indicates the sectors that sell inputs to many other sectors. The sparse columns represent the lack of substitution possibilities. Few sectors serve as important inputs to all other sectors and most sectors use few intermediate inputs in production. This author argues that a feature of the limited interaction is that it implies few possibilities of substitution among intermediate inputs. In the context of a dynamic stochastic general equilibrium model, these characteristics were shown to amplify aggregate volatility and sectoral comovement. The intuition is the following: a primary supplier of inputs will give the same signal to many sectors, increasing the probability that the responses of the purchasing sectors will be positively correlated. The higher the share, the higher is the importance of the transmitted signal to the receiving sector. If there are only few of these supplying sectors, the possible cancellation of the effects of the shocks is less likely to occur.

Input-output linkages can be seen in two ways: supply-side and demand-side linkages. The first one proposes that intermediate sector behaviour influences final good sector as they move up the production chain over time. In the demand type linkage, the developments of the final good sector determines the behaviour of the intermediate sector in the sense that higher production of the final good requires a higher level of inputs. Long and Plosser (1983) and Horvath (2000) introduce this mechanism in a multi-sector model. In this context, and as mentioned before, an increase in the demand for intermediate inputs create the opportunity of employment to increase in many sectors simultaneously. However, Horvath (2000) concludes that their results are still low to match empirical observations on sectoral comovement.

In the same framework, Kim and Kim (2003) discuss the role of different preferences. They conclude that sectoral comovement depends also on the specification of preferences over leisure. In the presence of indivisible labour[18], their model is able to create enough intersectoral linkages in order to explain sectoral employment comovement. However, in this framework, with divisible labour, only sectors with higher intersectoral linkage are able to dominate the leisure-smoothing negative effect. With divisible labour, they prove that sectors with weak intermediate input use present negative comovement. In these cases, the intersectoral linkage effect is dominated by the leisure-smoothing effect creating negative comovement in some sectors. As a result, they also explain that, with some form of worker's reluctance to substitute labour across sectors, positive comovement is present.

Summing up, in the presence of indivisible labour, the intersectoral channel seems sufficient to generate comovement, while with divisible labour, the model is not able to produce sectoral employment comovement. In this case, the intersectoral linkages

[18]Indivisibility of labour implies that the utility function is linear in leisure. This fact means that the elasticity of substitution between leisure in different periods is infinite, which implies that there is no leisure smoothing.

effect is more than compensated by the leisure-smoothing negative effect. Then, it is necessary to create workers reluctance to substitute labour across sectors. In this case, a low substitutability of labour supply is necessary to create employment sectoral comovement.

Other potencial sources of comovement derive from the two-sector models framework of the RBC literature - the consumption goods industry and the investment goods industry - a particular case of the multi-sector models. Some examples are the introduction of habit preferences and limited labour mobility (Boldrin, Christiano and Fisher (2001)), the importance of monetary factors through a working capital channel (Jin and Zeng (2002)) and the role of wage stickiness (DiCecio (2005)).

4.2 The Portuguese case

In the previous section we discussed some theoretical causes for sectoral comovement. In the following subsection we discuss the relevance of such factors in light of the Portuguese economy.

Empirical Regularities of Portuguese Input-Output Matrices

As we have shown before, the input-output matrices may have an important role on the explanation of sectoral comovement of aggregate cyclical fluctuations. Horvath (1998) demonstrates that U.S. input-output matrices are characterised by sparse columns and few full rows. Few sectors serve as important inputs to all other sectors and most sectors use few intermediate inputs in production. These characteristics were shown to amplify aggregate volatility and sectoral comovement. Are these characteristics present in the Portuguese economy? If so, input-output channel may have an important role in the explanation of the observed sectoral comovement.

Using input-output matrices at different levels of disaggregation (6,22 and 56 sectors)[19] collected by *INE*, Table 9 displays the fraction of non-zero elements in the Portuguese input-output matrices. Figures suggest that the number of non-zeros is affected by aggregation. As expected, the number of non-zero elements decreases with the level of disaggregation, from 92 to 62 per cent, with 6 and 56 sectors, respectively. The fullness in the rows is also influenced by aggregation. Table 10 illustrates the number of rows which are completely full, more than 2/3 full, more than 1/2 full and more than 1/3 full. The aggregated matrices are represented by many full rows while the disaggregated matrix has few full or more than 2/3 full rows. Therefore, the Portuguese economy is characterised by the existence of few sectors that are important input suppliers to all other sectors. In fact, the sectors with full rows are the ones that supply inputs to many

[19] Sectoral description are defined in Appendix A.

other sectors and consequently the ones that contribute the most to aggregate volatility. Table 11 points out the sectors with the fullest rows (in the 56 sectors case) and the number of sectors they supply for different "zero" tolerance levels (0.1, 0.05, 0.01 and 0).[20] The "Other business activities" is clearly the most important sector. In the top three input suppliers we also have "Manufacture of coke, refined petroleum and nuclear fuel" and "Manufacture of chemicals and chemical products".

Different aggregation has also impact on the size distribution of the non-zero elements in the input-output matrix. Table 12 displays Gini coefficients for the share weights averaged across the columns of the different levels of disaggregation.[21] This coefficient measures the dispersion of the share weights in the column. Values close to one stand for very unequal share weights, while values close to zero mean that share weights are nearly the same. Dispersion increases with the level of disaggregation, reaching 0.86 for the 56 sectors matrix (0.60 for the most aggregated one).

Labour Market

Labour market mobility in the Portuguese economy, in particular inter-sectoral mobility, has not been subject of many studies. An exception is Carneiro and Portugal (1998) where employment reallocation in the manufacturing industry is took into account for the 1983-1990 period. At a sectoral level, they conclude that job creation and destruction flows do not imply a simple reallocation from contraction industries to expansion ones. On the contrary, the net employment changes in the manufacturing sector are better characterised as intra-sectoral changes. Their results show that more than 75 per cent of total employment is due to the employment changes between firms of the same sector. The study points out the presence of some mobility of the Portuguese labour market but not at an inter-sectoral level. This mobility is in contrast to what we should expect given the rigidity of the employment protection regulation. In fact, Blanchard and Portugal (2001) confirm that despite the higher employment flows induced by the entry and exit of firms, job destruction and creation is substantially lower in Portugal when compared to the United States. The presence of a strong employment protection regulation may be one of the causes for such evidence.[22] The labour market immobility assumption, which prevents labour from being reallocated between sectors after a shock, seems to be somewhat supported by these results.

Labour supply is a very difficult component of labour economics and it has never been estimated for the Portuguese economy. However, it seems that the substitutability of labour supply should be somewhat low. In fact, in a low-income level country with a

[20] Table is sorted on the tolerance level of 0.05.

[21] The Gini coefficient is given by $\frac{1}{2\bar{\gamma}M^2}\sum_i\sum_j \mid \gamma_{ij} - \gamma_{kj} \mid$.

[22] For a complete description of the employment protection legislation see Bover, Garcia-Perea and Portugal (2000).

high level of participation rate (above 70 per cent in the last five years) it is not natural the presence of a high elasticity of the labour supply.[23]

As we have discussed, intersectoral comovement could be due to the direct effects of common shocks or to complementarities that propagate shocks across sectors. However, an important feature remains: whether the economy is mainly driven by aggregate or sector-specific shocks. Next, we discuss briefly this feature, studying the comovement of a simple measure of total factor productivity (TFP).

Total Factor Productivity

Productivity shocks are an essential ingredient of RBC models (King and Rebelo (2000)).[24] When there is no measurement error in the inputs (labour and capital), these shocks coincide with the solow residual. However, previous studies point out that cyclical variations in labour effort and capital utilization can significantly contaminate the solow residual, namely with implausible large results for the probability of technical regress (Burnside, Eichenbaum and Rebelo (1996)).

