OmniaScience

Journal of Industrial Engineering and Management
JIEM, 2014 – 7(4): 961-994 – Online ISSN: 2014-0953 – Print ISSN: 2014-8423
http://dx.doi.org/10.3926/jiem.1092

Characterization of cyclical phases in the manufacturing industry in Spain

Mercè Sala, Teresa Torres, Mariona Farré

Lleida University (Spain)

mercesa@econap.udl.cat, *torres@econap.udl.cat*, *mariona.farre@econap.udl.cat*

Received: January 2014
Accepted: July 2014

Abstract:

Purpose: The purpose of this paper is to characterize the cyclical phases of the manufacturing industry in Spain and detect which industries have more influence on the Spanish business cycle. We assume that economic growth is a priority; we are going to determine which industries have a more/less appropriate cyclical behavior according this priority. We analyze if the industries with better cyclical behavior are the ones that achieve greater co-movement with the business cycle of the Spanish economy, as this means they have a positive influence on economic activity.

Design/methodology: We examine the disaggregated quarterly IPI data of 16 manufacturing industries. Our methodology follows three steps. Firstly, we define cycle turning points; we follow the Harding and Pagan (2002) methodology. Secondly, we characterize the cyclical phases of the manufacturing industries in terms of duration, amplitude, deepness and steepness. We also determine the degree of inter-industrial cyclical synchronization and between industries in the cycle of the Spanish economy. This analysis is performed in two ways. On the one hand, we use the concordance index and the correlation coefficient. On the other hand, we work with indicators based on a consistency table. In the third step, we apply a multi-objective methodology, specifically the compromise programming, to determine which industries have a more/less appropriate cyclical behavior according to the growth priority.

Findings: The business cycle of the Spanish economy is positively influenced by high- and medium-tech industries, which have demonstrated their competitive capacity in international markets, and by medium- low-tech industries, with major strengths in R&D, and in survival and consolidation strategies. These results enable manufacturing industries to exert a positive effect on the business cycle that is weakened because many of them show a high correlation between employment and cyclical fluctuations.

Originality/value: The study is original and useful on various levels. Firstly, the study of sectoral cycles makes it possible to identify common trends in the growth of business activities and to see the interdependence of fluctuations. Secondly, it will be easy to deduce which sectoral disruptions generate the greatest impact on economic activity. Finally, because the analysis of the manufacturing industry cycle has not yet carried out.

Keywords: Business cycle, Manufacturing industry, Expansion, Contraction, Synchronisation

1. Introduction

Business cycles are one of the features that are most closely linked to economic activity. Cyclical fluctuations in economic variables have considerable effects on prospects, forecasts and decision-making. One of the most widely recognized works in this field is by Burns and Mitchell (1946, pp. 3) who stated that "A cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own".

The interest that business cycles have generated has given rise to a great deal of literature. Many of the works discuss whether co-movements influence the degree of integration or whether integration generates a higher degree of synchronization. This is not a closed debate and, indeed, has intensified since late 2007. This is particularly true in the Economic and Monetary Union (EMU). The process of monetary integration increased development of empirical studies on European business cycle synchronization. The results show a remarkable lack of consensus. Crespo-Cuaresma and Fernández-Amador (2013) and Jiménez-Rodríguez, Morales-Zumaquero and Égert (2013) summarize the most important findings. Whereas some authors emphasize that there is evidence of a European business cycle, others don't support such existence. There are researchers that point out that the synchronization seems to coincide with the beginning of the Exchange Rate Mechanism, while we can find papers that find that the correlation increased more in the previous period (1971-1979). Also, other researches conclude that the convergence period started in the nineties and the desynchronisation increased at the end of the decade. Even in recent papers, it is said that a global cycle is diluting the European cycle. As Aguiar-Conraria, Martins and Soares (2013) point out, the heterogeneity in the results may be related to use different concepts of the business cycle or/and different econometric models or/and different data. Instead, we found greater consensus in the analysis of the effects of the 2007 financial crisis. In this case the studies tend to conclude that in the actual crisis context, member countries show high asymmetries.

In this sense, Gächter, Rield and Ritzberger-Grünwald (2012) find an important degree of asymmetries in the Euro Area business cycle since the outbreak of the financial crisis in 2008. In the same way, Enders, Jung and Müller (2013) develop a cycle model which shows a heterogeneous adjustment in the EMU since the crisis of 2007. Furthermore, Michaelides, Papageorgiou and Vouldis (2013) note that the economic fragility of Portugal, Italy, Ireland, Greece or Spain, poses questions about the nature of the crisis and its transmission mechanisms. Caporale, De Santis and Girardi (2014) conclude that the recent crisis and the increasing divergence between the core and the periphery raise questions about the future stability of EMU. In their opinion some convergence in the area must be achieved with a higher degree of policy coordination. It is evident that an analysis of the characteristics of the business cycle in each country helps understand the reasons for the asymmetric shocks in the EMU and their consequences. This analysis is the field in which our work is framed.

We deal with the business cycles of manufacturing industries in the Spanish economy in the 1980–2011 period. The main goal is to characterize the cyclical phases of the manufacturing industry in Spain and detect which industries have the most influence on the Spanish business cycle. Our analysis follows three steps. Firstly, we characterize the cyclical phases of the sixteen manufacturing industries in terms of duration, amplitude, deepness and steepness. We also determine the degree of inter-industrial cyclical synchronization and between industries in the cycle of the Spanish economy.

Secondly, we assume that economic growth is a priority. Thus, from the point of view of the economy as a whole, the cyclical characteristics of the manufacturing industries we obtained in the first step of our analysis are used to define an appropriate cyclical behavior on the basis of the following premises:

- Industry reaches higher/lower duration and amplitude
- Industry does not present significant asymmetries in deepness and steepness
- Industry reaches significant levels of inter-industrial synchronization.

We apply a multi-objective methodology that allows us to consider the cyclical characteristics of manufacturing industries and to determine which industries have a more/less appropriate cyclical behavior according to the above premises.

Thirdly, we take the information about synchronization and study its relationship with the behavior of cyclical phases in industry. A significant synchronization of a particular industry with the business cycle implies that its cyclical evolution transcends and influences the cyclical evolution of the Spanish economy. Therefore, it is desirable that the industries whose behavior in their cyclical phases is more closely in line with the above premises should be the ones that achieve greater co-movement with the business cycle of the Spanish economy, as this means they have a positive influence on economic activity.

The importance of cyclical synchronization between the manufacturing industry and the business cycle goes beyond what has been discussed. It should be highlighted that depending on the specific characteristics that define industries with a major/lesser influence on the cyclical fluctuation of the Spanish economy, the final outcome will be different. We therefore classify the manufacturing industries based on key variables such as their impact on economic activity, their technological level, the intensity of labor, productivity and the degree of competitiveness in foreign markets. This allows us to extend the analysis of the effects that may result from the fact that the cycle of the Spanish economy is more or less correlated with one industry or another.

The study is useful on various levels. Firstly, because everybody is aware of the importance of the manufacturing industry in the production structure of a country. Despite the fact that quantitative weight has been lost over the past few years, its influence over the rest of business activities cannot be questioned thanks to the linkages that it creates in its role as a demander/supplier of products or service requester. As highlighted by Cartaya, Sáez and Zavarce (2010), the study of sectoral cycles makes it possible to identify common trends in the growth of business activities and to see the interdependence of fluctuations.

Secondly, because we characterize the cyclical phases of the Spanish manufacturing industry by providing information about turning points, the duration and amplitude of recessions and expansions, as well as about the degree of synchronization. Furthermore, as it is known which industries have a greater correlation with the cycle of the Spanish economy, it will be easy to deduce which sectoral disruptions generate the greatest impact on economic activity. All this information is useful for the policy makers in order to adopt economic policy measures.

Finally, because the analysis of the manufacturing industry cycle has not yet been done. In Spain and in the field as a whole, we highlight works such as that by Bergé and Jordà (2013), Dolado, Sebastián and Vallés (1993), Belaire-Franch and Contreras (2002), Doménech and Gómez (2005) or Doménech, Estrada and Gozález-Calbet (2007). In a study on the variations observed in Spanish business cycles after integration, we find Pérez, Escriche and García

(2007) or Gardeazábal and Iglesias (2000). Business cycle synchronization between Spain and EMU is studied in Borondo, González and Rodríguez (1999) or Aguiar-Conraria et al. (2013). Barrios and De Lucio (2003) evaluate evidence synchronization with Portugal and Konstantakopoulou and Tsionas (2014) with OECD countries. In disaggregated terms, the literature is less extensive. On a regional level, for example, the studies by Cuadrado, Mancha and Garrido (1998), De la Fuente (2002), Gadea, Gómez-Loscos and Montañés (2006), Gadea, Gómez-Loscos and Montañés (2012) and Bandrés and Gadea (2013) can be cited. The cyclical fluctuations in Spain's industrial sectors are discussed in García-Carro, Cruz, López and Ameneiro (2007). Whilst Jimeno and Campillo (1993) and Goerlich-Gisbert (1999) examine the effects of aggregate and specific shocks in sectors for different periods. Berman and Pfleeger (1997) look at which industries employment and demand show the greatest sensitivity to cyclical fluctuations. The service sector is dealt with in an analysis conducted by Cuadrado and Ortiz (2001). However, a disaggregated analysis of manufacturing industry remains to be conducted, which is one of the contributions of this paper.

The paper is organized as follows. In the second section, the data and statistical sources are described. In the third, the methodology is presented. In the fourth, we report the results and finally, in the fifth discuss the conclusions.

2. Data and statistical sources

To analyze the cycle, the quarterly seasonally adjusted Industrial Production Index (IPI) provided by EUROSTAT –Industry, trade and services/Short-term business statistics/Industry production index/ quarterly data/ (2005=100) (NACE Rev.2)– was used for the 1980:1–2011:2 period. The decision to use the IPI was due to the fact that disaggregated quarterly GDP series on a sector-by-sector basis are not available. As Gadea et al. (2012) point out, although the IPI only covers a part of economic activity, its performance follows postulates very similar to those of the GDP, which makes it a good indicator of the business cycle.

To corroborate this statement, the series S_{IPI}, S_{PIB} were devised, where S is a binary variable that takes the value of 1 in expansion and zero in recession, based on which we proceeded to calculate the correlation coefficient between the two series with a result of 0.88 (t=4.13, P=0.00). Additionally, following the methodology described in section 3.1, the turning points for the IPI and the GDP were calculated. The turning points of the IPI detect the main cyclical phases of the Spanish economy, namely, the crisis of the early 1990s, the recovery that began in the mid-1990s, the long period of expansion, with high points of growth between 1998 and 2000, and the recession that began in mid-2008. If GDP is taken as a reference series, the IPI does not show any additional cycles, and the average lags of the peaks and troughs are not significant (-0.6 and -0.7, respectively). The results show that the IPI is a good indicator of the business cycle in the Spanish economy.

In the study, 16 manufacturing industries and the IPI (Spanish business cycle indicator) for the whole of the Spanish economy were considered (Table 1).

