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How many regional business cycles are there in Spain? A MS-VAR approach

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Resumen del estudio y aplicación a la economía aragonesa

El objetivo de este trabajo es detectar la posible existencia de ciclos económicos regionales en España y analizar su relación con el ciclo común a nivel nacional. Para ello se utilizan modelos no lineales, adoptando herramientas modernas para el análisis del ciclo económico como son los modelos *Markov-switching* en su versión univariante MS-AR o multivariante MS-VAR. Los resultados obtenidos permiten extraer interesantes implicaciones tanto para la predicción del ciclo económico español, como desde la óptica de la política económica regional.

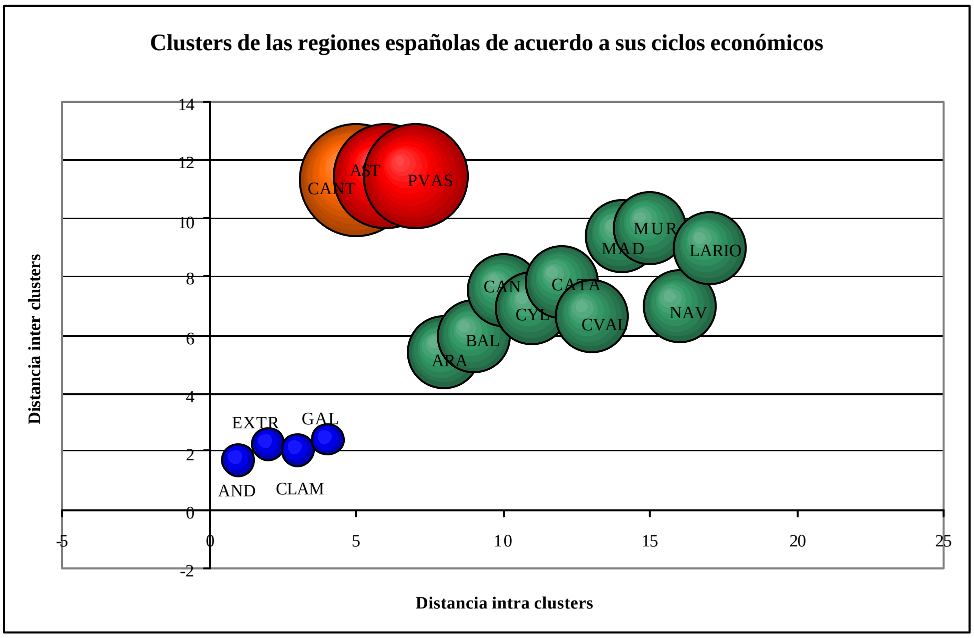
La motivación de este trabajo se basa en tres hechos fundamentales. En primer lugar, en la literatura internacional, la metodología MS está adquiriendo un interés creciente a la hora de identificar los patrones cíclicos de los agregados económicos. Sin embargo, y en segundo lugar, a pesar de las ventajas de esta metodología, los estudios son todavía escasos, se han aplicado principalmente a países y la literatura que considera un nivel de desagregación inferior ha sido escasa -debido sobre todo a la no disponibilidad de datos. Además, en todos ellos, se utilizan datos de empleo como proxies de indicadores de actividad. En tercer lugar, tiene un interés particular en España, un país con características apropiadas por el tamaño y diversidad de sus regiones y su grado de descentralización fiscal, y donde la literatura previa es muy escasa. Por un lado, están los trabajos que analizan el ciclo económico español en relación a otros países, básicamente sus principales vecinos europeos y, por otro lado, están los estudios que miden el ciclo en España como un todo sin profundizar en comportamientos regionales.

Por estos motivos, utilizando las técnicas recientes de modelos de régimen cambiante y profundizando a un nivel de desagregación inferior, nuestro trabajo pretende identificar los patrones cíclicos de las regiones españolas a través de un enfoque no lineal y utilizando, por primera vez, las series de producción industrial (IPI) que se ajustan mejor al ciclo económico. De este modo, se pretende contribuir a una mejor interpretación de las fluctuaciones económicas de un país explicadas a partir de sus ciclos regionales.

Para identificar los hechos estilizados de los diecisiete ciclos regionales, sobre las series del IPI previamente corregidas de atípicos y ajustadas estacionalmente, se aplican modelos *Markov-switching* autorregresivos univariantes. Estos modelos tratan de caracterizar la evolución de una variable, en este caso la tasa de crecimiento del IPI, a través de un proceso de media condicionada a un estado específico de la naturaleza capturado a través de una variable inobservable que sigue un proceso estocástico. La aplicación de esta técnica muestra que los modelos de dos regímenes (recesión y expansión) no son capaces de capturar de forma adecuada el ciclo económico en la mayor parte de las regiones, por lo que se utiliza un tercer régimen que recoge los períodos de fuerte crecimiento, y que puede interpretarse en términos de convergencia real. Las regiones con dos regímenes son Andalucía, Islas Canarias, Castilla La Mancha y Extremadura, mientras que el resto cuentan con tres. Cada una de las diecisiete regiones españolas tiene un ciclo económico particular, con diferencias respecto al resto. En concreto, en Aragón el término independiente en períodos de recesión (régimen 1) es de -2,04%, en expansión de 0,21%, mientras que en periodos de fuerte crecimiento es de 2,27%. Por su parte, la probabilidad y duración de un periodo de crecimiento (0,62% y 4,87 meses, respectivamente, en el caso de una expansión y 0,22% y 2,86 meses, respectivamente, para crecimiento elevado) son mayores que los de una recesión (0,16% y 2,14 meses, respectivamente).

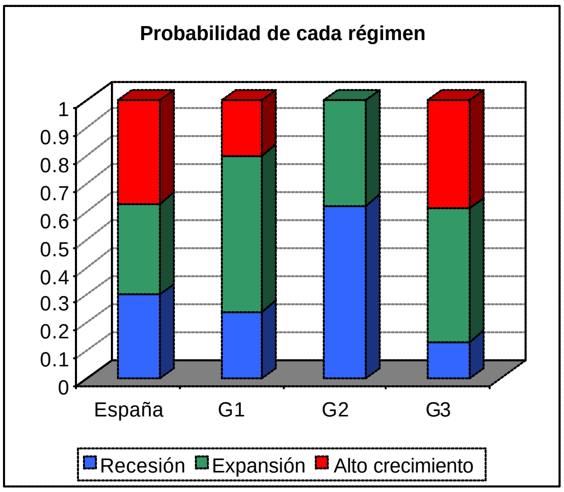
	Aragón
Constante (en función del régimen)	
?1	-2,04
	(0,01)
?2	0,21
	(0,001)
?3	2,27
	(0,003)
Varianzas (en función del régimen)	
s21	0,001
s22	0,001
s23	0,001
Persistencia del régimen 1	
Probabilidad ergódica	0,16
Duración	2,14
Persistencia del régimen 2	
Probabilidad ergódica	0,62
Duración	4,87
Persistencia del régimen 3	
Probabilidad ergódica	0,22
Duración	2,86
Máxima verosimilitud	460,37
Test LR de linealidad	(0,000)

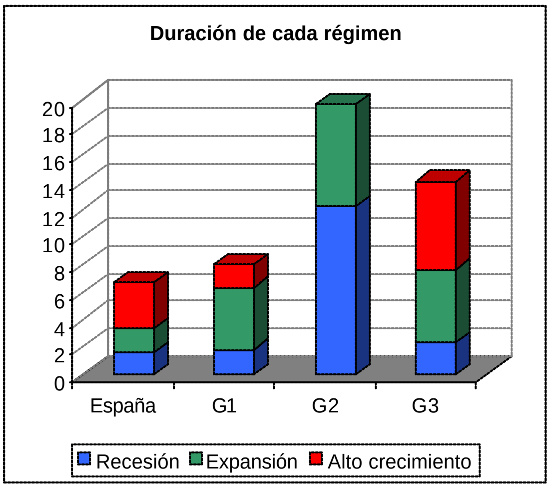
En base a los resultados anteriores se construyen, en primer lugar, diversas medidas de sincronización que muestran que los ciclos regionales están lo suficientemente relacionados como para plantear la existencia de patrones comunes. En segundo lugar, y atendiendo a las diversas características de cada ciclo regional –media, probabilidad y duración de cada régimen-, un posterior análisis cluster (jerárquico y partitivo) trata de buscar los rasgos comunes en lo que se refiere a similitud de los ciclos económicos para establecer grupos de regiones. Obteniéndose finalmente tres clusters. El grupo 1 estaría formado por Aragón, Baleares, Canarias, Castilla y León, Cataluña, Comunidad Valenciana, Madrid, Murcia y La Rioja. El grupo 2 incluye Andalucía, Extremadura, Castilla La Mancha y Galicia y el grupo 3 Asturias, Cantabria y el País Vasco. Así, el grupo 2 agrupa a las cuatro regiones españolas con menores niveles de ingresos per capita y el tercero está formado por las industrializadas regiones de la costa cantábrica, mientras que el primer grupo, más amplio, agrupa al resto de regiones. En el siguiente gráfico, el eje OX representa la distancia intra-cluster, mientras que el eje OY recoge la distancia inter-cluster. Además, las diferencias entre cada grupo se reflejan en el tamaño de los círculos y muestran la mayor o menor similitud dentro de ellos, aunque no son significativos en sí mismos ya que dependen de la asignación inicial aleatoria de los centros. Por otra parte, los resultados del método de k-medias muestran que en el grupo más grande, formado por diez regiones, Aragón presenta la menor distancia dentro del grupo actuando como centro de gravedad.