Solow Residual

Value Added (Y_t) is produced according to a constant return to scale production function that combines labour (N_t) and capital (K_t)

$$Y_t = A_t(K_t)^{\alpha}(N_t)^{1-\alpha} \tag{7}$$

To each sector a productivity series (A_t) could be constructed as the residual of value added minus weighted factors inputs according to the following log expression:

$$\ln A_t^j \equiv \ln Y_t^j - \alpha^j \ln(K_t^j) - (1-\alpha^j)\ln(N_t^j) \tag{8}$$

The main problem in considering this expression is an accurate measurement of the inputs. King and Rebelo (1998) highlighted the fact that solow residual based measures of technology shocks that not account for unmeasured variations in labour and capital will tend to be more volatile and procyclical than true shocks to technology. Burnside, Eichenbaum and Rebelo (1996) recommend energy usage as a proxy for capacity utilization. Horvath (2000) shows that failing to correct for varying capital utilization would overstate the cross-sector correlation in sectoral TFP. An indicator to use as a proxy of the labour hoarding is not so consensual.[25] This kind of correction turns out to be

[23]For the United States and United Kingdom, empirical labour economics studies find a relatively low wage elasticity of labour supply (Altonji(1982) and Ashenfelter and Altonji (1980)).

[24]Some studies reject the importance of the technology shock. For example, Gali (2004) concludes that exogenous variations in technology plays a very limited role as sources of the business cycle.

[25]For further details on the labour hoarding see Burnside and Eichenbaum (1996), King and Rebelo (2000) and Felices (2003).

difficult due to data availability. As a result, the sectoral productivity series is given by

$$\ln A_t^j \equiv \ln Y_t^j - \alpha^j \ln(e_t^j) - (1-\alpha^j)\ln(N_t^j) \tag{9}$$

where e_t^j is the level of energy that each sector j use in time t.

The cost shares for capital and labour are calculated for the 22 sectors using annual data from 1977 to 1999 by dividing the cost of inputs by the value of GVA. The energy level was taken from the input-output matrices (other sectors use of sector "Electricity, gas and water"). Table 13 displays the business cycle comovement of sectoral TFP (cross-sectoral correlations). There is some evidence that TFP in different sectors moves together. However, this behaviour seems to be weaker than for GVA and employment. Therefore, there seems to be some evidence that changes in productivity are partly dominated by an aggregate shock. The results obtained are much in line with those of Hornstein (2000).

5 Concluding remarks

This work documents that, over the business cycle, activity in almost all sectors of the Portuguese economy expands and contracts simultaneously, confirming an important feature of the business cycle literature. This behaviour is consensual among the three different ways used to measure comovement: cross-correlation with the aggregate, cross-sectoral correlation and the importance of intersectoral comovement to aggregate volatility.

The main result of this work is that despite some existing differences in terms of trend and volatility, this phenomenon is observed in terms of both, GVA and employment, and it is in line to what is observed in the United States.

Some possible causes for the existence of such phenomenon are considered in light of the business cycle literature. We analyse the role of the input-output channel in a multi-sector framework. Apart from the previous characteristic, there are some factors specific to the Portuguese economy, in particular the importance of the international trade. Further, it is also important to take into account the nature of each sector, namely if it is more or less tradable and consequently their different market structures.

Therefore, the consideration of an open economy framework, with the presence of the mentioned characteristics, may be relevant and necessary to understand what's behind sectoral comovement observed in the Portuguese economy. Such assessment is a task for future research.

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Tables and Figures

Table 1 - Portuguese economic activity

Breakdown by sectors of activity

Share in total gross value added (in percentage)

	1953-1974	1975-2003
AGRICULTURE, FORESTRY AND FISHING	17.0	7.1
MINING AND QUARRYING	0.3	0.4
MANUFACTURING	26.3	23.0
ELECTRICITY, GAS AND WATER	1.7	2.9
CONSTRUCTION	8.5	8.6
SERVICES	46.2	58.0
TOTAL	100.0	100.0

Share in total employment (in percentage)

	1953-1974	1975-2003
AGRICULTURE, FORESTRY AND FISHING	36.6	15.0
MINING AND QUARRYING	0.6	0.4
MANUFACTURING	21.8	23.1
ELECTRICITY, GAS AND WATER	0.6	0.8
CONSTRUCTION	5.8	9.0
SERVICES	34.6	51.8
TOTAL	100.0	100.0

Table 2 - Standard deviation and relative volatility

	Gross Value Added 1953-2003		Employment 1953-2003	
	Standard Deviation	Relative Volatility	Standard Deviation	Relative Volatility
Total	0.03	1.00	0.01	1.00
Agriculture, Forestry and Fishing	0.05	1.89	0.02	1.50
Mining and Quarrying	0.13	4.60	0.05	4.15
Food products, beverages and tobacco	0.04	1.53	0.01	1.23
Textiles and textile products	0.11	4.01	0.03	2.43
Leather, leather products and footwear	0.10	3.63	0.03	2.63
Wood and products of wood and cork	0.11	4.05	0.04	3.12
Pulp, paper, paper products, printing and publishing	0.08	2.85	0.05	4.16
Chemical, rubber, plastics and fuel products	0.08	3.05	0.03	2.91
Other non-metallic mineral products	0.07	2.42	0.03	2.15
Basic metals and fabricated metal products	0.09	3.35	0.03	2.50
Machinery and equipment	0.17	6.25	0.05	4.00
Transport equipment	0.14	5.05	0.08	6.50
Manufacturing nec	0.08	3.03	0.06	5.36
Electricity, gas and water	0.10	3.49	0.02	1.62
Construction	0.07	2.47	0.05	4.02
Wholesale and retail trade; repairs	0.03	1.06	0.02	1.71
Hotels and restaurants	0.06	2.25	0.03	2.46
Transport and storage	0.04	1.62	0.02	1.94
Post and telecommunications	0.06	2.11	0.02	1.67
Financial intermediation	0.07	2.57	0.02	2.06
Real estate, renting and business activities	0.02	0.79	0.05	4.55
Community Social and Personal Services	0.02	0.60	0.01	0.94

Table 3 - Volatility decomposition

Percentage of the total variance due to the covariance of each sector with the aggregate

	Gross Value Added			Employment		
	1953-2003	1953-1974	1975-2003	1953-2003	1953-1974	1975-2003
Agriculture, Forestry and Fishing	6.7	12.5	3.0	-7.7	-20.0	-6.9
Mining and Quarrying	0.7	0.8	0.6	1.4	3.2	0.9
Food products, beverages and tobacco	1.3	0.0	2.5	2.2	2.3	2.1
Textiles and textile products	6.7	8.7	4.7	14.3	27.1	10.5
Leather, leather products and footwear	0.9	0.7	1.0	1.4	0.3	1.8
Wood and products of wood and cork	4.5	4.8	4.0	2.9	2.3	2.4
Pulp, paper, paper products, printing and publishing	2.0	1.9	1.6	3.1	2.4	3.1
Chemical, rubber, plastics and fuel products	0.9	-0.6	1.8	2.6	6.1	1.7
Other non-metallic mineral products	1.0	0.3	1.7	1.3	2.4	1.3
Basic metals and fabricated metal products	3.1	3.5	3.0	3.3	3.1	3.1
Machinery and equipment	3.3	1.7	3.9	4.7	7.8	3.8
Transport equipment	1.4	0.2	2.6	1.3	1.4	1.6
Manufacturing nec	0.6	0.4	0.7	4.9	1.0	5.2
Electricity, gas and water	0.5	0.5	0.8	0.3	0.0	0.4
Construction	27.5	36.6	20.7	23.2	36.5	20.7
Wholesale and retail trade; repairs	16.3	14.3	15.9	15.5	24.0	13.7
Hotels and restaurants	1.0	0.5	1.2	3.5	1.2	3.5
Transport and storage	2.4	1.9	2.9	1.5	-3.1	2.7
Post and telecommunications	1.5	0.4	2.7	-0.5	-3.5	0.2
Financial intermediation	6.6	2.6	11.4	1.8	1.8	2.2
Real estate, renting and business activities	5.5	3.1	7.8	7.8	1.6	12.1
Community Social and Personal Services	5.4	5.4	5.6	11.3	1.8	14.5