	Nomenclature
Manufacture of food products	FOOD
Manufacture of beverages	BEV
Manufacture of tobacco products	TOB
Manufacture of textiles and wearing apparel	TEXT
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	WOOD
Manufacture of paper and paper products; printing and reproduction of recorded media	PAP
Manufacture of chemicals and chemical products; basic pharmaceutical products and pharmaceutical preparations	CHEMIC
Manufacture of rubber and plastic products	PLAS
Manufacture of other non-metallic mineral products	NMET
Manufacture of basic metals and fabricated metal products, except machinery and equipment	METAL
Manufacture of fabricated metal products, except machinery and equipment	METALPRO
Manufacture of computer, electronic and optical products; manufacture of electrical equipment	COMP
Manufacture of electrical equipment	ELECTR
Manufacture of machinery and equipment n.e.c.	MACHIN
Manufacture of motor vehicles, trailers, semi-trailers and of other transport equipment	VEHIC
Manufacture of furniture; other manufacturing	OTHER
Total Spanish IPI	BC

Table 1. Manufacturing industries

3. Methodology

3.1. Determination of turning points

In this section, we present the methodology used to characterize the cyclical phases in growth cycles of the Spanish manufacturing industry. The first step in our analysis was to define turning points, peaks (P) and troughs (T). The fluctuations in the cycle cover periods of growth and periods of decline. The growth of the cycle is the time that passes between the initial trough (T_i) and the peak (P), and is called expansion. The decline of the cycle is the time that passes between the peak (P) and the last trough (V_f), and is called contraction.

Based on the work by Burns and Mitchell (1946), extensive literature can be found that focuses on the study of the specific characteristics of business cycles, which fall back on at least two different methodologies. The first, of a non-parametric nature, uses algorithms for defining turning points; the most traditional one is that developed by Bry and Boschan (1971), which Harding and Pagan (2002) adapted for quarterly data. The second, based on the regime switching model proposed by Hamilton (1989), has been developed using econometric techniques.

As quarterly data were used, we followed the Harding and Pagan (2002) methodology for obtaining the peaks and troughs. Firstly, a local maximum/minimum was defined as the highest/lowest point between the two preceding and following quarters to its position. That is, y_t is a peak in time t if y_t is the max (y_{t-2}….y_{t+2}) and it is a trough if y_t is the min (y_{t-2}….y_{t+2}). Secondly, only completed cycles may be used, as a result of which a peak must be followed by a trough and vice versa. Contraction is the time that passes from the end of one peak to the next trough, whilst expansion is the period of time from the end of a trough and the following peak. A complete cycle is the time that passes from the first peak to the last trough and lasts for at least five quarters. As Harding and Pagan (2002) stated, the minimum duration of 15 months established by Bry and Boschan (1971) is on a par with 4 or 5 quarters, depending on the month in which a turning point occurs and the relative figures of the months in a quarter. This is why the turning points have been calculated using 4 or 5 quarters without this being at odds with the turning points and, therefore, the results are presented based on 5-quarterly intervals.

This methodology is appropriate because it satisfies the three minimum requirements to be met by an algorithm that detects cyclical phase.

- Determine a potential set of turning points,
- ensure that peaks and troughs alternate,
- establish a set of rules that re-combine the turning points defined after steps one and two in order to satisfy pre-determined criteria concerning the duration and amplitudes of phases and complete cycles (Harding and Pagan, 2002).

3.2. Measuring business cycle features

We will go on to characterize the cycle in terms of duration, amplitude, deepness and steepness. To do so, the analytical indicators defined below are required. Their choice was based on two main criteria. Firstly, they are easy to calculate and interpret, and, secondly, they are the most commonly used in this field.

The duration of a contraction (expansion) will be the number of quarters that elapse between the peak of a cycle to its last trough (trough of a cycle and its last peak). The amplitude of a contraction (expansion) is calculated as the percentage change, in absolute value, between the value in the trough (peak) and the previous peak (trough). The amplitude estimates gains in terms of production in expansion phases and the losses in the contraction phases. The average duration (D) and amplitude (A) of each phase can thus be obtained.

Deepness and steepness of phases are two components that can make cycles asymmetrical. Deepness occurs when troughs are deeper than the height of the peaks, or vice versa, which denotes asymmetry in the distribution of a series (without trends) and is associated with the amplitude of contractions in relation to expansions. Steepness means that recession phases have steeper slopes than growth phases, and vice versa, and denotes asymmetry in the distribution of the first differences. Sichel (1993) proposes contrasts for evaluating the presence of the two types of asymmetry. In the case of deepness, contrast uses the estimation of the asymmetry coefficient (Dc), which is calculated as:

$$D(c) = \left[T^{-1} \left(\sum_t (c_t - \bar{c} \right)^3 \right] \Big/ \sigma(c)^3 \tag{1}$$

Where c_t is the cyclical component, $\sigma(c)$ is standard deviation and T is the size of the sample.

If the contractions are deeper than the expansions, the average value of the deviations below the average will be above the average value of the deviations above it. The series will have a negative value in this asymmetry.

In steepness asymmetry contrast uses the estimation of the asymmetry coefficient ST(Δ c), which is calculated as:

$$ST(\Delta c) = \left[T^{-1} \left(\sum_t (\Delta c_t - \Delta \bar{c} \right)^3 \right] \Big/ \sigma(\Delta c)^3 \tag{2}$$

$\Delta\bar{c}$ and $\sigma(\Delta c)$ are the simple average and the standard deviation of Δc_t. If contractions show a greater steepness than expansions, the first difference of the series will have a negative value in the steepness asymmetry (see Appendix A.1 for further details about contrast for evaluating the presence of the two types of asymmetry).

3.3. Cycle synchronization

The presence or absence of asymmetries in the features of the phases affects the synchronization of cycles over time, understood as the amount of time two industries (*i,j*) are in the same phase. The analysis of cycle synchronization will be performed in two ways. Firstly, as expounded by Harding and Pagan (2002) we will use the concordance index (I), which for two industries (i,j) is defined as:

$$I_{ijt} = T^{-1} \left[\sum_{t=1}^{T} (S_{it}\ S_{jt}) + \sum_{t=1}^{T} (1 - S_{it})(1 - S_{jt}) \right] \tag{3}$$

Where S_{it}/S_{it} is a binary variable that takes the value of 1 when the industry i/j is in expansion and zero when it is in recession, and T is the number of observations. The index varies between one and zero. One denotes perfect concordance and zero the perfect absence of concordance.

The index is appropriate for several reasons. It is easy to interpret. Mathematically, it reflects the period of time in which both series are simultaneously in the same phase of expansion or contraction, which is what we wish to measure. It is able to determine whether industry cycles are pro- or counter-cyclical. However, it does not give any indication of whether the co-movements are statistically significant. Therefore, to overcome this difficulty the correlation coefficient (ρ) between S_{it} and S_{jt} is estimated and the statistical significance is analyzed according to Harding and Pagan (2006), (see Appendix A.2):

$$\frac{1}{T}\sum_{t=1}^{T}\left[\hat{\sigma}s_i^{-1}\left(S_{it}-\hat{\mu}s_{si}\right)\hat{\sigma}s_j^{-1}\left(S_{jt}-\hat{\mu}s_j\right)-\hat{\rho}s\right]=0 \quad (4)$$

The second analytical method from which we will calculate Q_{ij} statistics is based on a consistency table, which is distributed as $\chi 2$ with (s-1)x(s-1) degrees of freedom, and Pearson's contingency coefficient (CP_{ij}).

$$Q_{ij}=\sum_{r=1}^{s}\sum_{p=1}^{s}\left(\frac{n_{rp}-\hat{m}_{rp}}{\hat{m}_{rp}}\right)^2 \quad (5) \qquad CP_{ij}=\sqrt{\frac{s}{s-1}}\sqrt{\frac{Q_{ij}^2}{N+Q_{ij}^2}} \quad (6)$$

Where S is the number of states, n the frequencies observed and $\hat{m}$ the estimated marginal frequencies. If Q_{ij} is significant, this implies synchronization between industries i/j. Pearson's contingency coefficient ranges from zero, absent synchronization, and 1 which is the maximum level of synchronization.

3.4. Multi-criteria analysis

In this second step of the study, we analyze which manufacturing industries have the most appropriate behavior in their cyclical phases. Appropriate behavior means that economic growth is promoted. In each industry, this behavior is associated with the following factors:

- The industry achieves greater/lesser duration and amplitude—understood as gains/losses in terms of production—in the expansion/contraction phase.
- The industry has no significant asymmetries in deepness and steepness.
- The industry reaches significant levels of cyclical synchronization with other industries, a sign that industry-specific shocks do not alter inter-industrial cycles asymmetrically.

All this factors are goals we want to optimize. Given that it is not possible to optimize all of the objectives at the same time and reach the optimum solution, we work with a methodology that considers all of the objectives and obtains efficient solutions. We propose using a multi-criteria approach that is suitable in a context defined by the various objectives to be optimized and gives a set of efficient solutions.

Within the multi-criteria analysis, the technique that best suits our goals is compromise programming. It was initially developed by Yu (1973) and Zeleny (1973, 1974). It formulation consists in reducing the distance between the ideal point and the chosen solution to a minimum. The linear programming model to be resolved is as follows:

$$Min \ L1 = \sum_{g=1}^{n} W_g \frac{\left(f_g^{id} - f_g(x)\right)}{\left(f_g^{id} - f_g^{ai}\right)} \quad X \in F \qquad (7)$$

Where W_g = weight or weighting assigned to objective g; f_g^{id} = the ideal solution of the objective g; f_g^{ai}= the anti-ideal solution of the objective g; $f_g(x)$= the mathematical expression of the attribute *g-th*; X = the vector of decision variables; and F = the set of restrictions that define the set of possible solutions.

The indicators that are modeled in (7) are:

- Average duration in expansions (contractions): D_{ex} and D_{con}.
- Average amplitude in expansions (contractions): A_{ex} and A_{con}.
- Deepness and steepness asymmetries, which are estimated using the absolute value of the t-ratio: $|t_{Dc}|$ y $|t_{ST\,\Delta c}|$.
- Average of the concordance index (I).
- Average of the contingency coefficient (CP).

In the appendix A.3 we develop the explanation and specify the model expressed in (7). The followed methodology (see the appendix) will enable us to obtain one ranking for manufacturing industries. The industries are ranked from those that obtain the best results in the indicators described to those that obtain the worst results.

4. Results

4.1. Turning points and measuring business cycle features

Figure B.1 in the appendix B, shows the graphs with the turning points identified using the Bry and Boschan method, adapted by Harding and Pagan to quarterly series. In most of the industries, the downturn at the beginning of the 1980s, the crisis in the 1990s and the current one are recognized. An average of eight complete trough to trough cycles is detected. The data suggest that the current crisis is affecting the FOOD, BEV, PAP and CHEMIC industries to a lesser extent than others.

As noted in section 3.2, we will begin to measure the characteristics of the business cycle. First, Table 2 shows the average duration (D) and amplitude (A) of the phases of expansion and contraction. The average duration is 7.21 quarters for expansion and 6.06 for contraction, similar to that of the BC, which are 7.5 and 6.44, respectively. These results are in line with the empirical regularity in this field, which indicates that expansion periods are longer than contraction periods. Gadea et al. (2012) found the same evidence for the cyclical phases in Spanish regions. They show that whilst the most recent recessions have lasted almost as long as those in Europe, the most recent expansions have lasted longer in Spain, which could be interpreted as a symptom of the convergence experienced in the period of the study.