Una vez establecidos los tres grupos, la aplicación de modelos *Markov-switching* vectoriales autorregresivos (MS-VAR) a cada uno de ellos para observar los rasgos que los caracterizan, confirma la existencia de un ciclo común dentro de cada cluster de regiones. Para los grupos 1 y 3 es necesario un modelo con tres regímenes, mientras que en el grupo 2 un modelo de dos regímenes es válido, reflejando la debilidad de su proceso de convergencia nominal. El primer grupo que representa dos tercios del PIB español en 2004 muestra una duración de los períodos de recesión de 1,81 meses (con una probabilidad de tan solo 0,24), las expansiones tienen una duración de 4,53 meses y los períodos de crecimiento acelerado de 1,74 meses. En cuanto al segundo grupo, que tiene un peso del 24% sobre el PIB de 2004, las recesiones tienen una duración de 12,23 meses (siendo su probabilidad 0,62), mientras que las expansiones son en media de 7,4 meses. En el tercer grupo la duración media de una recesión es de 2,35 meses (con una probabilidad de 0,13), la de una expansión de 5,28 meses y la de crecimiento elevado es de 6,44 meses. En este tercer grupo, los períodos de crecimiento acelerado se suelen alcanzar tras un período de expansión y no directamente tras una recesión, sin embargo esto no sucede en el primer grupo.

A través de un análisis de Funciones Impulso Respuesta se puede observar que en el caso concreto de Aragón las recesiones –definidas como el paso de una expansión a una recesión-, son más suaves que en otras regiones de su mismo grupo, mientras que la respuesta a un crecimiento acelerado –transición de una recesión a un período de fuerte crecimiento- muestra una variabilidad normal respecto a las regiones de su grupo.





Por último, comparamos los resultados obtenidos para los ciclos regionales tras la aplicación de modelos MS-VAR con el ciclo obtenido con los datos a nivel nacional, analizado a través de un modelo MS-AR. El ciclo económico para España refleja la eficacia de estas técnicas para modelizar las sendas cíclicas regionales, ya que se identifican claramente los tres clusters regionales y su grado de sincronización con el ciclo español, siendo este último una síntesis de los regionales con asimetrías en direcciones opuestas. Mediante un análisis de sincronización se obtiene que la relación más significativa es con el grupo 1 y, dependiendo de la medida aplicada, también lo son los grupos 2 y 3. Así, el ciclo español reflejaría el comportamiento más estable del grupo 1 y mezclaría características más atípicas de los otros; ya que está caracterizado por un régimen largo con elevada probabilidad y con una tasa de variación moderada y por otros dos (recesiones y períodos de fuerte crecimiento) con probabilidades y amplitudes similares. De forma que estos resultados sugieren la posibilidad de aprovechar los ciclos de aquellas regiones más representativas y en una fase adelantada respecto a España para usarlos como referencia a la hora de predecir el ciclo regional. En este caso, el grupo 1 es el más representativo y, dentro de este, Aragón, que además se halla en una fase más adelantada del ciclo.

Finalmente, a raíz de los resultados obtenidos parece conveniente la identificación de los diferentes ciclos económicos regionales a la hora de diseñar políticas económicas adecuadas para cada región o cluster de regiones, ya que medidas excesivamente centralizadas no serían adecuadas para todas las regiones. Debido a las limitaciones que la moneda única impone a las políticas de estabilización, las medidas deberían adoptarse en el ámbito macroeconómico, aprovechando el amplio grado de descentralización fiscal de la economía española.

Abstract

This paper applies a modern approach to analyse the business cycle with the aim of revealing the stylised economic facts in the Spanish regions and determining how many cycles there are. We first apply a Markov-switching autoregressive model (MS-AR), which studies individual industrial production index of Spain as a whole and of each region. On the basis of these previous results we dassify regional cycles in three groups, corresponding with a larger first group and two others which represent extreme behaviours. The results obtained from the application of a Markov-switching vector autoregressive (MS-VAR) on these groups support the existence of three cycles in Spain that contribute to form the Spanish one. Our findings open the possibility of using the business cycles of some regions –the most representative or advanced- to forecast the Spanish economic activity and suggest avoiding the implementation of common policies between regions. So, the identification of different business cycles in Spain is necessary to devise adequate economic policies for each region or cluster of regions.

Keywords: Business Cycle, Synchronization measures, MS-VAR models, Regional policy.

JEL Classification: C22, C32, E32, R11

Resumen

Este trabajo aplica una moderna aproximación al análisis de los ciclos económicos, con el objetivo de capturar los hechos estilizados de las diecisiete regiones españolas y determinar el número de ciclos existentes. En primer lugar, se aplica un modelo *Markov-switching* autorregresivo (MS-AR) para estudiar el comportamiento del índice de producción industrial en cada una de las regiones. Tomando como base estos resultados, obtenemos una clasificación de los ciclos regionales en tres grupos, el primero es el más grande –agrupa a diez regiones- y otros dos, que presentan comportamientos más extremos. Los resultados obtenidos de la aplicación de un modelo *Markov-switching* vectorial autorregresivo (MS-VAR) sobre estos tres grupos confirman la existencia de tres ciclos en el país, que contribuyen a formar el ciclo español. Nuestros resultados dejan abierta la posibilidad de utilizar el ciclo económico de algunas regiones –en concreto, las más representativas o avanzadas- para predecir la actividad económica a nivel nacional, a la vez que previenen contra la puesta en funcionamiento de políticas comunes regionales. Por tanto, la identificación de los diferentes ciclos económicos en España es necesaria para diseñar políticas económicas adecuadas para cada región o cluster de regiones.

Palabras clave: Ciclo económico, Medidas de sincronización, Modelos MS-VAR, Política regional.

Código JEL: C22, C32, E32, R11

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Introduction

The aim of this paper is to provide empirical evidence for the existence of different common regional business cycles in Spain and to analyze their synchronization with the aggregate Spanish regional cycle. In order to do this, we use non-linear models which adopt the modern strategy to analyze cycle activity, that is, the Markov-switching vector autoregression model (MS-VAR). After the seminal paper of Hamilton (1989), there is now a rebirth of interest in this method as an alternative to classical business cycle measures[1]. Recent works, such as Krolzig (1997), Artis *et al*. (2005) and Krolzig and Toro (2005), amongst others, have highlighted the ability of this parametric approach to capture stylized business cycle features. MS-VAR models offer more robust statistical tools as well as helping to understand economic activity[2].

The motivation of this paper is based on three other main issues: a) In the international literature, the Markov Switching methodology is used more and more to identify the main cycle patterns of economic aggregates. Despite the advantages of this methodology, b) the studies have mainly been applied on countries and there are few concerning a lower level mostly because of the absence of adequate data[3.] On the whole, there have been few attempts to investigate regional business cycles and all of them use employment variables as a proxy for economic indicators of activity. c) The paper focuses on Spain, a country with appropriate characteristics and where the previous literature is scarce. On the one hand, there are studies that analyze the Spanish business cycle compared to other countries, basically its main European neighbors (Camacho et al., 2005)[4]. On the other hand, there are studies that try to measure the cycle in Spain as a whole without going into regional behaviors and mainly using GDP or employment variables, the latter being a less accurate indicator of economic activity than the industrial production index (Doménech and Gómez, 2005; Dolado et al., 1993). The exception –considering regional activity- is the paper by Cancelo and Uriz (2003) applied to Spanish regions but also with employment data[5].

To sum up, our paper intends, using the recent technique of switching regime models and looking at a lower geographical level, to identify the cyclical patterns of Spanish regions in order to establish the degree of intracountry co-movements. Besides, we

[1] A survey of these kinds of models and their applications can be found in Hamilton and Raj (2002).
[2] Nevertheless, Harding and Pagan (2002a, b) criticize the MS approach because it depends on the validity of the statistical model and, as a consequence, it is less robust that classical business cycle dating techniques.
[3] As far as we know, the only paper to do so is Rodríguez and Villemaire (2004) for Canada regions.
[4] A similar non-linear method such as STAR models has been applied by Cancelo and Mourelle (2005) in order to capture the asymmetric behaviour in international GDP.
[5] This paper analyses turning points, co-movements and bi-directional causality, without using non-linear models.

use, for the first time, the series of industrial production indexes that better fit the economic cycle and, thus, contribute to a better understanding of the economic fluctuations in the country, explained by considering regional effects.