Table 4 - Aggregate volatility and sectoral composition effect

	Estimated Variances [(a)]		Counterfactual Variance [(b)]	Efffect of changing sectoral shares on variance [(c)]	
Sectoral shares	53-74	74-03	53-74	in variance units	as a % of total fall in variance
Sectoral variances	53-74	74-03	74-03		
Gross Value Added	0.00082	0.00062	0.00076	-0.00014	69.7

Notes:

(a) The variances are estimated using the approximation that the total economy business cycle is approximately the share-weighted average of the business cycle of the 22 sectors.

(b) The counterfactual variance is estimated using the same approximation. However, it is used the shares of the 1953-1974 period with the variances of the 1975-2003 period.

(c) This effect is an estimation of the reduction in the variance due to changes in the weights, evaluated at the average of the sectoral covariances matrices in the two periods. For further details see Stock and Watson (2003).

Table 5 - Cross-Correlation

	Gross Value Added 1953-2003			Employment 1953-2003		
	Correlation			Correlation		
	-1	0	1	-1	0	1
Total	0.60	1.00	0.60	0.56	1.00	0.56
Agriculture, Forestry and Fishing	0.20	0.52	0.33	-0.60	-0.35	-0.11
Mining and Quarrying	0.55	0.43	0.05	0.65	0.70	0.14
Food products, beverages and tobacco	0.39	0.34	-0.09	0.22	0.46	0.18
Textiles and textile products	0.30	0.59	0.41	0.52	0.89	0.52
Leather, leather products and footwear	0.28	0.34	0.22	-0.02	0.45	0.49
Wood and products of wood and cork	0.38	0.69	0.55	0.24	0.53	0.33
Pulp, paper, paper products, printing and publishing	0.32	0.34	0.04	0.40	0.68	0.45
Chemical, rubber, plastics and fuel products	0.00	0.22	0.09	-0.07	0.45	0.50
Other non-metallic mineral products	0.32	0.32	0.03	0.34	0.50	0.15
Basic metals and fabricated metal products	0.10	0.51	0.50	0.26	0.71	0.67
Machinery and equipment	0.41	0.42	0.05	0.53	0.76	0.44
Transport equipment	0.08	0.26	0.30	0.20	0.19	-0.06
Manufacturing nec	0.12	0.29	0.13	0.09	0.48	0.41
Electricity, gas and water	-0.21	0.02	0.09	0.01	0.18	0.21
Construction	0.51	0.79	0.55	0.54	0.79	0.48
Wholesale and retail trade; repairs	0.77	0.72	0.27	0.49	0.74	0.33
Hotels and restaurants	0.18	0.14	0.06	0.53	0.70	0.39
Transport and storage	0.06	0.51	0.52	-0.01	0.27	0.30
Post and telecommunications	0.28	0.38	0.22	0.05	-0.05	-0.10
Financial intermediation	-0.09	0.38	0.48	0.44	0.52	0.11
Real estate, renting and business activities	0.45	0.67	0.46	0.44	0.62	0.35
Community Social and Personal Services	0.39	0.40	0.10	0.24	0.50	0.31

Notes:

Correlation 0: Contemporaneous correlation
Correlation 1: Series leads aggregate one period
Correlation -1: Series lags aggregate one period

Table 6 - Comovement and aggregate volatility

1953-2003

Activity Measure	Variance				% due to comovement
	Data	Implied	components		
			VAR	COV	
Gross Value Added	0.00077	0.00068	0.00018	0.00050	73.0
Employment	0.00014	0.00012	0.00005	0.00007	58.5

1953-1974

Activity Measure	Variance				% due to comovement
	Data	Implied	components		
			VAR	COV	
Gross Value Added	0.00084	0.00082	0.00027	0.00055	67.3
Employment	0.00011	0.00005	0.00004	0.00001	26.8

1975-2003

Activity Measure	Variance				% due to comovement
	Data	Implied	components		
			VAR	COV	
Gross Value Added	0.00071	0.00062	0.00014	0.00048	77.3
Employment	0.00016	0.00021	0.00005	0.00016	74.9

Table 7 - Correlation of sectoral series with aggregate series

Sector	Value-Added		Employment	
	U.S.[(a)] 1950-1991	Portugal[(b)] 1953-2003	U.S.[(a)] 1950-1991	Portugal[(b)] 1953-2003
Metal mining	0.44	0.43	0.44	0.7
Coal mining	0.51		0.3	
Oil and gas extraction	0.73		-0.48^{+}	
Non-metallic mining	0.72		-0.31^{+}	
Construction	0.61	0.79	0.7	0.79
Food	0.44	0.34	0.29^{+}	0.46
Tobacco	0.38		0.19	
Textile mill products	0.46^{+}	0.59	0.66	0.89
Apparel	0.67		0.52	
Lumber and wood	−0.30	0.69	0.77	0.53
Furniture and fixtures	0.9		0.84	
Paper and allied	0.75	0.34	0.69	0.68
Printing	0.69		0.5	
Chemicals	0.77	0.22	0.77	0.45
Petroleum and coal	0.62^{+}		0.37^{+}	
Rubber and miscellaneuos plastics	0.78		0.85	
Leather	−0.39	0.34	0.46	0.45
Stone, clay, and glass	0.89	0.32	0.84	0.5
Primary metal	0.75	0.51	0.65	0.71
Fabricated metal	0.88		0.86	
Machinery, non-electrical	0.79	0.42	0.86	0.76
Electrical machinery	0.84		0.88	
Instruments	0.73		0.67	
Motor vehicles	0.77	0.26	0.79	0.19
Transportation equipment	0.49^{-}		0.62	
Miscellaneous manufacturing	0.65	0.29	0.47	0.48
Transportation	0.75	0.51	0.84	0.27
Communications	-0.45^{+}	0.38	0.55	-0.05
Electric utilities	0.66	0.02	0.58^{-}	0.18
Gas Utilities	-0.57^{+}		0.66	
Trade	0.82	0.72	0.81	0.74
Financial intermediation	0.22^{+}	0.38	0.24^{-}	0.52
Real estate, renting and business activities		0.67		0.62

Notes:
(a) Maximal Correlation . A correlation is the maximal correlation in absolute value of the contemporaneous, one period lagged, and one period leaded correlation between the industry variable and the corresponding aggregate variable. A plus (minus) superscript denotes that the industry variable is leading (lagging) the aggregate variabl. No superscipts indicates that the contemporaneous correlation is maximal. See Hornstein (2000) for further details.
(b) Contemporaneous Correlation

Table 8 - Total economy except mining, agriculture and government: Cross-Sectoral Correlations

	Value Added		Employment	
	U.S. 1950-1991	Portugal 1953-2003	U.S. 1950-1991	Portugal 1953-2003
Minimum	-0.72	-0.35	-0.64	-0.55
1st Quartile	-0.21	0.04	0.27	0.18
Median	0.39	0.17	0.44	0.42
3rd Quartile	0.57	0.29	0.59	0.56
Maximum	0.9	0.62	0.91	0.88
Average	0.24	0.16	0.38	0.34

Table 9 - Fraction of non-zero elements in Portuguese input-output matrices

	Number of Sectors		
	6	*22*	*56*
Total economy	0.92	0.87	0.62

Table 10 - Number of full rows in the Portuguese input-output matrices [(a)]

	Number of Sectors		
	6	*22*	*56*
Full Rows	5	13	2
>2/3 Full	5	17	30
>1/2 Full	5	20	34
>1/3 Full	6	22	40

(a) Number of rows in the matrices which satisfy the fullness criterion.