	Duration (D) expansion	Duration (D) contraction	Amplitude (A) expansion (%)	Amplitude (A) contraction (%) (in absolute values)
FOOD	8.71	7.00	6.81	1.57
BEV	7.22	5.80	6.48	2.34
TOB	6.44	6.00	14.94	12.23
TEXT	6.33	6.10	4.42	21.02
WOOD	7.33	5.20	5.52	8.99
PAP	6.89	5.60	7.52	3.05
CHEMIC	6.11	6.20	5.72	1.20
PLAS	7.00	5.40	6.59	3.49
NMET	6.78	5.70	6.49	6.81
METAL	7.75	6.22	9.04	7.40
METALPRO	7.88	6.11	10.30	8.44
COMP	8.13	6.00	11.30	12.27
ELECTR	7.00	7.00	10.84	5.46
MACHIN	8.38	6.63	10.91	9.54
VEHIC	6.78	5.60	11.53	7.90
OTHER	7.13	6.78	8.26	11.86
Average	7.21	6.06	8.39	7.50
BC	7.50	6.44	5.81	3.34

Table 2. Duration and amplitude of cycles phases (average) (Eurostat)

FOOD, COMP and MACHIN spend longer in expansion, and FOOD and ELECTR in contraction. The figures for these industries are higher than average and than the overall BC. TEXT and CHEMIC have the lowest average values in duration for expansion, and WOOD, PLAS and PAP for contraction. The values are lower than those for BC.

The average amplitude is 8.39% for expansion and 7.50% for contraction. As is the case of duration, amplitude is greater in expansion phases than in contraction phases. This means that manufacturing industries have a greater capacity to achieve gains in output in times of expansion than losses in contraction phases. It can also be observed that amplitude in the different phases has tended to decrease since the 1980s. This phenomenon has come to light in a number of studies and is known as “great moderation” (Summers, 2005).

In expansion phases, the TEXT, WOOD and CHEMIC industries show the lowest amplitude. Their values come close to the BC. Of the 16 industries, only the amplitude of the TEXT industry in expansion is lower than the BC, a clear sign of the difficulties that this industry shows in the period under study. Those with greatest amplitude are the TOB, COMP and VEHIC industries. Alongside them, the amplitudes of the METALPRO, ELECTR and MACHIN industries stand out because they are far higher than those of the BC. In general, manufacturing industries show a greater capacity for generating gains in expansion phases than BC, out of which high-tech industries (COMP, ELECTR, MACHIN) stand out.

In contraction phases, the amplitude of the PAP and PLAS industries is in line with the BC. There is a second group of industries that attain remarkable amplitudes, namely, the TOB, TEXT, COMP and OTHER industries. Whilst in the TOB and COMP industries it has been seen that there are gains in output in expansion phases, it has also been established that there are considerable losses in contraction phases. There is a third group of industries with particularly low amplitudes, albeit with great internal diversity, namely, the FOOD, BEV and CHEMIC industries. In general, losses in output associated with contraction phases are more significant in the manufacturing industry than in the BC.

We will now go on to analyze the tests proposed by Sichel (1993) to determine whether amplitude is sufficiently significant to provide deepness and steepness asymmetry to the cycles of the Spanish manufacturing industry. By applying the HP and BK filters, the results obtained are robust to the filter as they do not show significant differences. The null hypothesis of equality trends of BK(12) and HP(1600) is rejected by the t-test (t = 0,423). Given this equality, we just detrend the series using the HP filter. Table 3 shows data for the t-ratio D(c) y ST(Δc).

The sign of the deepness is that expected in view of the data in Table 2. In general, the higher amplitude in expansion phases than in contraction phases translates as a positive sign in the deepness estimation. However, deepness asymmetry is only significant in the TEXT (negative value) and METALPRO industries. Asymmetry in steepness has negative values, (except in the TEXT industry), which indicates that steepness is greater in contraction phases than in expansion phases. This asymmetry is only significant to a level of 10% in the BEV industry. The behavior of the TEXT industry should be highlighted as it is the only industry in which the contraction phases are significantly deeper but less steep, although not to a significant degree, than the expansion phases.

	t-deepness	t-steepness
FOOD	0.128	-1.068
BEV	0.929	-1.291**
TOB	0.676	-0.134
TEXT	-1.821*	0.618
WOOD	-0.940	-0.841
PAP	0.517	-0.889
CHEMIC	0.180	-0.542
PLAS	0.715	-0.813
NMET	-1.006	-0.954
METAL	0.946	-1.109
METALPRO	1.332**	-0.995
COMP	0.878	-0.642
ELECTR	1.085	-1.051
MACHIN	0.867	-0.928
VEHIC	0.580	0.053
OTHER	-0.310	-0.982
BC	-0.923	-0.462

* Significant to 5%
** Significant to 10%

Table 3. t-ratio deepness and steepness asymmetry (Eurostat)

From what has been stated thus far, by way of summary it can be said that Spanish manufacturing industries show differences in the characterization of their cyclical phases, although there is no evidence of significant asymmetries in deepness and steepness. Despite this difference, cyclical synchronization, understood as the proportion of time that the two industries (i,j) are in the same phase, may arise.

4.2. Cyclical synchronization

The various synchronization indicators used are shown in Tables B.1 and B.2 in the appendix B (I, t-ratio, χ^2 and CP). The four indicators fall in the same range and, in general, a significant degree of synchronization is observed in the cyclical phases of the Spanish manufacturing industry. The average t-ratio of the estimation (4) and χ^2 in (5) are significant to 99%. These results are shown in Figure 1, in which the values of the t-ratio are placed on the abscissa axis and those of χ^2 on the ordinate axis, with the origin of coordinates in the value of the ratios to 99% of the evidence of the non-rejection of the null hypothesis. Most of the values can be found in the upper right-hand quadrant.

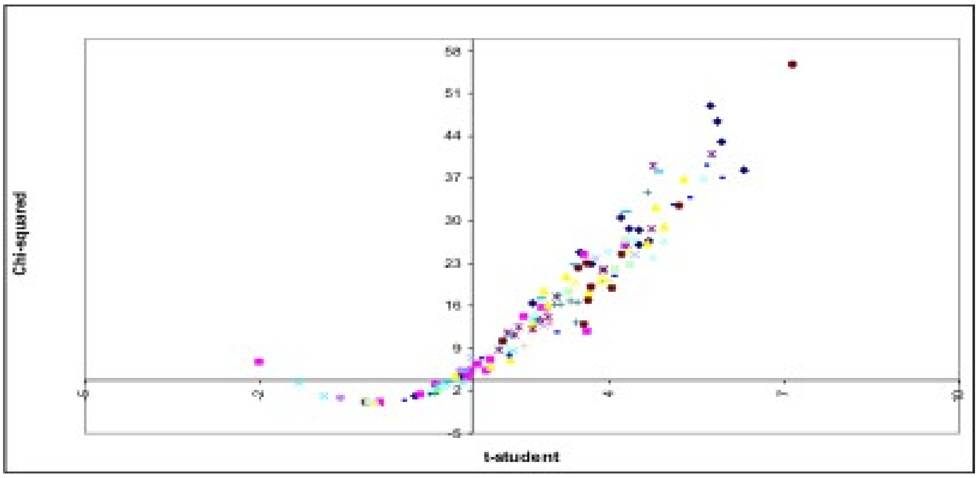


Figure 1. t-ratio and χ^2 (Eurostat)

As the four indicators show the same profile, Figure 2 can be used to determine which industries show the most and least synchronization with the rest and with the BC. The figure shows the average contingency index (CP) for each industry and the index with the BC, ranked according to the average CP value.

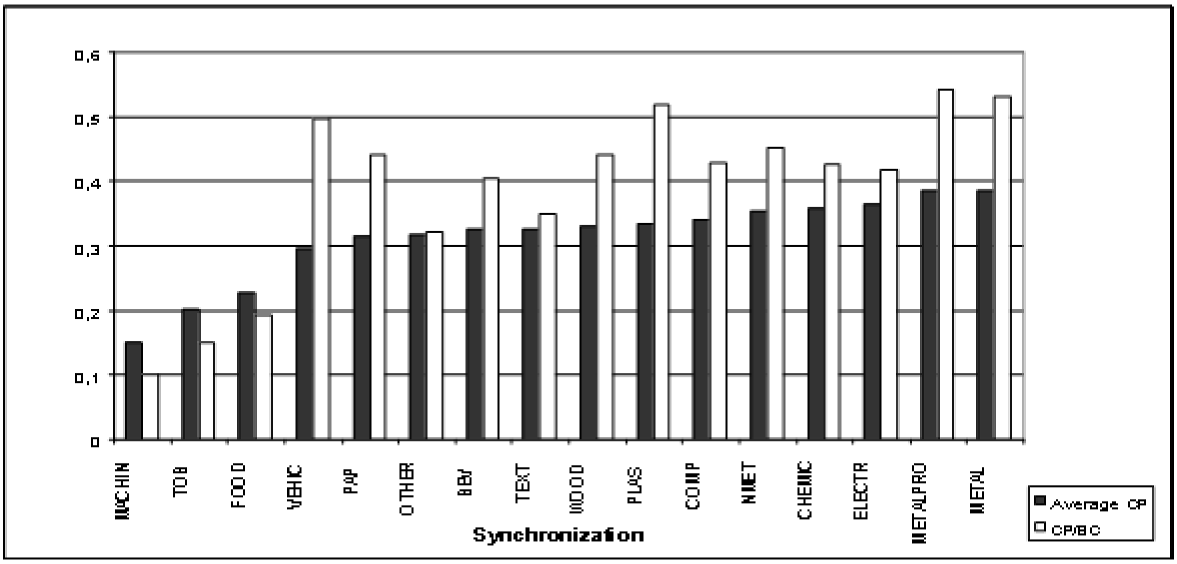


Figure 2. Average CP and CP for each industry with the BC (Eurostat)

According to Figure 2, the industries that show greatest synchronization with the rest of the manufacturing industry are the COMP, NMET, CHEMIC, ELECTR, METALPRO and METAL industries. Except for the NMET and CHEMIC industries, they all have high amplitude in the expansion phase, that is, they have a high capacity for attaining gains in output in times of expansion.

The industries that are most synchronized with the BC are the VEHIC, PLAS, METALPRO, METAL industries, all of which, except for the PLAS industry, have high amplitude in the expansion phase. The industries that are in least synchronization with the rest and the BC are the MACHIN, TOB and FOOD industries. If Tables B.1 and B.2 in the appendix are examined closely, it can be seen that the most outstanding case is the MACHIN industry. The statistics for this industry are not significant and do not enable us to reject the hypothesis of no synchronization in relation to the FOOD, TOB, WOOD, PAP, CHEMIC, NMET, METAL, METALPRO (50% of the total) and to the BC. In Table B.1, the t-ratio between the MACHIN and some of these industries is negative, which means that correlation is countercyclical. According to this, we can say that the MACHIN industry shows significant discrepancies in time in its cyclical phases in comparison with most of the Spanish manufacturing industry.

4.3. Multi-criteria analysis

Based on the cyclical characteristics of the manufacturing industries, we set out to explore which ones had the most appropriate behavior to favor economic growth. In order to rank the industries, a multi-criteria analysis was made (expression (8), appendix A.3). The ranking of industries is shown in Table 4. The industries are ranked from those that obtain the best results to those that obtain the worst.