The paper is organised as follows. Section 2 describes the data, identifying stylised facts in Spanish regions and describing the econometric methodology used. Section 3 seeks some common features to set clusters of regions. Section 4 analyses the existence of co movements inside every regional cluster set previously and their incidence in a macro-regional business cycle. Section 5 explores the common cluster cycle compared to the cycle obtained from the data at a national level. Finally, Section 6 concludes.

1. **Stylized facts in Spanish regions**

We use monthly industrial production indexes for all the 17 Spanish regions[6], with a working sample from 1991:10 to 2005:12 available with two different base years[7]. Our source is the Instituto Nacional de Estadística. With base year 1990, we have data from 1991:10 to 2002:12, while with base year 2000, the available data are from 2002:01 onwards, but our study only considers until 2005:12, thereby obtaining 171 observations for each region[8]. This is the first time this index has been used to measure regional business cycles in Spain, mainly due to the absence of long enough series. This decision could be controversial, but the lack of regional accounts series does not allow the use of GDP or other more representative measures of aggregate activity. Apart from the statistical restrictions, the industrial sector reflects the rhythm of the business cycle more accurately than employment data, which are the most commonly used in regional studies. The GDP shows a cyclical path similar to the industrial sector, but smoothed by the more stable behavior of the tertiary sector.

In fact, with a simple look at the growth rates of GDP and industrial added value since the 90s we appreciate similar profiles, although they are more pronounced in the case

[6] We consider the 17 Spanish Autonomous Communities that correspond to level two in the EUROSTAT nomenclature (NUTS2). We maintain the original Spanish names and the regions are denoted by Andalucia (AND), Aragón (ARA), Asturias (AST), Baleares (BAL), Canarias (CAN), Cantabria (CANT), Castilla y León (CYL), Castilla-La Mancha (CLM), Cataluña (CAT), Comunidad Valenciana (CVAL), Extremadura (EXTR), Galicia (GAL), Madrid (MAD), Murcia (MUR), Navarra (NAV), País Vasco (PVAS) and La Rioja (LAR).

[7] The Industrial Production Index (IPI) is a situational indicator that measures the monthly development of the productive activity of the industrial branches contained in the NACE-93, excluding construction. It therefore measures the joint development of quantity and quality, eliminating the influence of prices. Data are obtained through a continuous monthly survey, which includes more than 13,200 industrial establishments every month.

[8] Data from 2001:01 to 2002:12 have also been provided by the Instituto Nacional de Estadística. The authors have linked the two series (1991:10 - 2002:12 and 2002:01 - 2005:12) for each region and so, the reliability derived from the data is our own responsibility.

of industrial production. Hence, in the period analyzed we can distinguish three big phases in the Spanish economic cycle. The end of expansion of the 80s, the profound crisis of 1992-1993 and the dilated recovery that began in 1994, which included high growth years and short slowing downs, more marked in the industrial activity.

Nevertheless, though better than employment data, we should recognize that the behavior of the industrial production index is not a perfect indicator of economic activity; rather, its goodness depends on the weight industry represents in each territory. In order to give a brief idea, in Spain industry weights 14.4% of GDP and for regions, only in CAN, BAL and EXTR is industry below 7% (but these regions together represent only the 8% of the total Spanish GDP), while in another eight regions (representing 44% on the total Spanish GDP) industry weights more than 15%, with PVAS and NAV very close to 25%. Therefore, we can see that the weight of the industrial sector in the Spanish regions shows some heterogeneity.

Industrial production index data are previously purged of outliers and seasonally adjusted[9]. A preliminary analysis is carried out applying the MZ_t-GLS unit root tests proposed by Ng and Perron (2001), which are modified forms of the Phillips-Perron test [Phillips and Perron (1988)] and based on the detrended GLS data. We also use the KPSS of Kwiatkowski et al. (1992) that tests for the null hypothesis of stationary. Both have been applied to two different specifications one that includes intercept and one that has intercept and trend. The results lead us to a very robust conclusion: we cannot reject the presence of a unit root in the series, whilst we can reject the null of stationarity[10]. Consequently, in the rest of the analysis we use the first difference of the series in logs (see Figure 2).

We use univariate Markov switching autoregressions (MS-AR) for each region in order to give a statistical characterization of the industrial production index growth, measuring macroeconomic fluctuations and detecting changes in its. Further, these preliminary results will serve for analyzing the degree of synchronization and common features of the business cycle across regions. Once we have identified these co-movements, we can estimate the multivariate version of the Markov switching model, MS-VAR, and find out the number and composition of regional cycles.

The Markov switching technique has become very popular since Hamilton (1989) used it to measure the U.S. business cycle. The MS-AR models try to characterize the evolution of a variable through a process of conditioned mean to a state of a specific nature, with its consequent volatility, finally representing a process of stochastic trend. The changes in value in this dynamic process will allow us to differentiate periods of expansions and contractions. Using the Markov Switching methodology, we have the following model:

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[9] This has been done by using the programme TRAMO-SEATS [Gómez and Maravall (1996)]. The original and adjusted series are plotted in Figure 1.
[10] Detailed results of these tests are available from the authors upon request.

$$\Delta y_t - m_{s_t} = f_1\left(\Delta y_{t-1} - m_{s_{t-1}}\right) + ... + f_p\left(\Delta y_{t-p} - m_{s_{tt-p1}}\right) + e_t \text{ with } e_t \approx NID\left(0, s^2\right) \quad [1]$$

where the mean growth rate m_{s_t} depends on the state s_t and may be negative in the first regime (contraction, s_t=0) and positive in the second (expansion, s_t =1) and the third regimes (high growth period, s_t =2). The variance of the disturbance term e_t is assumed to be dependent through regimes, capturing the supposed higher volatility in recession phases. Regime shifts are governed by a stochastic and unobservable variable s_t, and the conditional density function of y_t is given by:

$$f(y_t \mid s_t = j, y_1, ..., y_{t-1}; a) \quad [2]$$

where the random variable s_t follows a Markov chain of order one with probabilities of transition p_{ij}, and a represents the vector of parameters that characterize the density functions conditional on each possible regime ($j = 1,2,...N$). The transition probabilities p_{ij} are defined as follows:

$$p_{ij} = P\left(s_t = j \mid s_{t-1} = i\right), \qquad \sum_{j=1}^{N} p_{ij} = 1 \quad [3]$$

When the conditional process is subject to shifts in the mean, there is a once-and-for-all jump in the time series. In contrast, we can use a more plausible model with shifts in the intercept that imply a smooth adjustment of the time series after regime shifts. If we assume that the model is linear in each regime, say s_t=m, we obtain the following autoregressive process:

$$\Delta y_t = u_m + a_{m1}\Delta y_{t-1} + ... + a_{mp}\Delta y_{t-p} + e_t \quad [4]$$

We use Maximum Likelihood to estimate the model, based on a version of the Expectation-Maximization algorithm discussed in Hamilton (1990)[11].

For each region we look for the best model capturing its business cycle features. The number of regimes (2 or 3), the order of autoregressions and the changes in the variance are selected on the basis of their significance and the information criteria. The estimation results are in Table 1. The first idea we can extract at a regional level is that two-regime models are unable to capture the recent business cycle in most regions. Consequently, we extend the analysis to a third regime that covers high growth periods. So, we have two groups, the two-regime regions (AND, CAN, CLM and EXTR), and the three-regime regions (the rest). We consider regime-dependant

[11] The MS-VAR package for Ox has been employed in the computations [Krolzig, 1998].

heteroskedasticity although we do not find relevant differences of volatility between regimes. We also observe that linearity is rejected in all the regions with the exception of AND.

The second idea that emerges from the inspection of Table 1 is that each of the seventeen Spanish regions has a particular business cycle in which the intercepts in recessions (regime 1) vary from -0.06% in LAR to -3.16% in MAD; in expansions (regime 2) ranges between 0.01% in the PVAS and 1.54% in AST; and, finally, high growth or boom periods (regime 3) show values between 0.11% in LAR and 3.77% in MAD.

The third idea is that, in general, the average duration and probabilities of regimes (expansions/contractions/boom periods) differ between regions (Table 1 and Figure 4). The probability and duration of an expansion are higher than those of a recession, except in the cases of CLM, EXTR and AND. Although this is also true in AST, GAL and the PVAS, it is widely compensated by the sum of probabilities/durations of expansions and high growth periods. These conclusions are consistent with traditional characterizations of business cycles (see Burns and Mitchel, 1946).