Table 11 - The primary suppliers of inputs in Portugal and their total row links [(a)]

	Tolerance [(b)]			
Sectors	0.1	0.05	0.01	0
74 Other business activities	23	42	56	56
23 Manufacture of coke, refined petroleum products and nuclear fuel	8	20	36	56
24 Manufacture of chemicals and chemical products	8	13	35	52
40 Electricity, gas, steam and hot-water supply	4	13	40	55
70 Real estate activities	3	11	32	54
22 Publishing, printing and reproduction of recorded media	1	9	30	55
60 Land transport; transport via pipelines	4	9	35	55
27 Manufacture of basic metals	7	8	12	21
64 Post and telecommunications	3	8	28	55
50 Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	0	7	22	55
29 Manufacture of machinery and equipment n.e.c. (not elsewhere classified)	3	7	23	47

(a) Sectors which have the fullest rows in the Portuguese input-output matrix and the number of sectors they supply with inputs
(b) Different degrees of zero tolerance used when counting for non-zero links.

Table 12 - Input-Share Gini Coefficients[(a)]

	Average	Standard deviation
6 sectors	0.60	0.04
22 sectors	0.76	0.08
56 sectors	0.86	0.06

(a) Average and standard deviation of Gini coefficients for input-use shares in the columns in Portuguese input-output matrices.

Table 13 - Frequency distribution of Cross-Sectoral Correlations (1977-1999)

	TFP
Minimum	-0.85
1st quartile	-0.08
median	0.13
3rd quartile	0.30
maximum	0.91
average	0.12