Inter-industrial ranking
VEHIC
COMP
PLAS
METALPRO
CHEMIC
METAL
PAP
WOOD
NMET
BEV
ELECTR
TOB
FOOD
OTHER
MACHIN
TEXT

Table 4. Ranking according to the multi-criteria model (Eurostat)

This ranking was compared with the data about the synchronization of industries with the BC. A significant synchronization of a particular industry with the business cycle implies that its cyclical evolution transcends and influences the cyclical evolution of the Spanish economy (empirical evidence could be found in García-Carro et al. (2007) or De Miguel (2009)). Therefore, it is desirable that the industries whose behavior in their cyclical phases is more closely in line with the above premises should be the ones that achieve greater co-movement with the business cycle of the Spanish economy, as this means they have a positive influence on economic activity.

In Figure 3, the values of the index of concordance between the BC and industries (Table B.1, appendix B) are placed on the abscissa axis, and the values of the sum of $f_g(x)$ attributes (g=8) of expression (8) in appendix A.3 on the ordinate axis (this sum, $\sum_{g=1}^{n} \frac{f_g(x)}{f_g^{id} - f_g^{ai}}$, determines the results obtained by optimizing expression (8)), with the origin of coordinates in the average values.

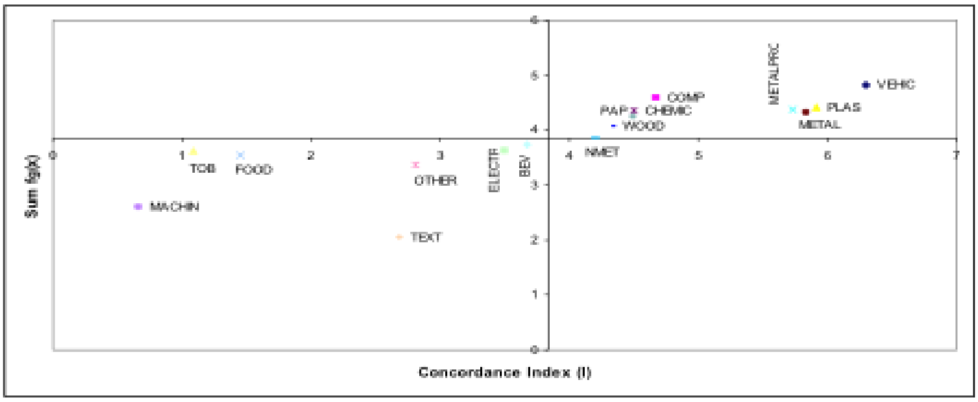


Figure 3. Concordance index BC/industries and the sum of fg(x) attributes (Eurostat)

The industries in the upper right-hand quadrant are those that attain positions above average both in the ranking as in co-movements with the BC. These industries show an appropriate cyclical behavior and thanks to their high degree of synchronization with the BC, their positive influence has an impact on economic activity. VEHIC, PLAS, METAL and METALPRO are at the top of the ranking, followed by COMP, CHEMIC, PAP and WOOD. At the opposite extreme, we find TOB, FOOD, MACHIN and TEXT. The relationship between these industries and the business cycle can be seen in greater detail by adding the specific characteristics of the industries to the analysis (Table B.3, appendix B).

The position of VEHIC shows that it is a strategic activity in the Spanish economy. The significant gains in terms of production during expansion phases (11.53 in amplitude, according to the data in Table 2) and its ability to drive the economy forward make it a decisive foundation of the business cycle. Furthermore, the positive effect on growth in the last expansion phases of the Spanish economy was heightened because it took advantage of its strong points. Amongst these, it is worth highlighting the relatively greater exposure to the foreign sector than the rest of industries (25.4% competitiveness, Table B.3, appendix B), the considerable investments made in R&D (particularly notable in the fields of energy efficiency, sustainability, new materials as carbon fiber and new vehicle features) and the reduction in logistics costs due to the location of suppliers near factories.

However, this is an industry in which it can be seen that contraction phases rapidly impact on employment. According to Berman and Pfleeger (1997), employment and final demand in the VEHIC industry have a close correlation with cyclical fluctuations because they provide articles whose consumption can be relatively easily postponed in time. Indeed, the peaks of the turning points of employment in VEHIC have a minimum lag average with regard to those of its IPI cycle (0.5), with a negative rate of change in employment during contraction phases (amplitude in contraction) of -2.5%. However, this is lower than the average of the manufacturing industry (-3.8%). It should be highlighted that the employment amplitude in contraction in VEHIC, fell to -4% in the contraction phase entered into in the fourth quarter of 2007. It can be observed that in the current crisis, the fall in employment and demand has been particularly significant, and that government anti-cycle programs to provide funding for the purchase of vehicles (Renove, PIVE and similar) have failed to change this trend.

From what has been discussed, it can be seen that we are dealing with an industry with a huge direct impact on changes in the cyclical phase of the Spanish economy, and with important indirect impacts because demand and employment are sensitive to these changes. In advanced countries such as Spain, the future of the sector and the role it will play in the evolution of the business cycle depends on its ability to overcome the overcapacity of the sector, avoid possible relocations and support the segments that will increase the demand for cars in the next few years, as would be the case of hybrid, electric and ecological vehicles.

The influence of PLAS, METALPRO and METAL on the business cycle, as well as their high inter-industrial correlation (Figure 2 and Table B.1/appendix B), is to a large extent due to their ties with the construction and automotive sectors. If it is taken into account that the expansion cycle of the construction sector has come to an end, the leading role played by these industries in the cycle of the Spanish economy will depend on whether they know how to redirect their weaknesses to turn them into opportunities. Three can be highlighted. Firstly, the ties of the automotive and construction sectors discussed above, which have resulted in their cyclical phases being extremely dependent on these activities. However, the trend towards over-recruitment in production activities by the manufacturers of end products has contributed to the survival and consolidation of a high offer of plastic and metal processing subcontractors, most of which are small businesses. This offer could potentially attract investments in the automotive, aeronautics and railway industries. Secondly, they are medium-low tech industries, relatively labor intensive and clearly in need of innovation, and the incorporation of new technologies. This type of specialization limits its capacity to generate added value. However, they have a great deal of potential in the R&D that has not been developed yet, which would enable them to increase inter-industrial linkages. This would be the case, for example, of bioplastics and plastic materials used as heat and sound insulators. The same is true of the move towards precision engineering in the manufacture of metal products. Thirdly, in recession phases the average drop in unemployment is slightly over -3%, with a short delay in respect of the phases of the cycle of their IPI of between a quarter and a quarter and a half. It has been observed that employment in these industries show a high correlation with cyclical fluctuations, with high job losses in contraction phases, although this is offset by the fact that they do not suffer great losses in terms of production in contraction phases (Table 2).

As discussed above, in order to prolong the future of the positive influence of PLAS, METALPRO and METAL on the business cycle, these opportunities must be seized by taking advantage of the potential of innovation and reducing the sensitivity of employment to cyclical phases. It is also important to boost certain strong points specific to each industry. Thus, the figures in Table B.3, appendix B show high productivity in METAL and PLAS, a notable degree of competitiveness and innovation in METAL, and a high turnover in METALPRO.

COMP, CHEMIC, PAP and WOOD make up the other industries that are in the upper right-hand quadrant of Figure 3. Their cyclical behavior has an impact on the business cycle, although to a relatively lesser degree. In this case, we are dealing with two different types of industries insofar as their intrinsic characteristics are concerned. On the one hand, COMP and CHEMIC are high and medium-high-tech industries that are not labor intensive, and with relatively high levels of productivity.

The chemical sector contributes approximately 11% of the manufacturing GVA and over 1% of Spanish GVA, which means that its good behavior in its cyclical phases and its innovative nature have a positive impact on the business cycle. The sensitivity of employment in the sector to the fall in economic activity is lower than average in the manufacturing industry (amplitude in recession phases is -2.4%). The COMP industry has a far lower impact than CHEMIC on manufacturing GVA and Spanish GVA (1.5% and 0.2%, respectively), but it is a strategic sector due to the importance and development of ICTs. Its direct influence on the business cycle is positive in expansion phases because it has higher gains than average in terms of production (11.30 amplitude, Table 2) but it is also very sensitive to contraction phases (12.27). One advantage of COMP is that jobs are not very sensitive to cyclical changes, namely, amplitude in contraction phases is -2.2%, which has a positive effect on the business cycle.

On the other hand, the PAP and WOOD industries do not have a particularly relevant cyclical behavior. They are placed in the middle of the ranking (Table 4) and their correlation with the cyclical phases of economic activity is almost average. These features are not very different in comparison with the COMP and CHEMIC industries. This begs the question of where the difference in fact lies. PAP and WOOD are relatively labor intensive industries and employment is very sensitive to recession phases (amplitude of -3.3% and 4.8%, respectively). They are further characterized by low productivity levels, low technological intensity and the marked lack of large businesses. These characteristics mean that their innovation is limited and that internationalization is difficult, which also explains poor exports. The efforts made to improve their competitiveness have focused on a strategy of low labor costs and prices. For many years, this strategy conferred on them a certain degree of competitiveness but this ended with the appearance on the scene of new international competitors. Their main destination is the domestic Spanish market, which is a limited market. The positive effects on the business cycle are dissipated by these weaknesses, despite the good behavior of their cyclical phases. The possibility of taking advantage of their strengths depends on improving human capital and providing more funding for R&D that favors their competiveness in the long-term in order to lay the foundations for growth in foreign markets.

TOB, FOOD, MACHIN and TEXT can be found on the other extreme of Figure 3. In the multi-criteria model expressed in (8), an industry will be better ranked if there is a high correlation with the rest of the manufacturing industries. The co-movement in the phases is interpreted as a sign of fewer asymmetrical industry-specific shocks. This is essential if it is taken into account that according to Sala, Farré and Torres (2011), industry-specific shocks in Spain are of major significance in explaining innovative output. We removed these variables (I, CP) from the multi-criteria model (expression (8), appendix A.3) and kept to the characteristics of duration, amplitude, deepness and steepness. As a result, the TOB, FOOD, MACHIN and TEXT industries were ranked much higher. We would therefore underscore the idiosyncratic nature of these four industries, which makes them particularly susceptible to asymmetrical industry-specific shocks.

TOB, FOOD and TEXT are industries with little influence on the cyclical evolution of the Spanish economy. The low productivity of the TEXT industry is compounded by the low competitiveness of the TAB, and all three share a low technological level. FOOD and TEXT are traditional industries in the Spanish economy, although they have different idiosyncrasies. The FOOD industry is the main industrial activity in the Spanish industry in terms of turnover and employment. It is not an industry characterized by its levels of innovation, but it has proven to be the industry that best resists the onset of contraction phases. According to Table 2, the losses in output in contraction phases are the lowest (1.57), alongside CHEMIC. Job losses in recession phases are the lowest in the whole of the manufacturing industry (-1.8%). However, the few inter-industrial linkages and low gains in output in expansion phases largely reduce its ability to drive the economy forward and its influence on the business cycle.