We also show the time path of smoothed filtered and predicted probabilities. The filtered probability –depicted by the shaded area- presents the optimal inference on the state variable for a given regime *m* at time *t* using only the information up to time *t*, $P(s_t=m/y_t)$, whereas smoothed probability –the thick line- displays the optimal inference using the full sample, $P(s_t=m/y_T)$. Finally, predicted probabilities –the thin line- stand for the optimal inference on regime *m* at time *t* using all information at time *t-1*, $P(s_t=m/y_{t-1})$. The graphical analysis shows that univariate MS-AR does not fully capture the business cycle of regions and depicts significant differences between them and high volatility (Figure 3). The inherent extreme behavior of the industrial cycle in relation to aggregate activity is stressed at the regional level and turning points of individual regions do not seem to move together. Furthermore, this type of models are only able to fit some features such as non-linearity and asymmetry but obviously do not screen co-movements between regions. Hence, this method has let us to obtain cycle dating and a first picture of the regional business cycle, showing that they seem to have important disparities. Thus, we can affirm the existence of 17 non-identical regional business cycles in Spain. Nevertheless, it is possible these cycles to exhibit a great amount of synchronization, which could be interpreted as a sign that regional economies move together. Consequently, synchronization between regions should be studied in depth using adequate measures in the following section.

2. Business cycle synchronization

In this section we focus on the study of the possible relationship between the cyclical patterns of regional industrial activity. In particular, we want to explore their possible synchronization. To that end, we can use different measures of the synchronization of cycles such as Pearson's coefficient and the c^2 test both based on a contingency table and the index and test statistic of concordance proposed by Harding and Pagan (2004). Finally, if we find some degree of synchronization, we apply a cluster analysis with the aim of obtaining groups of regions with similarities in their cyclical evolution, which could provide useful information about the behavior patterns followed by regional cycles in Spain.

According to Harding and Pagan (2004), for each *i*-region we can build a binary random variable S_{it}, taking value 1 when the *i*-region is in an expansion phase and zero when it is in a recession phase. The concordance index for two regions *i*, *j* is defined as follows:

$$I_{ij} = T^{-1}\left[\sum_{t=1}^{T}(S_{it}S_{jt}) + \sum_{t=1}^{T}(1-S_{it})(1-S_{jt})\right] \qquad [5]$$

where T is the sample size. I_{ij} measures the proportion of time that two regions are in the same phase[12]. Notice that this index only shows similarities in the periodicity of regional cycles, independently of the length of the expansion and recession phases. Although this measure is very easy to interpret and offers a first picture of synchronicity in regional cycles, it has the disadvantage that it does not provide a statistical way of knowing whether the co-movements are significant or not. To solve this problem, Harding and Pagan (2004) suggest an alternative method based on the correlation between S_{jt} and S_{it}. They recommend estimating the coefficient $r_{S_{ij}}$ -which reflects the correlation between S_{it} and S_{jt} by using the generalized method of moments[13].

Starting with the following moment condition:

$$E[s_{S_{it}}^{-1}(S_{it} - m_{S_i})s_{s_j}^{-1}(S_{jt} - m_{S_{jt}}) - r_{S_{ij}}] = 0 \qquad [6]$$

[12] This index has been used by Krolzig and Toro (2005) for the European case.

[13] This method is robust to higher serial correlation and heteroskedasticity and, additionally, it does not matter which of the regions is the endogenous one [See Harding and Pagan (2004) and Hall and McDermott (2004)]. A new approach based on the bootstrap approximation of the t-ratio's true distribution is proposed by Camacho et al. (2004).

where m_{S_t} and $s_{S_t}^{-1}$ are, respectively, the mean and standard deviation of the time series S_{it}, we can estimate the value of $r_{S_{ij}}$ and test if $r_{S_{ij}} = 0$ using the t-test in its implicit estimator equation:

$$\frac{1}{T}\sum_{t=1}^{T}\hat{s}_{S_{it}}^{-1}(S_{it}-\hat{m}_{S_{it}})\hat{s}_{S_{jt}}^{-1}(S_{jt}-\hat{m}_{S_{jt}})-\hat{r}_{S_{ij}}=0 \qquad [7]$$

Finally, the well-known c^2 independency test is based on a contingency table where the frequencies of expansion and recession observations are counted for the two regions. This statistic has the following expression:

$$Q_{ij}=\sum_{u=1}^{s}\sum_{v=1}^{s}\frac{(n_{uv}-\hat{m}_{uv})^2}{\hat{m}_{uv}} \qquad [8]$$

where *s* is the number of regimes, *n* denotes the joint observed frequencies and *m* the estimated marginal frequencies[14]. This statistic is distributed under the null of independency as a c^2 with (s-1)x(s-1) degrees of freedom. We can also compute the contingency coefficient which lies in the range 0-1 from less to more cycle commonality[15].

$$C_{ij}=\frac{1}{\sqrt{5}}\sqrt{\frac{Q_{ij}^2}{Q_{ij}^2+T}} \qquad [9]$$

The results of the concordance index and the estimation of $\hat{r}_{S_{ij}}$ and its t-test are reported in Table 2, whilst the outcome of the contingency tables analysis is shown in Table 3 for the case of two and three regimes. Finally, Table 4 summarizes all the synchronization measures and, at the bottom, we can find two figures that show m_{S_t} and a naïve comprehensive measure calculated as the average of the other indicators. Different measures obtain noticeably different ranges of values. We observe that the pair-wise correlations r^s_{ij} are typically smaller than those obtained with the concordance index, which are around 0.6, suggesting that the stronger correlation between industrial regional cycles detected with I_{ij} is biased by the values of mean $m_{S_{ij}}$. The pair wise values obtained with the contingency analysis are also relatively small. Nonetheless, the evidence for rejecting the null hypothesis of no association is quite

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[14] We compute the two alternatives of the contingency test considering two or three regimes. For countries with three regimes, which correspond to recession, growth and high growth, a dichotomous distinction between recession and expansion has been made.
[15] This method has been applied by Artis et al. (2004) to analyze the synchronization of the European business cycle and by Cancelo and Uriz (2003) who suggested using simulation techniques instead of the chi-square distribution.

strong between regions, around 50% when we consider the HP t-test and the Pearson independence test with 2 regimes –over 70% if 3 regimes are taken into account. Furthermore, we can see that CAT, NAV and ARA are the regions most connected with the rest, while AND, EXTR and CLM are the most isolated. Summarizing, in spite of the differences, we can conclude that the regional cycles are sufficiently correlated to explore the possibility of inferring some common cycles across Spanish regions.

Before doing so, we identify groups of regions by applying a cluster analysis: regions in the same cluster will have more synchronization and similar business cycle features between them than regions in other groups. In the previous study we have only used categorical variables which describe the path of the cycle. However, we should note that the univariate MS-AR for individual regions has provided more information about the business cycle for each region including the number of regimes, the mean growth in each regime, the dating and duration of recession and expansion phases and the probabilities of each regime. Consequently, several variables collecting these characteristics of the business cycle are used in the clustering algorithms[16].

Two types of clustering methods have been used: the hierarchical and partitioning algorithms. The first starts by forming a group for each individual. New items are then added employing some criterion of similarity, in our case minimizing the increase of the Euclidean square distance within clusters. The process goes on until all the individuals are in a single cluster[17]. As a result, it is necessary to select the most suitable number of clusters, according to the history of the clustering, which shows the increase of the coefficient of the average distance each time that a new item is added to some group. A graph of this distance and the number of steps is very useful in the selection process. The sequence of clustering is displayed in a typical plot called a *tree diagram* or *dendrogram* (Figure 5) where we can see the detailed clustering process. The most important jump in the coefficient of distances is observed around the 13th and 14th sequence. In the 12th we have a big cluster formed by ARA, CVAL, BAL, NAV, MAD, MUR, CAN and CYL. In the 13th sequence GAL, LRIO and CAT are added to this group, in the 14th, CANT, in the 15th CLM, EXTRT and AND, and in the final sequence AST and PVAS. Looking at these results, 4 or 5 clusters seem the most suitable decisions.

This method offers us a first solution to the clustering and the number of clusters present in our set of regional business cycles. In a second step, we apply a non-hierarchical clustering method called *k-means*, that requires previously deciding the number of groups. This method is of the partitioning type, so called because they get a single solution and begin by defining the initial k-centers or seeds according to some similarity measure, and the individuals are included in each group in function of their minimum distances. At each iteration, the center distance is re-calculated and the final

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[16] Figures 4 show the values of these variables by regions.
[17] Because of the different scale of the variables used, they have been previously standardized.

solution is reached when the center of the k-groups, in other words, the assignation of individuals to groups, does not change and the process has converged. The result with k=4 groups determines that AND, CLM, EXTR and GAL are included in the first cluster, CANT in the second, AST and PVAS in the third and the rest of the regions in the fourth[18]. We observe that the only difference with the hierarchical method is the case of Galicia (GAL). The previous results about the synchronization with other regions are not conclusive because they are similar in the two possible groups. Moreover, GAL is one of the regions with lowest m_s but with a high degree of relationship with other regions. Finally, we have decided to include it in the same group as AND, EXTR and CLM because of its income homogeneity and because the *k-mean* methods is preferred to the hierarchical in order to get the best partition, given the number of clusters. This technique also gives us the significance of the variables used in the building of clusters. The length and probability of regimes are the most relevant variables and the mean growth in expansions the least.