Figure 1
Share in total manufacturing (in percentage)
GVA

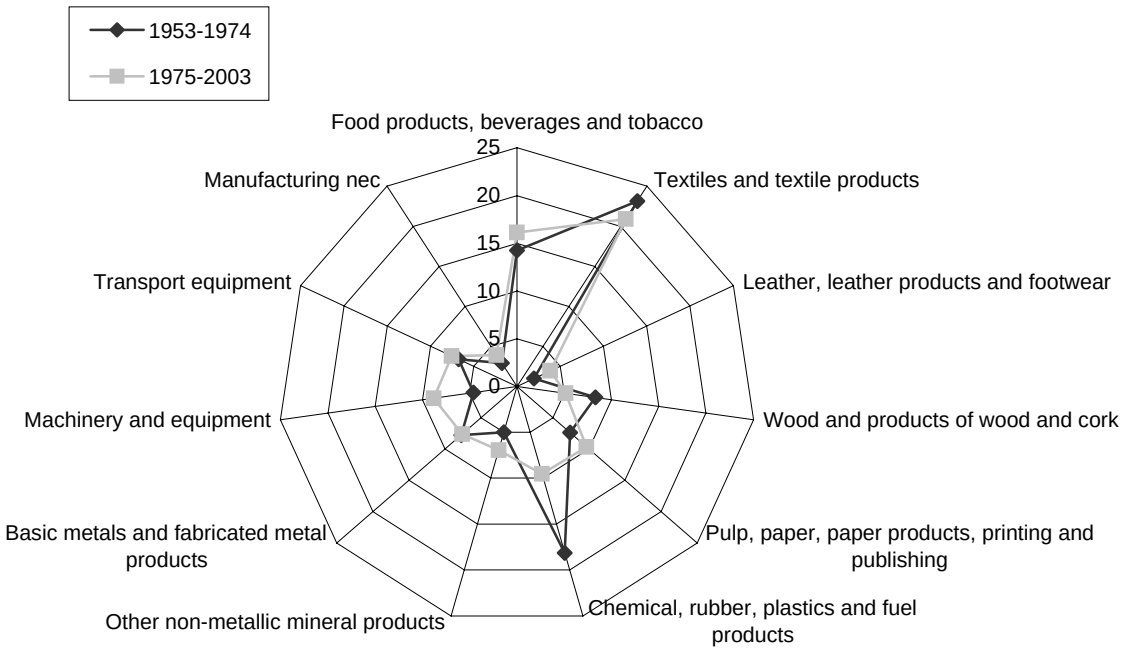


Figure 2
Share in total manufacturing (in percentage)
Employment

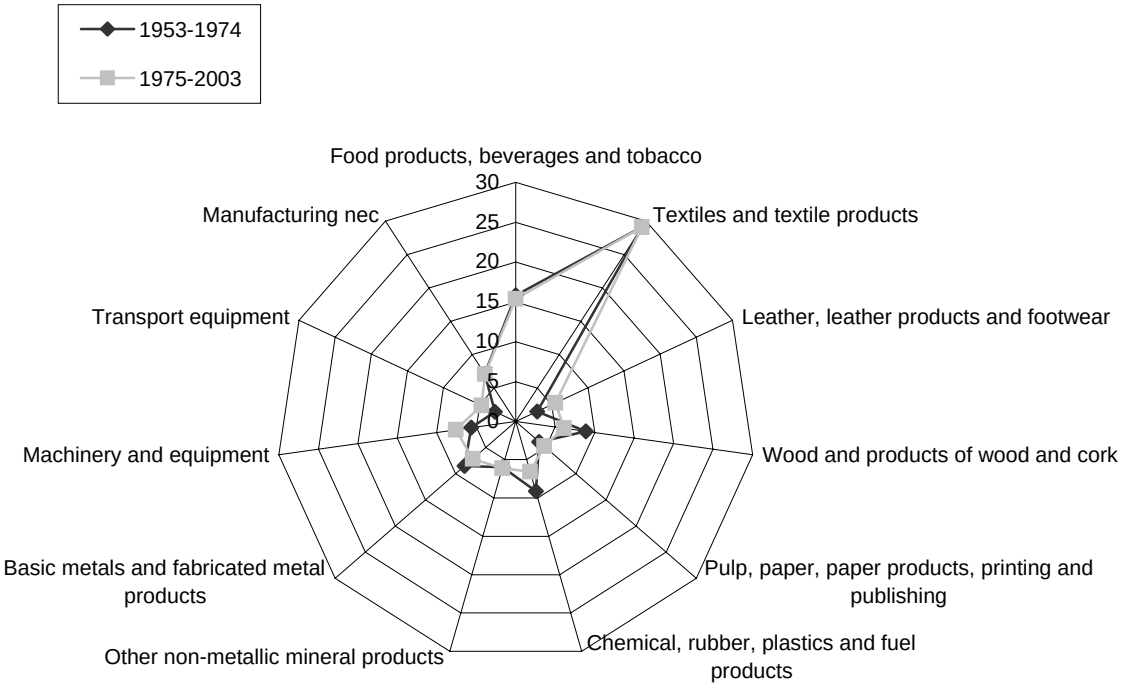


Figure 3
Share in total services (in percentage)
GVA

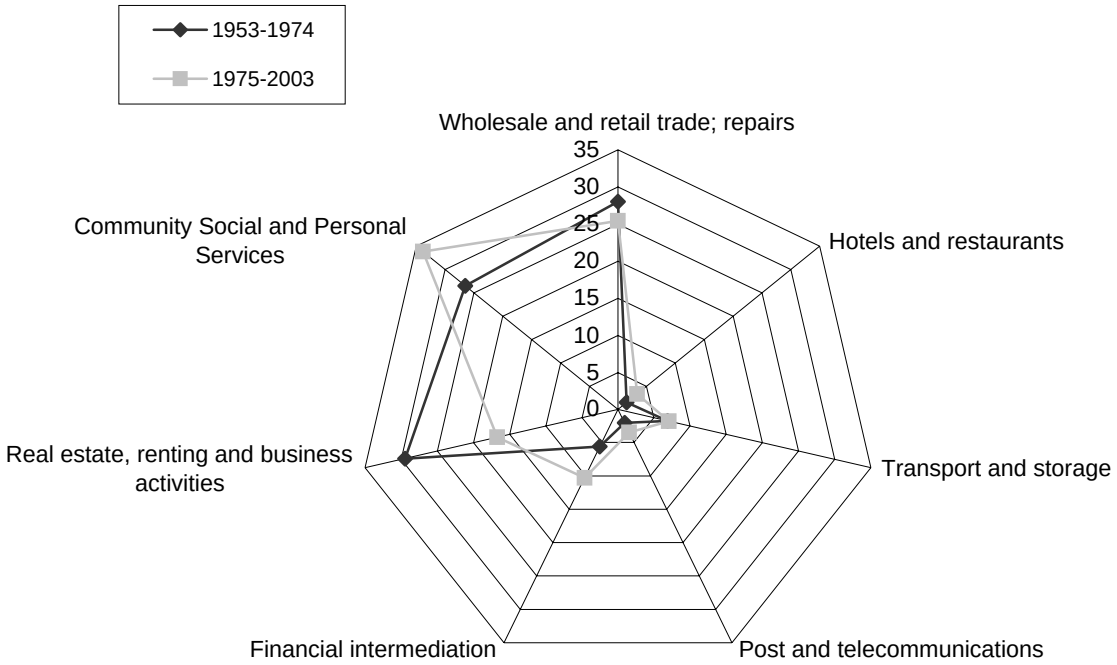


Figure 4
Share in total services (in percentage)
Employment

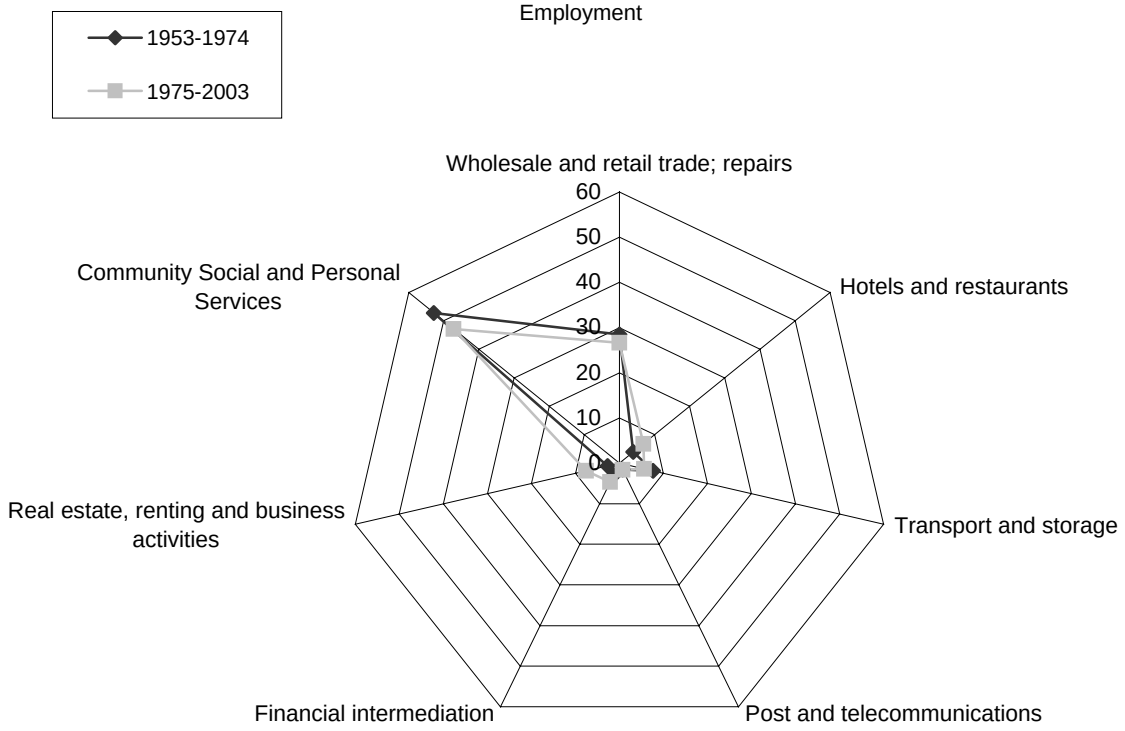


Figure 5
Gross Value Added vs. Employment
Business Cycle

Figure 6
Employment