TEXT is one of the Spanish economy’s most traditional industries and amongst those that has suffered the most from the processes of globalization and relocation, spurred on by the intensity of labor and the ease with which products can be shipped. Since the 1990s, production has shifted to countries with lower production costs, particularly of labor. This process has meant that it is amongst the industries with the highest job losses, namely, -3.9% of amplitude in contraction phases. Furthermore, the data in Table 2 show that its expansion phases are shorter than the average for Spanish industry and that its output gains/losses in expansion/contraction phases are relatively low/high. Thus, the behavior of the cycle and its intrinsic characteristics has few positive effects on the business cycle.

Although the reality described above still dominates the TEXT industry, it should be pointed out that a process of change has been observed that is starting to give good results. To this regard, two great strengths of the industry can be highlighted. Firstly, some of the businesses that used to manufacture conventional textile products have transformed their production structures to make innovative products to cover new needs in domestic and foreign markets that are on the rise. This would be the case of businesses devoted to the manufacture of technical textiles for use in sectors such as agriculture (netting to protect harvests), automotion (upholstery, airbags, safety belts), sport (special fabrics, nets, artificial grass), packing and transport (slings, sacks, rope), personal protection (uniforms) and health (bandages, dressings). Secondly, fashion is booming and is therefore a major source of demand. Spain has made inroads through its internationally recognized creative output and brands that differentiate its products, which have made it possible to gain a share on foreign markets. If this strategy continues along these lines, the industry may be more resistant to contraction phases in the future, and its technological intensity and competitiveness in international markets could improve. If innovate products increase linkages with other industries and, therefore, the cyclical inter-industrial correlation, certain changes can be expected in the impact the industry has on the cycle of the Spanish economy.

MACHIN has different features to those of the other three industries. As Table 2 shows, it is one of the industries with the greatest duration and amplitude in its expansion phases and according to the data in Table B.3, appendix B, its characteristics place it in a suitably competitive and innovative environment. The problem lies in that its suitable cyclical behavior and its intrinsic properties do not transfer to the economy due to the low correlation with all other industries and the BC. Thus, the spillover effect is cut short by the industry itself.

5. Conclusions

Studies on business cycles and their results are of great interest to analysts and policy makers. This paper examines the characteristics of cyclical phases in manufacturing industries in the Spanish economy. Research was conducted into the IPI of 16 manufacturing industries in order to extract information about sectoral business cycles and establish their relationship with the cycle of the Spanish economy.

The research shows that there are signs of discrepancies in the indicators that characterize cycles, although generalizations can be made about some of the characteristics. In line with this, Spanish industries follow an empirical regularity according to which expansion phases last longer than contraction phases. In general, manufacturing industries has a greater capacity than BC to achieve gains in output, stand out medium-and high teach industries (COMP, ELECTR, MACHIN and VEHIC). The amplitude of the phases follows the "great moderation" pattern, within a dynamic in which gains in output in expansion exceed losses in contraction. The deepness and steepness asymmetries are not present in the cyclical phase of most industries.

There is a relationship between instances of lower inter-industry synchronization and lower synchronization with the BC. In contrast, it is not as clear whether the industries with greater synchronization with the rest are also those that show greater synchronization with the BC. This means that industries that are more inter-correlated deplete in their own linkages its ability to drag the rest of the economy or be dragged by other sectors. These two facts reduce the leading role played by the Spanish manufacturing industry in changing the cycle of the Spanish economy.

It should also be noted that the VEHIC, PLAS, METAL and METALPRO industries stand out for their positive influence on the business cycle, whilst the TOB, FOOD, MACHIN and TEXT industries have a low influence. The results show that the VEHIC industry obtains the best intra-industry results. This must be regarded as a positive feature for various reasons. Firstly, because it is among the industries that provides a high percentage of Spain's GDP. Secondly, because it has high inter-sectoral linkages that favor the transfer of industrial shocks. Thirdly, because it is a medium-tech industry. However, there are also negative factors such as the fact that employment and demand are particularly sensitive to cyclical changes. To reduce this sensitivity and maintain its strategic position within the Spanish economy, the industry must adjust its production to expand demand segments and eliminate the excess capacity that characterizes it.

The cycle of the Spanish economy has been heavily influenced by three sectors, which in turn depended heavily on construction (PLAS, METALPRO, METAL). Its ability to continue having a positive effect on economic activity depends mainly on its ability to reduce the sensitivity of employment to cyclical phases and innovate. It also favors the demand generated by some industries when certain activities linked to their production lines are outsourced.

The analysis also brought to light that COMP and CHEMIC, high and medium-tech industries, determine the evolution and characteristics of the cyclical phases of the Spanish economy. However, no significant influence has yet been detected by the others industries with the greatest technological capacity (ELECTRIC and MACHIN).

TEXT and FOOD show remarkable peculiarities. Both are traditional industries in Spain, although our analysis reveals that their influence on the business cycle is reduced. The TEXT industry stands out for its high amplitude in recessions, as it is the only one in which deepness asymmetry is clearly significant. This reflects the difficulties that this industry has experienced with losses in production due to strong foreign competition and relocations. In recent years, endeavors have been made to restructure the sector to make new products and create brand identity, which have had positive results in domestic and foreign markets. If the strategy succeeds in extending relations with other industries and other sectors, the future influence of TEXT on the business cycle could increase.

FOOD is the industry that contributes more to GDP and employment. The industry is characterized by the greatest duration, both in expansion and recession, by a low amplitude in contraction and by a low level of cyclical synchronization with the rest of the industries and with the BC. Thus, one of the leading industries in the Spanish economy is an industry with major asymmetries both in expansion and contraction phases, which hinders its inter-sectoral linkages with the other industries.

According to our analysis, the business cycle of the Spanish economy is positively influenced by high- and medium-tech industries (VEHIC, COMP and CHEMICAL), which have demonstrated their competitive capacity in international markets, and by medium- low-tech industries (PLAS, METAL, METALPRO), with major strengths in R&D, and survival and consolidation strategies. These results enable the Spanish manufacturing industry to have a positive effect on the business cycle. These effects are in turn counteracted because many of the industries show a high correlation of employment with cyclical fluctuations. The high job losses in contraction phases weaken their impact on economic growth. This fact has been confirmed by the crisis in mid-2008. The manufacturing industry has offset the negative consequences of the recession through a major adjustment in employment. Spanish manufacturing industries must increase productivity. Even more so when during the period of economic crisis Maroto-Sánchez and Cuadrado-Roura (2013) find a pro-cyclical relationship between the manufacturing industries and the productivity, while construction and services show a countercyclical behavior. On the other hand, industries must innovate processes and products in order to take advantage of the good cyclical behavior of many of them. It is in this way that they will be able to become an axis in the process of the Spanish economic growth.

References

Aguiar-Conraria, L., Martins, M.M.F., & Soares, M.J. (2013). Convergence of the Economic Sentiment cycles in the Eurozone: A time-frequency analysis. *Journal of Common Market Studies*, 51(3), 377-398. http://dx.doi.org/10.1111/j.1468-5965.2012.02315.x

Bandrés, E., & Gadea, M.D. (2013). Crisis económica y ciclos regionales en España. *Papeles de Economía Española*, 138, 2-30.

Barrios, S., & De Lucio, J. (2003). Economic integration and regional business cycles: Evidence from the Iberian Regions. *Oxford Bulletin of Economics and Statistics*, 65(4), 497-515. http://dx.doi.org/10.1111/1468-0084.t01-2-00059

Belaire-Franch, J., & Contreras, D. (2002). A Pearson's test for symmetry with an application to the Spanish business cycle. *Spanish Economic Review*, 4(3), 221-238. http://dx.doi.org/10.1007/s101080200048

Bergé, T.J., & Jordà, O. (2013). A chronology of turning points in economic activity: Spain, 1850-2011. *SERIEs*, 4(1), 1-34. http://dx.doi.org/10.1007/s13209-012-0095-6

Berman, J., & Pfleeger, J. (1997). Which industries are sensitive to Business cycles?. *Monthly Labor Review*, 120(Feb. 1997), 19-25.

Borondo, C., González, Y., & Rodríguez, B. (1999). Convergencia cíclica dentro de la UE: el caso de España. *Moneda y Crédito*, 208, 171-220.

Bry, G., & Boschan, Ch. (1971). *Cyclical analysis of time series: selected procedures and computer programmes*. New York: National bureau of Economic Research.

Burns, A.F., & Mitchell, W.C. (1946). *Measuring Business Cycles, NBER, Studies in Business Cycle*. New York: Columbia University Press.

Caporale, G.M., De Santis, R., & Girardi, A. (2014). Trade intensitu and output synchronisation: On the endogeneity properties of EMU. *Journal of Finantial Stability,* In Press. http://dx.doi.org/10.1016/j.jfs.2014.01.003

Cartaya, V., Sáez, F., & Zavarce, H. (2010). *Ciclos de actividad económica y comovimentos sectoriales en Venezuela*, Documentos de Trabajo 110 Gerencia de Investigaciones Económicas, Banco Central de Venezuela.

Crespo-Cuaresma, J., & Fernández-Amador, O. (2013). Business cycle convergence in EMU: A first look at the second moment. *Journal of Macroeconomics*, 37, 265-284. http://dx.doi.org/10.1016/j.jmacro.2013.02.001

Cuadrado, J.R., Mancha, T., & Garrido, R. (1998). *Convergencia regional en España: Hechos, tendencias y perspectivas*. Madrid: Ediciones Argentaria-Visor.

Cuadrado, J.R., & Ortiz, A. (2001). Business cycle and service industries: General trends and the Spanish case. *The Service Industries Journal*, 1(21), 103-122.

http://dx.doi.org/10.1080/714005005

De La Fuente, A. (2002). On the sources of convergence: A close look at the Spanish regions. *European Economic Review*, 46(3), 569-599. http://dx.doi.org/10.1016/S0014-2921(01)00161-1

De Miguel, C. (2009). Ciclo industrial en España ¿Hemos tocado fondo?. *Economía Industrial*, 372, 211-220.

Dolado, J.J., Sebastián, M., & Vallés, J. (1993). Cyclical patterns of the Spanish economy. *Investigaciones Económicas*, XVII(3), 445-473.

Doménech, R., Estrada, A., & Gozález-Calbet, L. (2007). *Potential Growth and Business Cycle in the Spanish Economy: Implications for Fiscal Policy*. Working Papers 0705, International Economics Institute, Universidad de Valencia.

Doménech, R., & Gómez, V. (2005). Ciclo económico y desempleo estructural en la economía española. *Investigaciones Económicas*, XXIX(2), 259-288.

Enders, Z., Jung, P., & Müller, G.J. (2013). Has the Euro changed the business cycle?. *European Economic Review*, 59, 189-211. http://dx.doi.org/10.1016/j.euroecorev.2012.12.003

Gadea, M.D., Gómez-Loscos, A., & Montañés, A. (2006). *How many regional business cycles are there in Spain? A MS-VARapproach*. Documento de Trabajo Fundear (Serie Investigación) 27/06.

Gadea, M.D., Gómez-Loscos, A., & Montañés, A. (2012) Cycles incide cycles: Spanish regional aggregation. *Series*, 3(4), 423-456. http://dx.doi.org/10.1007/s13209-011-0068-1

García-Carro, B., Cruz, A.I., López, I., & Ameneiro, M. (2007). Los ciclos de la industria española: evaluación de sus relaciones dinámicas, casualidades e impactos. *Economía Industrial*, 363, 223-236.