Figure 6 illustrates the results of the *k-mean* method, displaying the intra-cluster distance on the OX axis and the inter-cluster distance on the OY axis[19]. We can see that in the big cluster formed by ten regions ARA has the minimum distance within the group and acts as its centre of gravity. Conversely, LRIO has the maximum distance. In the cluster which includes AND, CLM, EXTR and GAL, the first behaves as the attractor of the group while GAL is situated at the extreme, in accordance with its geographic situation. Finally, we observe that the cluster formed by AST and PVAS and the individual CANT are very close both for the intra-groups and inter-groups distances. For this reason, and also taking into account the previous results of synchronization and in order to avoid one-member groups, we decided to put these three regions into the same group to carry out the MS-VAR analysis. To sum up, and in order to clarify the notation, we hereafter call G1 the group formed by ARA BAL, CAN, CYL, CAT, CVAL, MAD, MUR and LRIO, G2 that which includes AND, EXTR, CLM and GAL and G3 AST, CAN and PVAS. Notice that the second brings together the four Spanish regions with the lowest per capita income levels, the third is made up of the industrial Cantabrian coast regions and the large first group includes the rest[20].

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[18] The solution with k=5 has been ruled out because the results offer more heterogeneity between the regions of each cluster.

[19] The distance between groups is also displayed by the size of the balls and reflects the similarity within them but is not significant in itself because it depends on the initial random center assignation. The first group, selected by alphabetical order, is used as the numerary.

[20] Cancelo and Uriz (2003) analyze contemporaneous co-movements in employment for Spanish regions. They found three groups of regions in terms of cyclical synchronization (when investigating number of turning points or bidirectional causality, other patterns are found). The first group, with a high degree of cyclical synchronization -where the null of independence is rejected across members-, is formed by AND, ARA, AST, CYL, CAT, CVAL, GAL, PVAS and LRIO. The second group includes CAN, CLAM, MAD, MUR and NAV (due to the similar number of nonrejections of cyclical independence hypothesis, groups 1 and 2 could form the same group, although three regions, CAN, MUR and NAV, could be considered an intermediate group). And finally, in the third group, where employment cycles are driven by specific factors, would be BAL, CANT and EXTR.

In short, synchronicity measures have offered a preliminary picture of the degree of synchronization and give support to the possibility of common cycles. Clustering techniques have grouped the different regions according to their cycle characteristics. Thus, in spite of the differences, we can distinguish groups of regions that share similar characteristics in their business cycles. The next step is to estimate the joint business cycle for each region. To do so, an MS-VAR model will be used in the next section to identify the common cycles in the three groups.

3. Measuring business cycle by MS-VAR method

There has been little use of non-linear techniques in Spain and this has focused on the business cycle of the country as a whole and in comparison with other European countries. Little attention has been devoted to investigate cross-regional transmission of shocks. However, as we have seen in the last section, the coincidence of regime shifts and, thus, the great degree of concordance of measures applied is high enough to suggest the idea of common regime shift generating processes for the three groups of regions and to move to the multivariate MS-VAR models.

We apply a MS-VAR method to each of the three groups of regions obtained in the previous section. We consider models with more than two regimes, as in Section 2, and assume that the variance is the same in all regimes. We consider the following MS-VAR process:

$$y_t = v(s_t) + A_1(s_t)y_{t-1} + ... + A_p(s_t)y_{t-p} + e_t \qquad [10]$$

where $y_t = (y_{1t}, ..., y_{nt})$ is a *n* dimensional time series vector, *v* is the vector of intercepts, $A_1, ..., A_p$ are the matrices containing the autoregressive parameters and e_t is a white noise vector process such that $e_t | s_t \sim NID\ (0, \Sigma(s_t))$.

Three-regime models have been chosen for the G1 and the G3 groups of regions, and a two-regime model for the G2, the three of them based on results of Section 2. The number of lags has been selected in accordance with their significance and information criteria, and the results are reported in Table 5.

The first group of regions, which can be considered the leader group because it represents two thirds of the total Spanish GDP in 2004, shows a duration of contractionary periods of 1.81 months, whereas expansions last 4.53 months and the average duration of high growth periods is 1.74 months. Thus, the probability of this group of regions being in a recession in the period considered is only 0.24. In the full system, only LRIO has an atypical behavior with a very flat cycle, confirming the univariate analysis which shows little difference between the mean in normal and high growth phases. As we mentioned earlier, LRIO showed some differences depending on the clustering method and was finally placed at the end of the first group (see Figure 6)[21].

In the second group of regions, which brings together the poorest and the biggest regions and weights 24% of the total Spanish GDP, recessions tend to last 12.23 months, while the average duration of normal growth periods is lower, 7.40 months. The ergodic probability of being in an expansion is 0.38. The absence of a high growth regime and their slow rate of growth seem to point to an unsatisfactory convergence process despite being the main cohesion fund receivers among the Spanish regions.

Finally, in the third group of regions -the Cantabrian coast group-, the average duration of a recession is 2.35 month, whereas the length of an expansion is 5.28 months and a high growth period lasts 6.44 months. In this case, the probability of being in a recession is 0.13, while the probabilities of being in a normal growth or in a high growth period are both around 0.45. Therefore, in the period studied, the Cantabrian coast group presents the best results in terms of economic growth. Nevertheless, CANT shows atypical behavior because the second regime depicts a negative growth rate – lower than regime 1- but the third regime show an explosive expansion with a rate of 0.78%. This result confirms that obtained previously with the clustering method which separated this region from the rest of Cantabrian coast[22].

It is worthwhile remembering at this point that the industrial sector in G3 has the largest weight, around a 19% of total activity, and its regions are among the most dynamic and richest in recent years. Conversely, the industrial sector in G2 only represents 11% although the per capita income level has arisen quite a lot in most of them. Finally, G1, the largest group, has an intermediate position with a weight of the industrial sector of 15% and different rhythms of growth[23].

The transition matrix in Table 5 shows that, in the third group of regions, high growth regimes are more commonly reached through the normal expansionary regimes and not directly from a contractionary period, but that in the first group of regions this rule does not hold[24]. In addition, probabilities and cycle dating by regimes and groups of regions are plotted in Figure 7. The classification of the regimes is carried out by

[21] Despite having one of the weightier industries within the heterogeneous first group, this region is characterized by an important agro business sector, probably less sensitive to economic cycle. However, it we use geographical arguments, this region should be included in G1 as we have done.
[22] We have also explored the possibility of including CANT in G1. In this case, although it fits into a three-regime model, it causes some distortion to the behaviour of other regions. However, when a two-regime model is estimated for G3, CANT depicts the same pattern as PVAS and AST with a very long-lasting growth regime. For this reason we have decided to maintain the three-regime model in accordance with the AIC information criterion.
[23] See Regional Accounts 2004, published by INE (http://www.ine.es).
[24] There is a great deal of controversy in the literature about this question. While in Krolzig and Toro (1998) or Artis *et al* (2004), high growth regimes are only reached through normal growth regimes, in Sichel (1994) and Clements and Krolzig (2002), contractions are typically followed by high growth periods that allow the output to return to its pre-recession level.

assigning the observation at time t to the regime $m \in \{1,2,3\}$ with the highest smoothed probability[25]

$$m^* = \arg\max_m P(s_t = m / y_t) \qquad [10]$$

Although a significant volatility remains in this cycle dating, the model achieves a better representation of the main stylized facts on the Spanish economy, especially for G1. The recession troughs appear at the beginning (during the 90s crisis) and from the slow-down of 2001 to today, reflecting the stagnation of industrial activity. The normal growth regime lasts the longest and, finally, peaks of high growth appear disseminated throughout period. The other two groups offer more extreme cycle dating regimes for the recession phase –G2- and for high growth in the case of G3.

Once we have analyzed the existence of a common cycle within each cluster of regions, we move on to investigate the dynamics of transition of each region to changes in the regime of the state variable, through the use of Impulse Response Functions[26]. An Impulse Response Function traces the response of a variable of interest to an exogenous shock. In particular, we analyze the response, in terms of cyclical fluctuations, of the industrial production index in each group of regions to a change in regime. We choose the kind of shocks to study in function of the highest probabilities shown in the transition probabilities matrix (Figure 5). So, for G1 we will study the shifts from an expansion to a recession (probability of 0.35) and from a recession to a high growth period (0.37). For G2 we will analyze the effects of the only two possibilities, expansion to recession (0.08) and recession to expansion (0.14). And, for G3 we will focus on the effects of shifts from expansion to recession (0.31) and from expansion to high growth period (0.13).