Contemporaneous Correlation
1953-2003

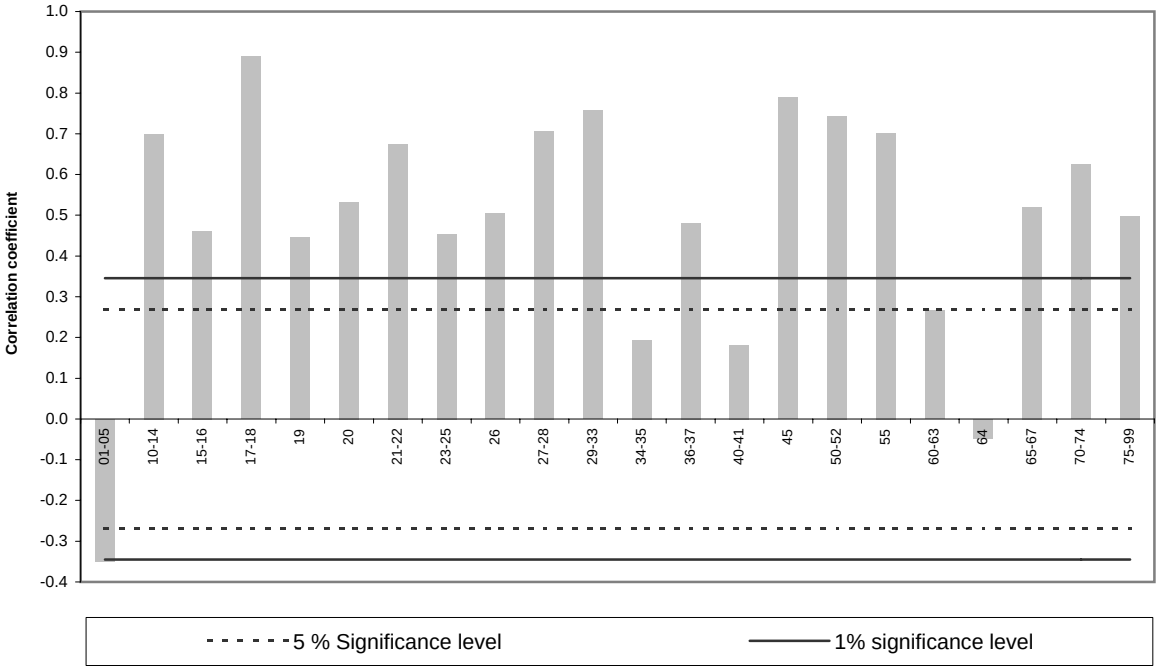


Figure 7
Employment
Contemporaneous Correlation

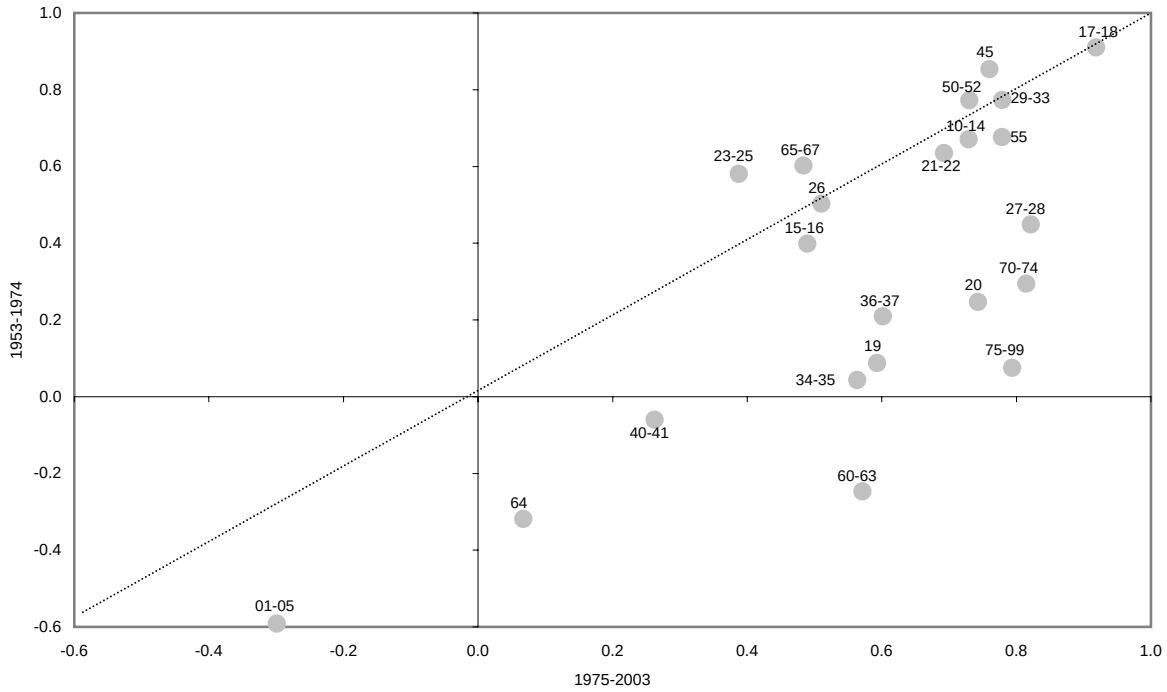


Figure 8
Gross Value Added
Contemporaneous Correlation
1953-2003

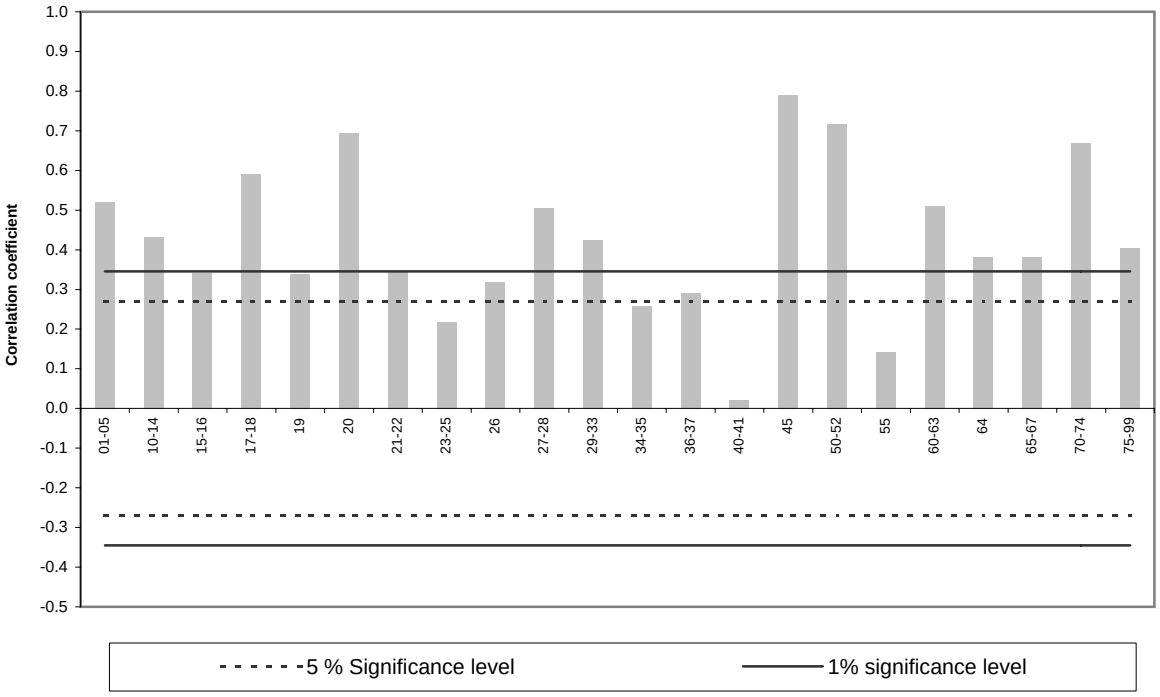


Figure 9
Gross Value Added
Contemporaneous Correlation

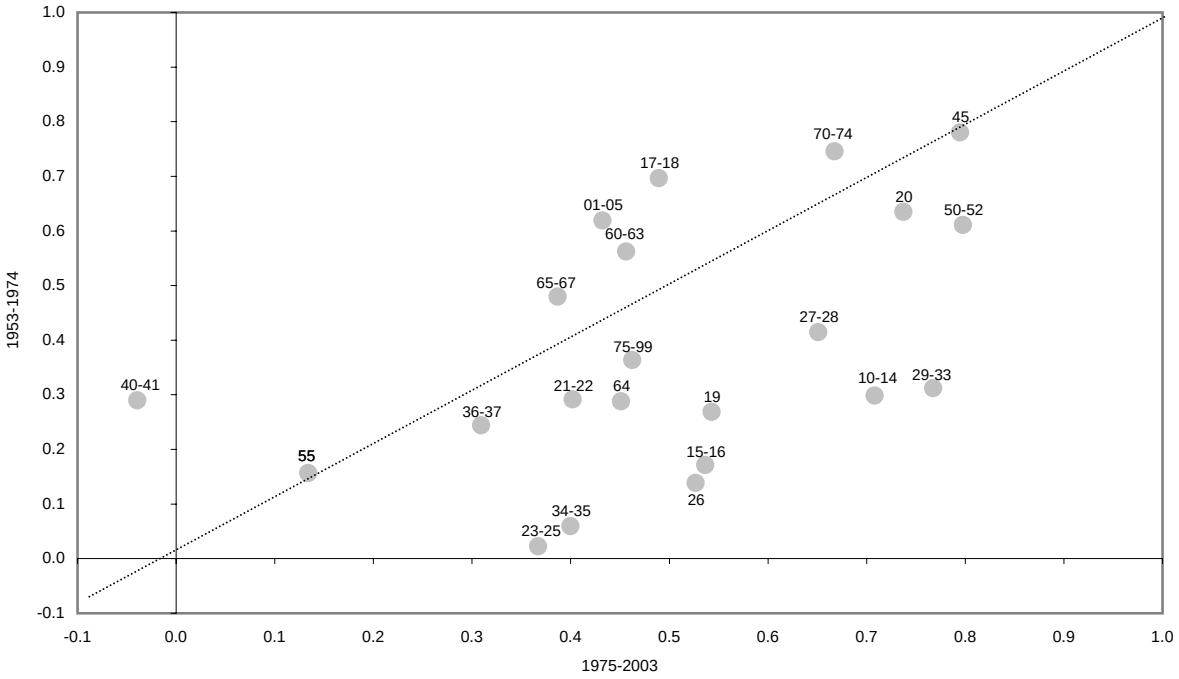


Figure 10
Frequency Distribution of Cross-Sectoral Correlations
Employment - Total economy
1953-2003