Gardeazábal, J., & Iglesias, M.C. (2000). ¿Causan los ciclos del G7 el ciclo español?. *Revista de Economía Aplicada*, VIII(24), 39-80.

Gächter, M., Ried, A., & Ritzberger-Grünwald, D. (2012). Business Cycle Synchronization in the Euro Area and the Impact of the Financial Crisis. *Monetary Policy & The Economy, Quarterly Review of Economic Policy, Oesterreichische Nationalbank*, Q2/12, 33-60.

Goerlich-Gisbert, F.J. (1999). Shocks agregados versus shocks sectoriales: un análisis factorial dinámico. *Investigaciones Económicas*, XXIII(1), 27-53.

Hamilton, J. (1989). A new approach to the economic análisis of nonstationary time series and the business cycle. *Econometrica*, 57(2), 357-384. http://dx.doi.org/10.2307/1912559

Harding, D., & Pagan, A. (2002). Dissecting the Cycle: A Method-ological Investigation. *Journal of Monetary Economics*, 49(2), 365-381. http://dx.doi.org/10.1016/S0304-3932(01)00108-8

Harding, D., & Pagan, A. (2006). Synchronization of cycles. *Journal of Econometrics,* 132(1), 59-79. http://dx.doi.org/10.1016/j.jeconom.2005.01.023

Jiménez-Rodríguez, R., Morales-Zumaquero, A., & Égert, B. (2013). Business cycle synchronization between Euro Area and central and eastern European countries. *Review of Development Economics*, 17(2), 379-395. http://dx.doi.org/10.1111/rode.12038

Jimeno, J.F., & Campillo, M. (1993). La importancia de los shocks agregados y de los shocks microeconómicos en la economía española. *Revista Española de Economía*, 10(2), 321-348.

Konstantakopoulou, I., & Tsionas, E.G. (2014). Half a century of empirical evidence of Business cycles in OECD countries. *Journal of Policy Modeling*, 36(2), 389-409.

http://dx.doi.org/10.1016/j.jpolmod.2014.01.006

Maroto-Sánchez, A., & Cuadrado-Roura, J.R. (2013). The key of the productive structure in the countercyclical productivity in Spain. *Economic and Business Letters*, 2(3), 86-93.

Michaelides, P.G., Papageorgiou, T., & Vouldis, A.T. (2013). Business cycle and economic crisis in Greece (1960-2011): A long run equilibrium analysis in the Eurozone. *Economic Modelling*, 32, 804-816. http://dx.doi.org/10.1016/j.econmod.2013.01.013

Newey, W.K., & West, K.D. (1987). A simple, positive semi-definite, heteroskedasticity, & autocorrelation consistent covariance matrix. *Econometrica*, 55, 703-708. http://dx.doi.org/10.2307/1913610

OECD (2005). *Measuring globalisation handbook on economic globalisation indicators*. OCDE.

Pérez, P.J., Escriche, L., & García, J.R. (2007). Las perturbaciones externas en la economía española tras la integración: ¿tamaño del shock o grado de respuesta?. *Revista de Economía Aplicada*, XV(45), 5-39.

Romero, C. (1993). *Teoría de la decisión multicriterio: conceptos, técnicas y aplicaciones*. Madrid: Alianza Editorial.

Sala, M., Farré, M., & Torres, T. (2011). Fluctuaciones cíclicas, shocks y asimetrías. Un análisis desagregado para las regiones e industrias españolas. *Revista de Estudios Regionales*, 91, 97-123.

Sichel, D. (1993). Business cycle asymmetry: A deeper look. *Economic Inquiry*, XXXI, 224-236. http://dx.doi.org/10.1111/j.1465-7295.1993.tb00879.x

Summers, P.M. (2005). What Caused the Great Moderation: Some Cross Country Evidence. *Economic Review, Federal Reserve Bank of Kansas City*, Third Quarter, 5–32.

Yu, P.L. (1973). A class of solutions for group decisions problems. *Management Science*, 19, 936-946. http://dx.doi.org/10.1287/mnsc.19.8.936

Zeleny, M. (1973). Compromise programming. In J.L. Cochrane & M. Zeleny (Ed.), *Multiple Criteria Decision Making* (pp. 262-301). Columbia: University of South Carolina Press.

Zeleny, M. (1974). A concept of compromise solutions and the Method of the Displaced Ideal. *Computers and operations Research*, 1, 479-496. http://dx.doi.org/10.1016/0305-0548(74)90064-1

Appendix A: Methodology issues

A.1 Estimation of the asymmetry deepness and steepness coefficients

Asymmetry deepness coefficient D(c):

$$D(c) = \left[T^{-1} \left(\sum_t (c_t \;\; \bar{c} \right)^3 \right] \Big/ \sigma(c)^3 \tag{1}$$

Where c_t is the cyclical component, σ(c) is standard deviation and T is the size of the sample.

As the c_t values observed are self-correlating, we use heteroskedasticity and the autocorrelation consistent (HAC) estimation procedure of Newey and West (1987) with Bartlett weights to estimate D(c). The variable z_t, defined in (2), is regressed on a constant whose estimation is the same as that for D(c). As the quotient between the constant and its standard error is asymptotically normal, the significance of D(c) can be analyzed using the values of the t-ratio.

$$z_t = \frac{(c_t \;\; \bar{c})^3}{\sigma(c)^3} \tag{2}$$

Asymmetry steepness coefficient ST(Δc):

In steepness asymmetry, if contractions show greater steepness than expansions, the increases must be greater and more frequent than the decreases. Intuition therefore tells us that the first difference in the series must be taken (Δc_t). The asymmetry coefficient that approximates steepness ST(Δc) follows the same logic as used for deepness, but in this case on the series in first differences (Δc_t). Contrast uses the estimation of the asymmetry coefficient ST(Δc), which is calculated as:

$$ST(\Delta c) = \left[T^{-1} \left(\sum_t (\Delta c_t \;\; \Delta \bar{c} \right)^3 \right] \Big/ \sigma(\Delta c)^3 \tag{3}$$

Where $\Delta \bar{c}$ and σ(Δc) are the simple average and the standard deviation of Δc_t.

The asymptotic standard error for contrasting steepness is calculated in the same way as for contrasting deepness. The significance of ST(Δc) will be evaluated using the values of the t-ratio.

A.2. Estimation coefficient (ρ) between S_{it} and S_{jt}

The correlation coefficient (ρ) between S_{it} and S_{jt} is estimated using the generalized method of moments (GMM) proposed by Harding and Pagan (2006). The moment condition is as follows:

$$E\left[\sigma s_i^{-1}\left(S_{it}-\mu s_i\right)\sigma s_j^{-1}\left(S_{jt}-\mu s_j\right)-\rho s\right]=0 \qquad (4)$$

Where σs and μs are, respectively, the average and typical deviation of the series S_{it} and S_{jt}. This yields the estimator:

$$\frac{1}{T}\sum_{t=1}^{T}\left[\hat{\sigma} s_i^{-1}\left(S_{it}-\hat{\mu} s_i\right)\hat{\sigma} s_j^{-1}\left(S_{jt}-\hat{\mu} s_j\right)-\hat{\rho} s\right]=0 \qquad (5)$$

We use heteroskedasticity and the autocorrelation consistent (HAC) estimation procedure of Newey and West (1987) with Bartlett weights. The statistical significance can therefore be contrasted using the t-ratio.

A.3. Multi-criteria analysis

The multi-criteria technique makes it possible to consider decision-making problems with multiple objectives and obtain a set of efficient solutions. Within the multi-criteria technique, we work with compromise programming.

The process begins by calculating the payments matrix, which is a square matrix equal in size to the number of targets. The rows are constructed by optimizing each objective separately and calculating the values obtained in this solution for the other targets. Thus, the main diagonal of the matrix contains the solution in which all targets have their optimum value, which is usually an unattainable solution. Each element on the main diagonal is defined as an ideal point and the worst element of each column as an anti-ideal point, as from Pareto's standpoint this is not a desired or even optimum solution.

Compromise programming consists in reducing the distance between the ideal point and the chosen solution to a minimum. Of the standard set of metrics and measurements for calculating the distance LP, we took the one corresponding to p = 1 (Romero, 1993). The linear programming model to be resolved is as follows:

$$\mathit{Min}\ L1=\sum_{g=1}^{n} W_g\left|f_g^{id}-f_g(x)\right| \qquad X \in F \qquad (6)$$

Where W_g = weight or weighting assigned to objective *g*; f_g^{id} = the ideal solution of the objective *g*; f_g^{ai} = the anti-ideal solution of the objective *g*; f_g (x) = the mathematical expression of the attribute *g-th*; X = the vector of decision variables; and F = the set of restrictions that define the set of possible solutions.

Given that the indicators have different units of measure, we standardize them using the expression $\left(f_g^{id} - f_g^{ai}\right)$, as a result of which (6) becomes:

$$Min\ L1 = \sum_{g=1}^{n} W_g \frac{\left(f_g^{id} - f_g(x)\right)}{\left(f_g^{id} - f_g^{ai}\right)} \quad X \in F \tag{7}$$

In this paper, each component in the vector of decision variables X = [X1, X2, ….Xj] (j=16), is the fraction expressed on a per unit basis of the relative importance of each industry in the objective (g=8). Therefore, the model expressed in (7) yields the expression (8):

$$\begin{aligned} Min\ L1 = {} & W1 \frac{D_{ex}^{id} - \left[\sum_{j=1}^{16} D_{ex_j} \cdot X_j\right]}{D_{ex^{id}} - D_{ex^{ai}}} + W2 \frac{\left[\sum_{j=1}^{16} D_{con_j} \cdot X_j\right] - D_{con}^{id}}{D_{con^{ai}} - D_{con^{id}}} + \\ & + W3 \frac{A_{ex}^{id} - \left[\sum_{j=1}^{16} A_{ex_j} \cdot X_j\right]}{A_{ex^{id}} - A_{ex^{ai}}} + W4 \frac{\left[\sum_{j=1}^{16} A_{con_j} \cdot X_j\right] - A_{con}^{id}}{A_{con^{ai}} - A_{con^{id}}} + \\ & + W5 \frac{\left[\sum_{j=1}^{16} |t_{Dc}|_j \cdot X_j\right] - |t_{Dc}|^{id}}{|t_{Dc}|^{ai} - |t_{Dc}|^{id}} + W6 \frac{\left[\sum_{j=1}^{16} |t_{ST\Delta c}|_j \cdot X_j\right] - |t_{ST\Delta c}|^{id}}{|t_{ST\Delta c}|^{ai} - |t_{ST\Delta c}|^{id}} + \\ & + W7 \frac{I^{id} - \left[\sum_{j=1}^{16} I_j \cdot X_j\right]}{I^{id} - I^{ai}} + W8 \frac{CP^{id} - \left[\sum_{j=1}^{16} CP_j \cdot X_j\right]}{CP^{id} - CP^{ai}} \end{aligned} \tag{8}$$

Subject to $X_j \geq 0$ and $\sum_j X_j = 1$. Where j = industry; $W_1 = W_2 = \ldots = W_7 = W_8 = 1$, as we do not wish to give priority to any of the variables; and X_j is the fraction expressed on a per unit basis.