The effects of moving from an expansion to a recession (transition from regime 2 to 1) in Spanish regions of G1 in terms of timing are more or less imperceptible after a year and a half. These regions show two different dynamical patterns. For ARA, CAT, MUR, CAN and LRIO, recessions are milder –particularly, in the case of LRIO, the IRF shows a flat pattern-, whereas in MAD, CVAL, NAV, CYL and BAL the amplitude of fluctuations is higher (and similar between them) and reach their trough at the very beginning. In terms of magnitude, we can distinguish MAD, BAL, CVAL, MUR and NAV by their great initial negative incidence[27]. On the other hand, the response of G1 regions to a high growth period (regime 1 to 3) presents similar patterns; the highest variability is shown by CVAL, MAD and BAL, while on the other side, the effects on

[25] Further details of this rule can been found in Krolzig and Toro (2005).
[26] We use the methodology of Krolzig and Toro (1998), where the history is represented by a given state from which we shock the system whereas the nature of the shock is given by the specific state of nature to which we move, that is, cyclical shocks.
[27] The use of IPI to measure business cycles makes the graphical representation of Impulse Response Functions show more pronounced fluctuations than when using GDP (see, for example, Artis *et al*). Though it would have made cyclical patterns milder, we have chosen to use the more common orthogonalized IRF instead of cumulative ones.

MUR, CAT and LRIO are relatively weak. In terms of timing, the effects of high growth periods are completely diluted in eighteen months, but with great variability in the three cases (Figure 8).

The G2 group reaction to a recession (regime 2 to 1) finishes in fifteen months. The region that reacts most strongly –in terms of variability and magnitude of shifts- is AND, followed by CLAM and GAL. In the case of AND, the lowest point is reached at the beginning, whereas in the case of EXT it is not reached until approximately month three. The response patterns that characterize regions when an expansion takes place (regime 1 to 2) show similar trends to the response to a recession but with the opposite sign. Once again, the highest fluctuations are seen in the rate of growth of AND, followed by GAL and CLAM, while in EXTR they are milder. In terms of magnitude, GAL and CLAM suffer a parallel increase, with their peaks reached at month two. The cases of AND and EXTR are at the extremes, the magnitude of a boom in AND is achieved at month one and in EXTR not until month three.

Facing a Spanish recession (regime 2 to 1) for G3, the three regions have a similar pattern, which is closer in the case of CANT and PVAS. In terms of timing the three regions reach their lowest point in the initial period, but the magnitude of the decline in industrial production is more pronounced in AST. The effects disappear approximately in fifteen months. The pace for G3 when a boom (regime 2 to 3) occurs shows very similar results for the three regions in terms of synchronization. The peak is reached for AST, CANT and PVAS at the same time, while the variability is a little smoother in PVAS (Figure 8).

The findings employing Impulse Response analysis reflect the peculiar tendencies in the paths of IPI growth in each of the three clusters of regions when they face a change in regime.

4. Comparing the regional and Spanish cycles

Finally, we will study the Spanish cycle and compare the results with those obtained from the regional cycles. We will estimate an MS-AR model for the aggregate industrial production index in Spain applying the same methodology described in Section 2. Then, we will test the degree of synchronization at an intra country level in comparison with the whole country cycle.

The immediate conclusion that emerges in the analyses is that a two-regime model (contractions and expansions) is not able to capture adequately the business cycle in

Spain[28], as occurred in most regions. Therefore, we extend the model to three regimes, one recession cycle and two corresponding to moderate and high growth, respectively. Starting with a model with twelve lags, the final model has been selected according to the Akaike information criteria (AIC) and the significance of the intercepts and lags. Furthermore, information criteria and LR linearity tests corroborate the non-linear behavior of the Spanish business cycle. The outcome of the estimation is reported in Table 6 and the regime probabilities are plotted at the end of Figure 3. The normal growth regime has intercept mean of 0.3% and the smallest variance; the high growth regime shows a value of 0.91% and the biggest variance; and finally, the recession phase has an average of –0.87 and a lower variability than the high growth phase. As far as probability and length are concerned, the third regime is the most likely and longer-lasting, while the first is the least probable and the shortest-lived. In any case, there are no important differences in their unconditional (ergodic) probabilities, being around a third for each regime. Consequently, the three-regime model for the Spanish cycle is fairly symmetric. It is also worthwhile to look at the transition probabilities which reflect the persistence of regimes. We can see that it is very unlikely to go directly to the high growth regime, rather, this state can only be reached by starting from the normal growth regime[29]. However, it is more probable to pass to the recession regime from the high growth regime than from the normal growth regime. From the intermediate phase, the probability of going to either of the other two regimes is very similar. Finally, the plot of smoothed and filtered probabilities shows a similar path, reflecting the ability of the model to detect the three regimes and the cycle dating shows a high dispersion of observations across different phases. This path probably is the consequence of aggregating several non-synchronic but more concentrated paths, instead of symmetric and common regional cycles. This possibility will now be explored.

Table 7 summarizes the main features of the business cycle –duration and probabilities- of the regional groups in comparison with the Spanish one. With respect to the duration and probabilities of each regime, we can observe that the intermediate regime of G1 –the largest and formed by AR, BAL, CAN, CYL, CATA, CVAL, MAD, MUR, NAV and LRIO- is the most probable and longest-lasting, the other regimes being more extreme situations, both with a similar probability. In the case of G3 –AST, CANT and PVAS- the moderate growth regime is also the most likely but the third regime presents a bigger probability with respect to regime one. Finally, G2 –AND, CLM, EXTR and GAL-, with only two regimes representing contractions and expansions, has around two thirds of its probability in the recession phase. So, we can

[28] This is a similar result to that obtained by Krolzig and Toro (2005) with GDP data when they analyse the European cycle. The presence of the third regime, associated with high growth periods, is interpreted as a sign of convergence processes.

[29] As has been mentioned before, Krolzig and Toro (2005) find a similar result for the European cycle, highlighting the difference with respect to evidence for the U.S. where recession periods are followed by high growth recovery phases.

see the Spanish cycle as a synthesis of these three regional groups, and its apparent symmetry is really a mixture of asymmetries in opposite directions. In order to confirm this impression, we have carried out a synchronization analysis in the same way as that in Section 3 for individual regions. Considering only the two-regime model, the contingency coefficient shows a high and significant relationship between the cycle of Spain and G1 and G2, while in the case of G3 it is lower and non significant. Similar results are obtained with HP measures. Although the concordance index arranges the three groups as G1, G2 and G3 from high to low value, the estimation of the correlation coefficient and its t-test maintains G1 as the group of regions most synchronized with Spain, but removes G3. Nonetheless, if the more plausible model with three regimes is taken into account, G3 emerges as a regional set with a very similar cycle to Spain, having a similar coefficient and significance to G1.

To sum up, the MS-VAR model has shown its efficacy in modeling regional cycle paths in a system. A three-regional set with similar business cycle features has been identified and their estimation tells us their different degrees of synchronization with the Spanish cycle. So, this reflects the weight of the business cycle described by the large G1 -formed by 10 of the 17 regions- and mixes characteristics of the other two groups. Hence, a business cycle made up of a persistent, longer and very likely regime with a moderate rate of growth, and two others –recession and high growth regime- with similar probabilities and lengths is the best representation for this group. If we add the more atypical cases of G2 –only two regimes with a predominance of recession periods- and G3 with a longer and persistent high growth regimes- we can build the aggregate Spanish business cycle. These results suggest the possibility of taking advantage of the fact that G1 is the most representative and using it as a reference to forecast the national cycle, selecting the more advanced regions in this group.

5. **Conclusions**

The main goal of the paper is to improve our understanding of the business cycle in Spanish regions and determine how many cycles there are. To do so, we have applied a Markov switching vector autoregression model MS-VAR that provides an optimal inference of the turning points and other features of business cycle. A first univariate analysis allows us to capture the stylized facts –length, probabilities and mean growth in each regime- characterizing the economic activity in Spain and the individual regions. A three-regime model, corresponding to recession, normal and high growth phases, was needed in Spain and most regions to capture the cyclical paths accurately. Starting from these previous results, we have studied the degree of synchronization among regions in order to identify common cycles and we have obtained three groups between Spanish regions.

The first, a larger group formed by ten regions, exhibits a business cycle characterized by a likely and longest-lasting normal growth regime and two other regimes representing recessions and high growth, both with a lower and similar probability. A second group of Spanish regions that are traditionally the poorest and with slow rates of growth and that receive cohesion and structural funds (Objective 1) is clearly identified. Meanwhile the high growth period of the Cantabrian coast in the last fifteen years has determined the third group, characterized by the high weight of its industrial sector.