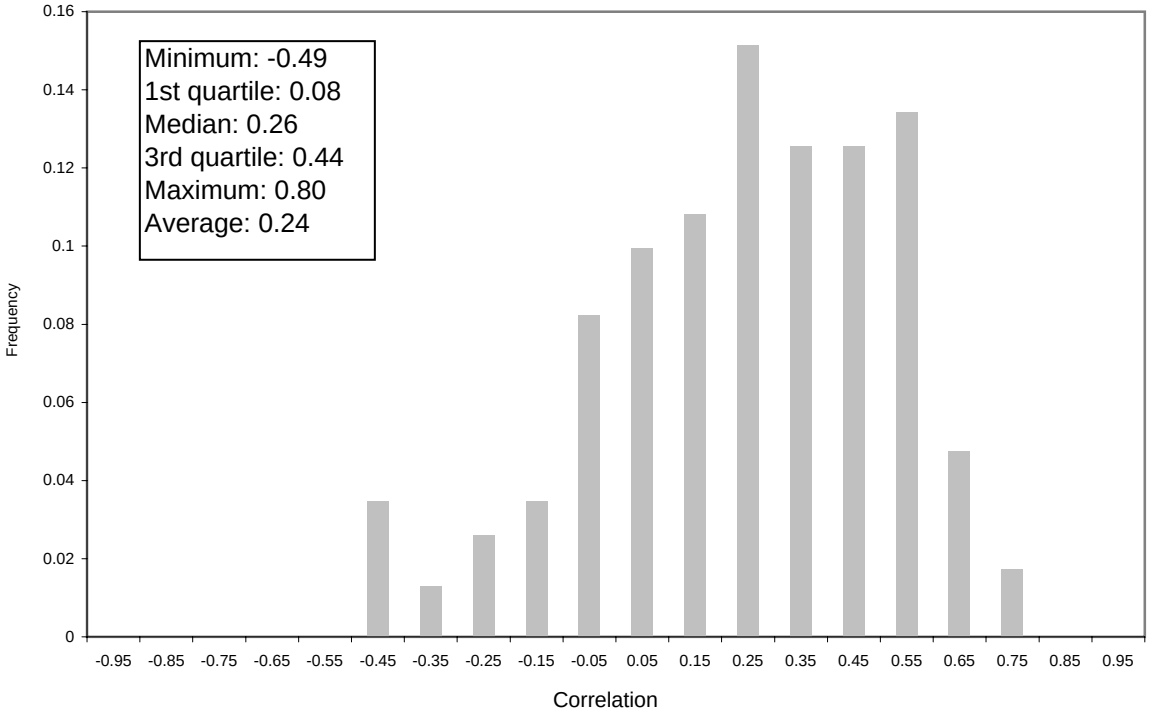


Figure 11
Frequency Distribution of Cross-Sectoral Correlations
Employment - Total economy

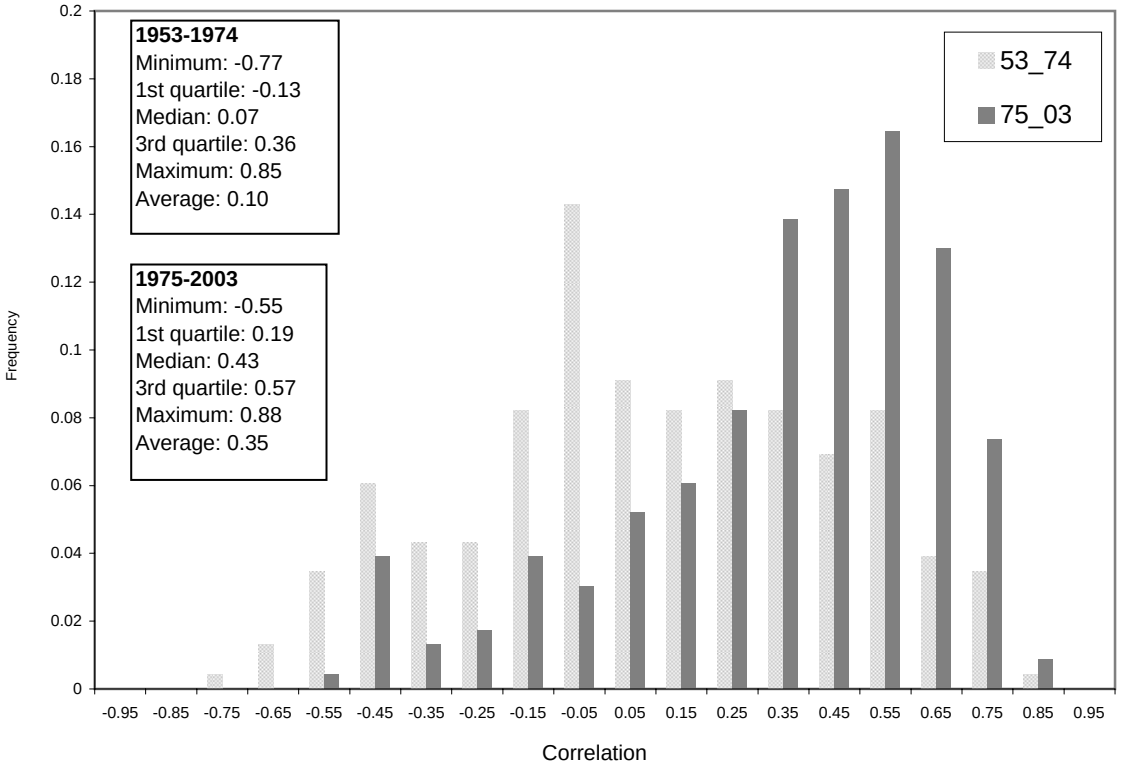


Figure 12
Frequency Distribution of Cross-Sectoral Correlations
Gross Value Added - Total economy
1953-2003