The program specified in expression (8) requires the restrictions $X \geq 0$ and $\sum X_j = 1$. The optimization yields a single X_j # 0, and equal to the unit, that which corresponds to the industry whose combination of the eight indicators minimizes the distance from the ideal point. We optimize j-1 models, the industry j whose X_j=1 in the previous model is removed. Finally we rank industries according to the results.

Appendix B: Results

	BC	FOOD	BEV	TOB	TEXT	WOOD	PAP	CHEMIC	PLAS
BC		0,598	0,720	0,576	0,686	0,737	0,744	0,744	0,805
FOOD	1,450		0,556	0,735	0,504	0,598	0,581	0,726	0,624
BEV	3,677	0,755		0,568	0,695	0,669	0,686	0,744	0,709
TOB	1,086	4,298	1,042		0,449	0,576	0,576	0,564	0,581
TEXT	2,686	0,069	2,866	-0,891		0,669	0,653	0,658	0,692
WOOD	4,329	1,578	2,669	1,153	2,945		0,763	0,684	0,650
PAP	4,495	1,029	2,935	1,094	2,371	5,212		0,769	0,735
CHEMIC	4,504	3,570	4,936	1,018	2,258	3,652	4,640		0,778
PLAS	5,914	1,949	3,851	1,197	3,090	2,168	4,300	5,898	
NMET	4,202	1,617	5,275	1,490	4,725	3,614	3,151	4,040	1,518
METAL	5,836	2,849	4,651	2,165	2,098	4,211	3,105	5,626	4,848
METALPRO	5,730	2,540	4,793	2,278	2,438	3,697	3,054	5,052	4,284
COMP	4,674	1,876	3,631	2,674	3,883	4,045	3,419	2,242	3,946
ELECTR	3,502	1,752	3,262	1,039	4,755	3,478	3,324	5,352	3,398
MACHIN	0,664	-2,003	1,354	-1,340	3,894	-0,185	-0,158	0,442	1,230
VEHIC	6,299	0,054	2,301	-0,962	5,741	3,560	2,265	1,761	2,828
OTHER	2,805	3,613	1,951	2,349	2,673	7,133	3,452	3,068	1,514

	NMET	METAL	METALPRO	COMP	ELECTR	MACHIN	VEHIC	OTHER
BC	0,754	0,814	0,822	0,737	0,729	0,547	0,788	0,669
FOOD	0,607	0,684	0,675	0,607	0,615	0,385	0,504	0,658
BEV	0,780	0,737	0,763	0,695	0,703	0,593	0,624	0,610
TOB	0,585	0,644	0,653	0,669	0,576	0,415	0,444	0,636
TEXT	0,746	0,636	0,661	0,712	0,788	0,712	0,795	0,661
WOOD	0,720	0,729	0,703	0,703	0,712	0,500	0,667	0,839
PAP	0,686	0,695	0,686	0,669	0,695	0,500	0,632	0,686
CHEMIC	0,709	0,786	0,761	0,624	0,769	0,521	0,624	0,658
PLAS	0,607	0,786	0,761	0,709	0,718	0,590	0,692	0,607
NMET		0,737	0,780	0,678	0,737	0,576	0,726	0,729
METAL	4,940		0,958	0,720	0,695	0,500	0,718	0,737
METALPRO	5,600	23,993		0,712	0,703	0,508	0,709	0,729
COMP	2,736	4,352	3,871		0,720	0,627	0,726	0,661
ELECTR	4,406	3,305	3,400	4,421		0,669	0,667	0,669
MACHIN	1,144	-0,123	-0,018	1,628	2,914		0,607	0,458
VEHIC	4,751	4,101	3,967	3,755	2,958	1,459		0,641
OTHER	3,968	4,293	4,347	2,878	2,811	-0,613	2,541	

Table B.1. Concordance index (I) in the upper triangle and t-student in the lower triangle (Eurostat)

	BC	FOOD	BEV	TOB	TEXT	WOOD	PAP	CHEMIC	PLAS
BC		4,482	22,981	2,758	16,481	28,688	28,490	26,134	43,089
FOOD	0,192		1,343	25,944	0,011	4,352	3,005	24,412	7,053
BEV	0,404	0,107		2,249	18,463	12,925	16,163	28,993	20,057
TOB	0,151	0,426	0,137		1,236	2,860	2,785	1,915	3,129
TEXT	0,350	0,010	0,368	0,102		14,097	11,149	11,637	17,601
WOOD	0,442	0,189	0,314	0,154	0,327		32,371	16,805	10,014
PAP	0,441	0,158	0,347	0,152	0,294	0,464		34,623	25,593
CHEMIC	0,427	0,415	0,446	0,127	0,301	0,354	0,544		37,063
PLAS	0,519	0,238	0,383	0,161	0,362	0,281	0,424	0,490	
NMET	0,453	0,208	0,488	0,168	0,442	0,403	0,349	0,389	0,207
METAL	0,531	0,344	0,427	0,278	0,264	0,414	0,362	0,501	0,496
METALPRO	0,542	0,329	0,463	0,293	0,309	0,373	0,348	0,467	0,460
COMP	0,429	0,206	0,363	0,324	0,395	0,371	0,318	0,249	0,383
ELECTR	0,417	0,227	0,387	0,150	0,499	0,398	0,366	0,473	0,403
MACHIN	0,100	0,233	0,189	0,166	0,397	0,016	0,007	0,052	0,168
VEHIC	0,497	0,007	0,238	0,110	0,509	0,314	0,254	0,244	0,358
OTHER	0,322	0,303	0,220	0,261	0,306	0,566	0,351	0,301	0,211

	NMET	METAL	METALPRO	COMP	ELECTR	MACHIN	VEHIC	OTHER
BC	30,483	46,413	49,014	26,667	24,876	1,188	38,316	13,625
FOOD	5,270	15,669	14,209	5,180	6,353	6,725	0,005	11,811
BEV	36,885	26,340	32,207	18,076	20,964	4,435	7,015	5,978
TOB	3,418	9,884	11,120	13,845	2,723	3,361	1,438	8,654
TEXT	28,708	8,822	12,484	21,783	39,089	22,079	40,945	12,178
WOOD	22,846	24,471	19,117	18,842	22,162	0,032	12,810	55,730
PAP	16,316	17,787	16,221	13,321	16,721	0,006	8,100	16,621
CHEMIC	20,885	39,128	32,677	7,701	33,784	0,317	7,377	11,637
PLAS	5,219	38,114	31,457	20,057	22,743	3,406	17,146	5,477
NMET		26,482	36,824	14,831	26,870	2,634	23,903	24,893
METAL	0,428		98,813	22,673	18,265	0,006	22,090	26,870
METALPRO	0,488	0,675		20,813	20,001	0,007	20,358	25,105
COMP	0,334	0,401	0,387		24,478	7,553	23,845	12,646
ELECTR	0,431	0,366	0,381	0,413		15,031	13,191	13,472
MACHIN	0,148	0,007	0,008	0,244	0,335		5,154	0,773
VEHIC	0,412	0,399	0,385	0,411	0,318	0,205		9,403
OTHER	0,417	0,431	0,419	0,311	0,322	0,081	0,273	

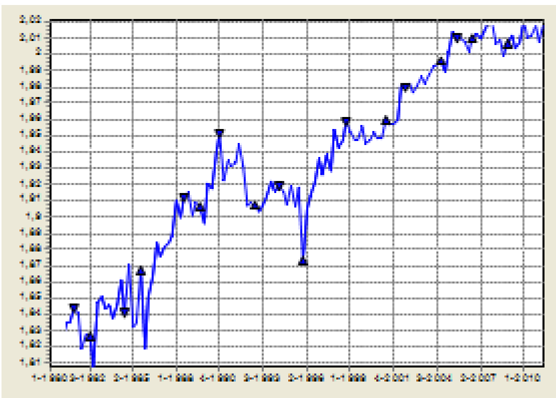
Table B.2. χ^2 in the upper triangle and contingency index (CP) in the lower triangle (Eurostat)

	% Manufacturing GVA	**% Manufacturing Employment**	**% Spanish GVA**	**% Spanish employment**	**Apparent labour productivity** (GVA per person employed)	**Competitiveness (Export Specialisation)**	**R&D/GVA**	**Classification according to technology[1]**
FOOD	15.8	16.5	1.7	1.8	50.3	9.9	17.0	L
BEV	4.5	2.5	0.5	0.3	95.3	1.7	14.8	L
TOB	0.3	0.1	0.0	0.0	115.5	0.1	7.0	L
TEXT	4.1	6.8	0.4	0.7	31.7	7.2	6.7	L
WOOD	1.8	3.2	0.2	0.3	29.6	0.6	10.4	L
PAP	6.2	6.1	0.7	0.7	53.1	2.4	13.1	L
CHEMIC	11.3	6.3	1.2	0.7	94.7	16.0	13.9	M-H
PLAS	5.2	4.9	0.5	0.5	54.9	3.8	13.2	M-L
NMET	6.2	6.3	0.6	0.7	51.5	2.8	15.3	M-L
METAL	4.4	3.3	0.5	0.4	69.9	9.0	15.2	M-L
METALPRO	10.7	13.7	1.1	1.5	41.1	3.7	8.6	M-L
COMP	1.5	1.6	0.2	0.2	50.3	2.8	12.1	H
ELECTR	3.7	3.6	0.4	0.4	54.2	5.4	12.1	H
MACHIN	5.8	5.3	0.6	0.6	57.6	7.3	6.6	M-H
VEHIC	11.9	9.6	1.3	1.0	64.7	25.4	13.4	M-H
OTHER	6.5	9.7	0.7	1.0	35.1	1.9	6.0	L

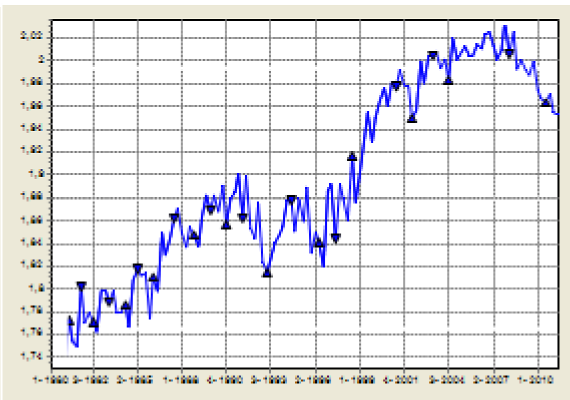
(1) According to OECD (2005) L: Low tech industries; M-L: Medium-Low tech industries; M-H: Medium-high tech industries; H: High teach industries (Eurostat and OCDE)

Table B.3. Main specific features of industries (2011)