The application of the MS-VAR model gives support to the previous results and estimates different business cycles with common regime shifts in the stochastic process of the industrial activity growth of each of the three groups. The Spanish cycle shows a high concordance with the first group and can be seen as a synthesis of these three regional groups, combining the more stable behavior of group 1 and the more extreme behavior of groups 2 and 3. Furthermore, using impulse-response functions provides a study of the transmission of shocks across regions.

Our findings have two interesting implications. First, the possibility of forecasting the Spanish cycle on the basis of regional analysis. Once regional cycles are fully identified, the most representative regions, or those with more advanced cycles in each group, might be used in order to forecast Spanish economic activity. Secondly, the results are also relevant for economic policy, because if we distinguish different regional cycles across regions, we should not apply a nationwide scope without focusing on particular areas. In other words, a centralized approach to policy making that does not consider localized measures to smooth regional fluctuations might not to be the most suitable. The regions of group two are a good example. The absence of a high growth regime emphasizes the poor convergence achieved in spite of European funds received in recent years. Due to the limitations for regional macroeconomic policy in the euro zone context, economic measures should be implemented at a disaggregated level, taking into account at least the common features of regional clusters and taking advantage of the wide possibilities that a decentralized fiscal policy offers.

Summarizing, our paper would add to the still relatively reduced empirical literature that employs the modern alternative of MS-models instead of the classical business cycle approach, especially at a regional level. The paper has shown that this method could be a useful statistical tool to capture essential business cycle features and leads us to meaningful results with different political implications.

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APPENDIX

A.1: Tables

Table 1: Univariate MS-AR models of the Business Cycle by Regions

	AND	ARA	AST	BAL	CAN	CANT	CYL	CLM	CAT	CVAL	EXT	GAL	MAD	MUR	NAV	P.VAS.	LAR
Regime-dependent intercepts																	
μ_1	-0.95	-2.04	-2.49	-2.24	-1.06	-1.15	-1.04	-0.04	-1.09	-2.34	-0.09	-0.38	-3.16	-1.46	-2.16	-0.07	-0.06
	(0.004)	(0.01)	(0.002)	(0.011)	(0.001)	(0.004)	(0.002)	(0.000)	(0.001)	(0.010)	(0.000)	(0.002)	(0.009)	(0.002)	(0.001)	(0.000)	(0.000)
μ_2	1.81	0.21	1.54	0.48	0.07	0.34	0.006	0.13	0.15	0.001	0.13	0.22	0.95	0.35	0.35	0.01	0.07
	(2.31)	(0.001)	(0.004)	(0.002)	(0.001)	(0.002)	(0.001)	(0.000)	(0.001)	(0.002)	(0.000)	(0.002)	(0.004)	(0.001)	(0.001)	(0.000)	(0.000)
μ_3		2.27	2.52	2.49		2.10	0.03		1.15	1.21		1.57	3.77	1.03	1.76	0.24	0.11
		(0.003)	(0.006)	(0.015)		(0.002)	(0.001)		(0.002)	(0.008)		(0.001)	(0.008)	(0.004)	(0.002)	(0.000)	(0.000)
Regime-dependent variances																	
σ^2_1	0.021	0.001	0.013	0.020	0.005	0.008	0.008	0.000	0.005	0.027	0.000	0.001	0.034	0.011	0.001	0.002	0.001
σ^2_2	0.024	0.001	0.012	0.009	0.006	0.008	0.006	0.000	0.003	0.014	0.000	0.008	0.022	0.007	0.009	0.000	0.000
σ^2_3		0.001	0.030	0.022		0.006	0.010		0.006	0.017		0.004	0.025	0.015	0.010	0.001	0.001
Persistence of Regime 1																	
Erg.Prob.	0.51	0.16	0.39	0.30	0.30	0.16	0.34	0.74	0.27	0.20	0.63	0.43	0.26	0.21	0.18	0.31	0.43
Duration	6.57	2.14	2.50	1.73	1.64	3.50	2.62	6.89	2.15	1.01	8.70	4.85	1.00	4.88	1.73	1.75	4.92
Persistence of Regime 2																	
Erg.Prob.	0.49	0.62	0.20	0.41	0.70	0.71	0.57	0.26	0.35	0.66	0.37	0.40	0.51	0.49	0.49	0.23	0.24
Duration	6.25	4.87	1.29	4.21	3.76	15.23	3.07	2.43	1.87	4.57	5.02	4.84	9.11	8.12	6.76	1.01	2.49
Persistence of Regime 3																	
Erg.Prob.		0.22	0.41	0.29		0.14	0.09		0.38	0.14		0.17	0.24	0.31	0.34	0.46	0.33
Duration		2.86	6.40	1.67		2.84	1.21		2.34	1.18		1.92	1.00	5.11	3.28	9.90	4.73
Log Lik.	355.45	460.37	336.90	370.72	520.46	497.15	473.81	882.74	521.82	363.44	829.54	506.28	328.09	474.28	456.00	791.20	875.84
LR lin.Test	(0.222)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Notes: The intercepts are expressed in ‰ and p-values are in parenthesis.

Table 2: Concordance Index and Estimation of correlation coefficient and Test of Harding and Pagan

	AND	ARA	AST	BAL	CAN	CANT	CYL	CLM	CAT	CVAL	EXT	GAL	MAD	MUR	NAV	P.VAS.	LAR
AND	-	0.07 (0.409)	0.08 (0.382)	0.05 (0.557)	0.34 (0.000)	0.06 (0.440)	0.15 (0.156)	0.13 (0.136)	0.17 (0.075)	0.05 (0.362)	0.13 (0.188)	0.14 (0.264)	0.02 (0.742)	0.14 (0.063)	0.24 (0.000)	0.14 (0.187)	0.11 (0.282)
ARA	0.551	-	0.10 (0.156)	0.19 (0.001)	0.13 (0.019)	0.11 (0.050)	0.05 (0.381)	0.05 (0.289)	0.11 (0.070)	0.18 (0.000)	0.09 (0.170)	0.08 (0.211)	0.18 (0.010)	0.05 (0.295)	0.13 (0.004)	0.14 (0.015)	0.07 (0.288)
AST	0.538	0.620	-	0.14 (0.060)	0.17 (0.040)	0.11 (0.040)	0.32 (0.000)	-0.03 (0.725)	0.28 (0.001)	0.14 (0.000)	0.12 (0.173)	0.15 (0.141)	0.08 (0.070)	-0.02 (0.732)	0.15 (0.017)	0.20 (0.016)	-0.02 (0.802)
BAL	0.513	0.734	0.582	-	0.25 (0.000)	0.11 (0.042)	0.05 (0.522)	0.02 (0.803)	0.14 (0.024)	0.14 (0.005)	0.11 (0.165)	0.20 (0.043)	0.10 (0.040)	0.10 (0.129)	0.09 (0.030)	0.20 (0.090)	0.06 (0.415)
CAN	0.601	0.709	0.608	0.709	-	0.13 (0.330)	0.13 (0.085)	0.03 (0.746)	0.17 (0.002)	0.11 (0.018)	0.22 (0.003)	0.11 (0.099)	0.17 (0.000)	0.12 (0.048)	0.15 (0.002)	0.09 (0.196)	0.02 (0.757)
CANT	0.519	0.816	0.665	0.728	0.690	-	0.02 (0.704)	-0.05 (0.414)	0.11 (0.050)	0.04 (0.307)	0.09 (0.146)	0.05 (0.294)	0.11 (0.043)	0.10 (0.051)	0.10 (0.069)	0.01 (0.805)	0.11 (0.039)
CYL	0.557	0.665	0.690	0.614	0.627	0.658	-	-0.04 (0.608)	0.22 (0.000)	0.11 (0.078)	-0.01 (0.887)	0.31 (0.000)	0.07 (0.116)	0.03 (0.649)	0.19 (0.002)	0.12 (0.127)	0.10 (0.203)
CLM	0.563	0.367	0.456	0.367	0.418	0.297	0.424	-	0.12 (0.05)	0.04 (0.426)	0.28 (0.000)	0.10 (0.156)	0.00 (0.971)	0.06 (0.381)	0.04 (0.450)	0.04 (0.617)	0.18 (0.030)
CAT	0.576	0.759	0.671	0.671	0.684	0.741	0.715	0.430	-	0.03 (0.376)	0.18 (0.013)	0.27 (0.007)	0.10 (0.015)	0.02 (0.000)	0.15 (0.002)	0.21 (0.010)	0.28 (0.000)
CVAL	0.494	0.778	0.576	0.703	0.677	0.785	0.633	0.323	0.665	-	-0.03 (0.224)	0.07 (0.349)	0.23 (0.000)	-0.02 (0.520)	0.10 (0.000)	-0.04 (0.439)	-0.02 (0.740)
EXT	0.570	0.462	0.538	0.487	0.538	0.418	0.506	0.665	0.513	0.405	-	0.21 (0.014)	-0.04 (0.254)	0.11 (0.162)	0.13 (0.022)	0.08 (0.282)	0.10 (0.299)
GAL	0.563	0.646	0.595	0.646	0.595	0.639	0.715	0.544	0.684	0.589	0.589	-	0.04 (0.514)	0.10 (0.087)	0.23 (0.000)	0.08 (0.224)	0.28 (0.001)
MAD	0.519	0.728	0.589	0.690	0.703	0.722	0.595	0.373	0.677	0.848	0.443	0.589	-	-0.03 (0.618)	0.12 (0.002)	0.00 (0.978)	0.00 (0.958)
MUR	0.551	0.772	0.557	0.722	0.696	0.829	0.627	0.367	0.734	0.715	0.525	0.658	0.665	-	0.07 (0.199)	0.08 (0.263)	0.09 (0.221)
NAV	0.544	0.842	0.627	0.728	0.703	0.810	0.709	0.373	0.791	0.759	0.456	0.690	0.734	0.766	-	0.06 (0.373)	0.09 (0.117)
PVAS	0.551	0.709	0.608	0.658	0.608	0.652	0.627	0.418	0.684	0.639	0.487	0.595	0.639	0.658	0.652	-	0.10 (0.237)
LAR	0.551	0.532	0.506	0.570	0.544	0.614	0.601	0.570	0.633	0.576	0.525	0.684	0.525	0.608	0.576	0.595	-