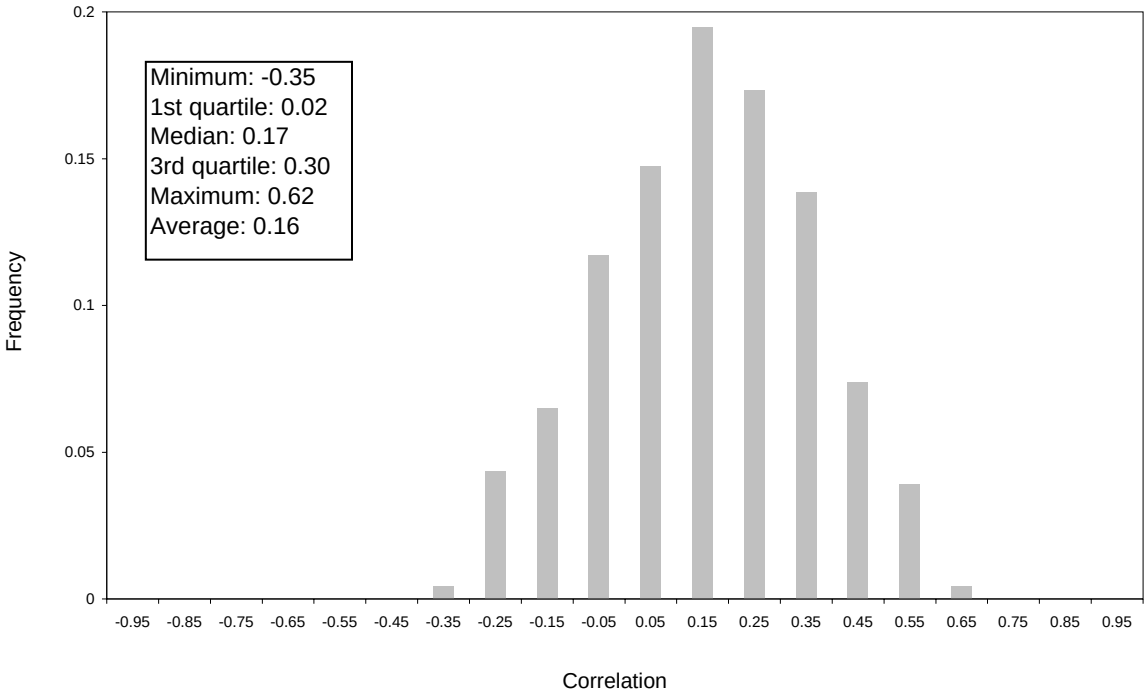
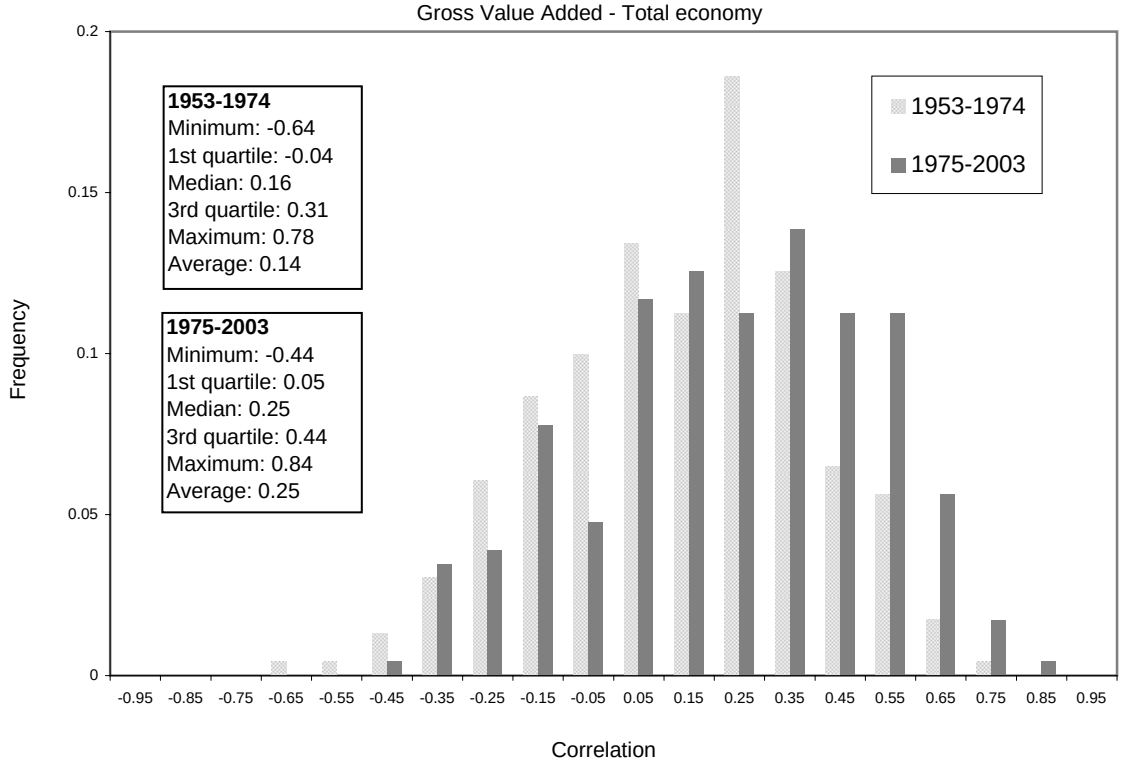


Figure 13
Frequency Distribution of Cross-Sectoral Correlations
Gross Value Added - Total economy



Appendix A - Sectoral Classification

6 Sectors	22 Sectors	*56 Sectors*
Agriculture, Forestry and Fishing	Agriculture, Forestry and Fishing	*01 - Agriculture, hunting and related service activities* *02 - Forestry, logging and related service activities* *05 - Fishing, aquaculture and service activities incidental to fishing*
Mining and Quarrying	Mining and Quarrying	*12 - Mining of uranium and thorium ores* *13 - Mining of metal ores* *14 - Other mining and quarrying*
Manufacturing	Food products, beverages and Tobacco	*15 - Manufacture of food products and beverages* *16 - Manufacture of tobacco products*
	Textiles and textile products	*17 - Manufacture of textiles* *18 - Manufacture of wearing apparel; dressing and dyeing of fur*
	Leather, leather products and footwear	*19 - Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear*
	Wood and products of wood and cork	*20 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials*
	Pulp, paper, paper products, printing and publishing	*21 - Manufacture of paper and paper products* *22 - Publishing, printing and reproduction of recorded media*
	Chemical, rubber, plastics and fuel products	*23 - Manufacture of coke, refined petroleum products and nuclear fuel* *24 - Manufacture of chemicals and chemical products* *25 - Manufacture of rubber and plastics products*
	Other non-metallic mineral products	*26 - Manufacture of other non-metallic mineral products*
	Basic Metals and fabricated metal products	*27 - Manufacture of basic metals* *28 - Manufacture of fabricated metal products, except machinery and equipment*
	Machinery and equipment	*29 - Manufacture of machinery and equipment n.e.c.* *30 - Manufacture of office, accounting and computing machinery* *31 - Manufacture of electrical machinery and apparatus n.e.c.* *32 - Manufacture of radio, television and communication equipment and apparatus* *33 - Manufacture of medical, precision and optical instruments, watches and clocks*
	Transport equipment	*34 - Manufacture of motor vehicles, trailers and semi-trailers* *35 - Manufacture of other transport equipment*
	Manufacturing, nec	*36 - Manufacture of furniture; manufacturing n.e.c.* *37 - Recycling*
Electricity, gas and water	Electricity, gas and water	*40 - Electricity, gas, steam and hot water supply* *41 - Collection, purification and distribution of water*
Construction	Construction	*45 - Construction*

6 Sectors	22 Sectors	*56 Sectors*
Services	Wholesale and retail trade and repairs	
		50 - Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
		51 - Wholesale trade and commission trade, except of motor vehicles and motorcycles
		52 - Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
	Hotels and restaurants	
		55 - Hotels and restaurants
	Transport and storage	
		60 - Land transport; transport via pipelines
		61 - Water transport
		62 - Air transport
		63 - Supporting and auxiliary transport activities; activities of travel agencies
	Post and telecommunications	
		64 - Post and telecommunications
	Financial Intermediation	
		65 - Financial intermediation, except insurance and pension funding
		66 - Insurance and pension funding, except compulsory social security
		67 - Activities auxiliary to financial intermediation
	Real estate, renting and business activities	
		70 - Real estate activities
		71 - Renting of machinery and equipment without operator and of personal and household goods
		72 - Computer and related activities
		73 - Research and development
		74 - Other business activities
	Community social and personal services	
		75 - Public administration and defence; compulsory social security
		80 - Education
		85 - Health and social work
		90 - Sewage and refuse disposal, sanitation and similar activities
		91 - Activities of membership organizations n.e.c.
		92 - Recreational, cultural and sporting activities
		93 - Other service activities