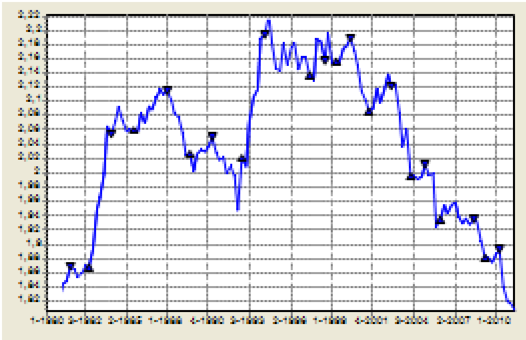
FOOD



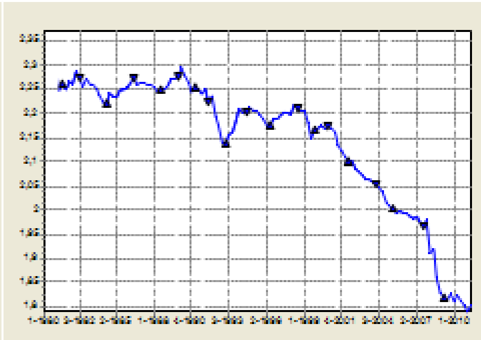
BEV



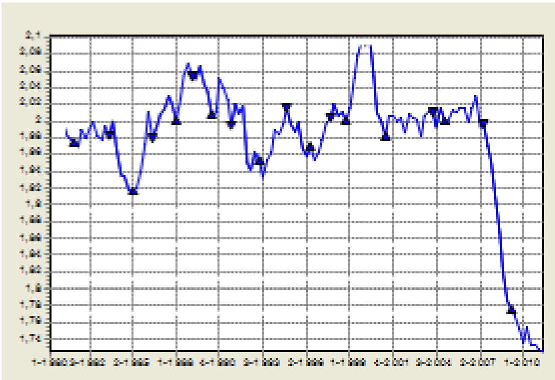
TOB



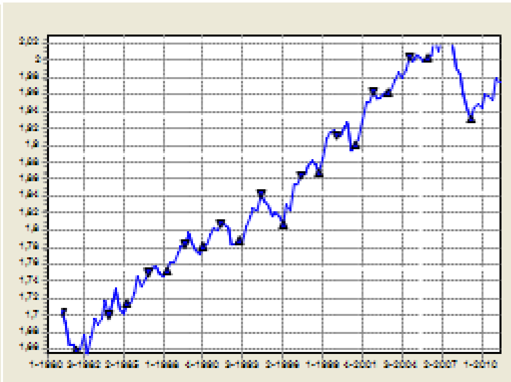
TEXT



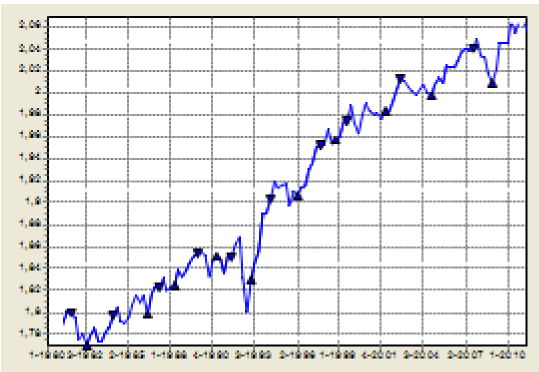
WOOD



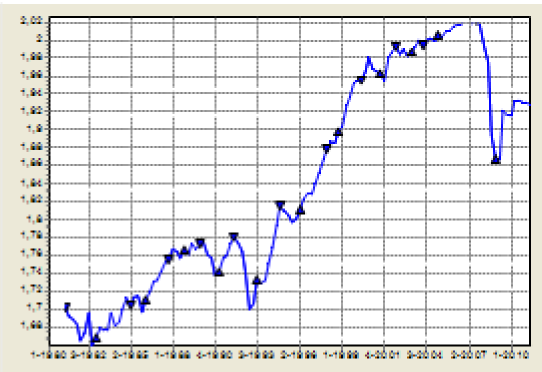
PAP



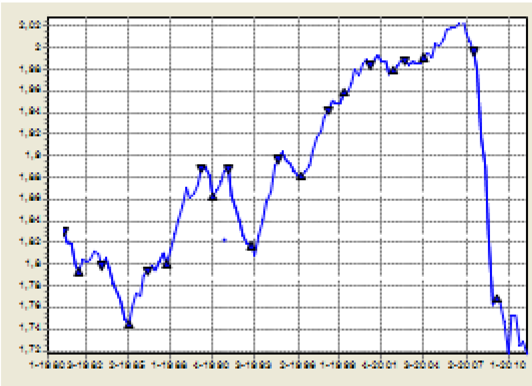
CHEMIC



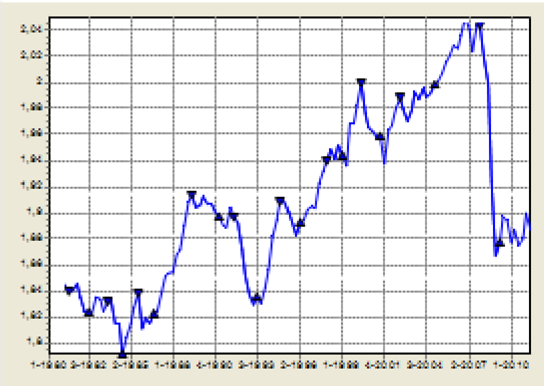
PLAS



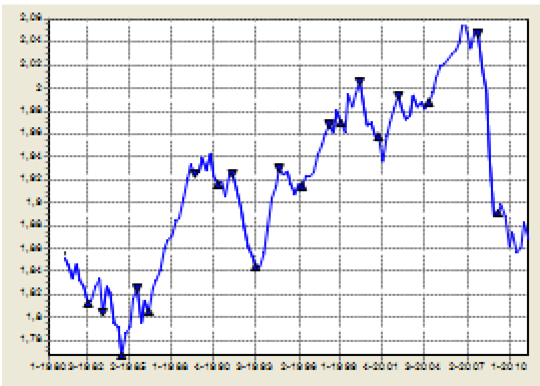
NMET



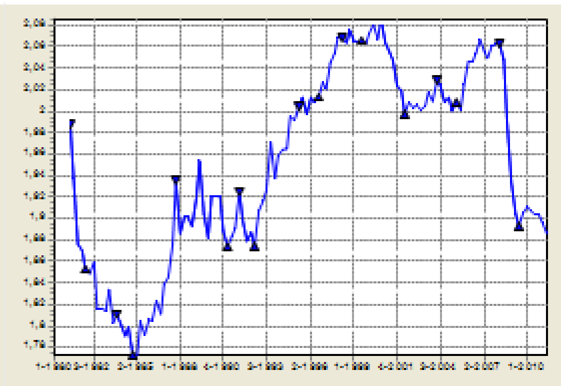
METAL



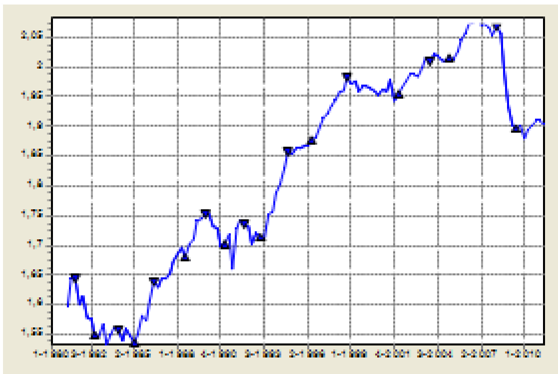
METALPRO



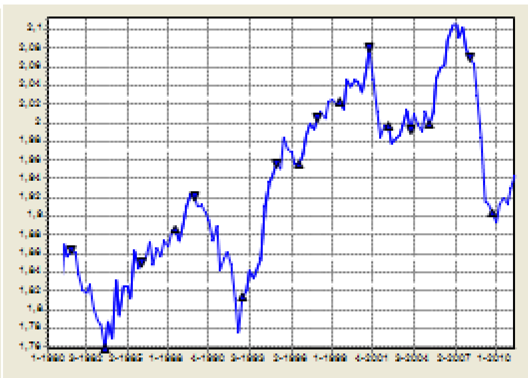
COMP

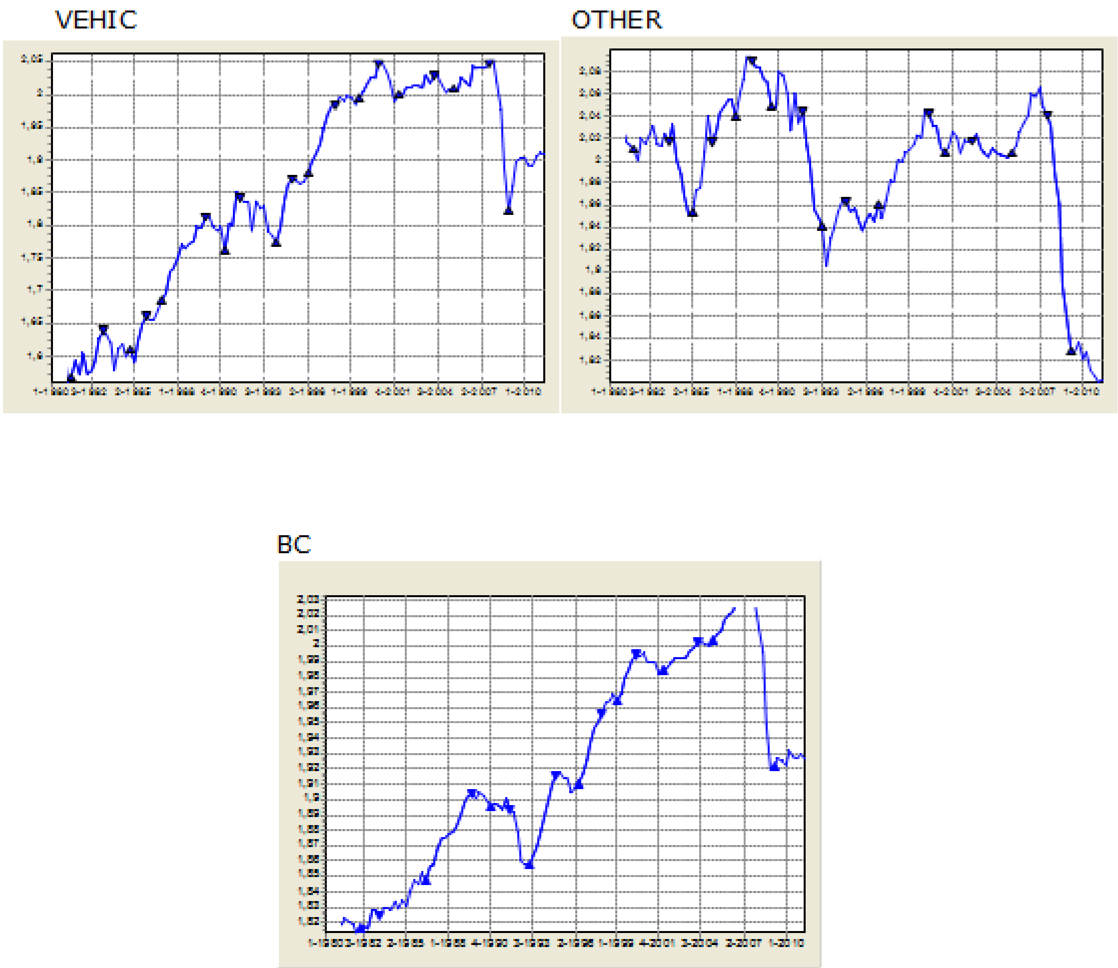


ELECTR



MACHIN





In the figure: ∇ *peak*; Δ *trough* (Eurostat, elaborated with the program BUSY)

Figure B.1 Turning points (ordinate axis: log original series)