Notes: In the bottom triangle, the concordance index is shown. In the top triangle, the estimation of the correlation coefficient is shown, with Test of Harding and Pagan, that is p-values, in parenthesis. The GMM method is used to obtain estimators robust to heteroskedasticity and series correlation by incorporating the HAC covariance matrix. We apply a quadratic kernel and the bandwidth selection is based on the variable method of Newey-West (1994).

Table 3: Contingency table (2 and 3 regimes)

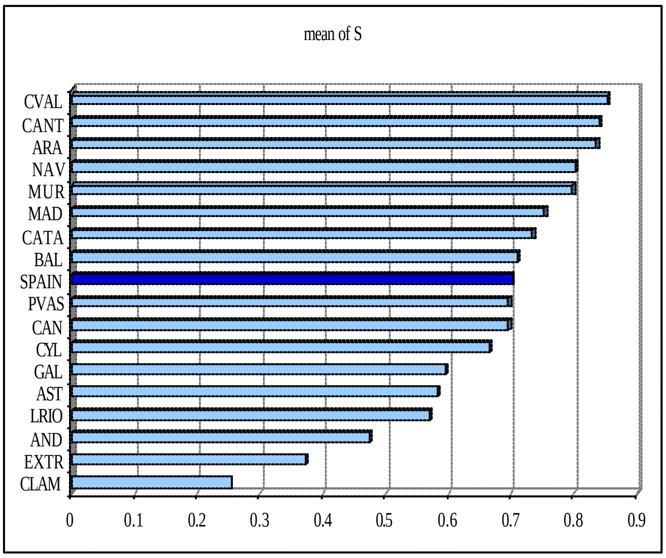
	AND	ARA	AST	BAL	CAN	CANT	CYL	CLM	CAT	CVAL	EXT	GAL	MAD	MUR	NAV	P.VAS.	LAR
AND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ARA	0.254	-	0.311	0.466	-	0.484	0.527	-	0.551	0.266	-	0.554	0.303	0.381	0.678	0.544	0.273
	(0.022)		(0.091)	(0.001)		(0.000)	(0.000)		(0.000)	(0.217)		(0.000)	(0.106)	(0.015)	(0.000)	(0.000)	(0.192)
AST	0.121	0.248	-	0.246	-	0.467	0.546	-	0.545	0.239	-	0.453	0.214	0.220	0.533	0.395	0.055
	(0.282)	(0.025)		(0.295)		(0.001)	(0.000)		(0.000)	(0.324)		(0.001)	(0.446)	(0.420)	(0.000)	(0.010)	(0.993)
BAL	0.072	0.380	0.150	-	-	0.415	0.457	-	0.321	0.387	-	0.382	0.403	0.470	0.453	0.281	0.320
	(0.520)	(0.000)	(0.179)			(0.005)	(0.001)		(0.072)	(0.012)		(0.014)	(0.007)	(0.001)	(0.001)	(0.164)	(0.074)
CAN	0.333	0.312	0.232	0.411	-	-	-	-	-	-	-	-	-	-	-	-	- -
	(0.002)	(0.004)	(0.037)	(0.000)													
CANT	0.140	0.434	0.407	0.351	0.232	-	0.318	-	0.518	0.240	-	0.438	0.252	0.610	0.661	0.165	0.364
	(0.211)	(0.000)	(0.000)	(0.001)	(0.037)		(0.067)		(0.000)	(0.320)		(0.002)	(0.270)	(0.000)	(0.000)	(0.704)	(0.025)
CYL	0.194	0.216	0.467	0.148	0.200	0.186	-	-	0.603	0.446	-	0.588	0.252	0.276	0.437	0.328	0.302
	(0.082)	(0.052)	(0.000)	(0.186)	(0.073)	(0.095)			(0.000)	(0.002)		(0.000)	(0.269)	(0.181)	(0.002)	(0.062)	(0.110)
CLM	0.164	0.143	0.012	0.106	0.052	0.150	0.018	-	-	-	-	-	-	-	-	-	-
	(0.142)	(0.203)	(0.914)	(0.343)	(0.647)	(0.181)	(0.871)										
CAT	0.276	0.422	0.411	0.253	0.311	0.342	0.445	0.168	-	0.349	-	0.691	0.242	0.529	0.630	0.420	0.403
	(0.012)	(0.000)	(0.000)	(0.022)	(0.005)	(0.002)	(0.000)	(0.132)		(0.036)		(0.000)	(0.311)	(0.000)	(0.000)	(0.004)	(0.007)
CVAL	0.047	0.217	0.072	0.237	0.165	0.231	0.069	0.010	0.007	-	-	0.364	0.805	0.341	0.318	0.051	0.279
	(0.678)	(0.050)	(0.524)	(0.033)	(0.139)	(0.038)	(0.539)	(0.927)	(0.954)			(0.024)	(0.000)	(0.044)	(0.077)	(0.951)	(0.171)
EXT	0.183	0.184	0.173	0.129	0.273	0.017	0.148	0.333	0.235	0.022	-	-	-	-	-	-	-
	(0.100)	(0.100)	(0.121)	(0.250)	(0.013)	(0.880)	(0.187)	(0.002)	(0.034)	(0.848)							
GAL	0.195	0.310	0.229	0.327	0.179	0.287	0.522	0.295	0.432	0.087	0.326	-	0.330	0.523	0.675	0.422	0.581
	(0.081)	(0.005)	(0.039)	(0.003)	(0.108)	(0.009)	(0.000)	(0.007)	(0.000)	(0.349)	(0.003)		(0.058)	(0.000)	(0.000)	(0.004)	(0.000)
MAD	0.104	0.252	0.155	0.297	0.356	0.215	0.040	0.006	0.215	0.686	0.024	0.125	-	0.263	0.391	0.192	0.347
	(0.353)	(0.023)	(0.165)	(0.007)	(0.001)	(0.053)	(0.720)	(0.957)	(0.053)	(0.000)	(0.830)	(0.239)		(0.224)	(0.011)	(0.563)	(0.038)
MUR	0.228	0.335	0.029	0.364	0.297	0.557	0.107	0.056	0.365	0.022	0.354	0.353	0.057	-	0.480	0.270	0.421
	(0.040)	(0.002)	(0.799)	(0.001)	(0.007)	(0.000)	(0.342)	(0.616)	(0.001)	(0.848)	(0.001)	(0.001)	(0.613)		(0.000)	(0.201)	(0.004)
NAV	0.210	0.600	0.271	0.381	0.315	0.471	0.394	0.096	0.552	0.220	0.120	0.454	0.323	0.364	-	0.421	0.250
	(0.059)	(0.000)	(0.014)	(0.000)	(0.004)	(0.000)	(0.000)	(0.385)	(0.000)	(0.048)	(0.286)	(0.000)	(0.003)	(0.001)		(0.004)	(0.279)
PVAS	0.185	0.312	0.232	0.254	0.102	0.075	0.200	0.052	0.311	0.001	0.117	0.179	0.142	0.158	0.126	-	0.311
	(0.097)	(0.004)	(0.037)	(0.022)	(0.363)	(0.505)	(0.073)	(0.647)	(0.005)	(0.995)	(0.296)	(0.108)	(0.206)	(0.158)	(0.261)		(0.090)
LAR	0.154	0.058	0.015	0.127	0.053	0.255	0.234	0.332	0.316	0.107	0.126	0.468	0.033	0.232	0.121	0.208	-
	(0.169)	(0.606)	(0.895)	(0.257)	(0.639)	(0.021)	(0.035)	(0.002)	(0.004)	(0.338)	(0.260)	(0.000)	(0.770)	(0.037)	(0.282)	(0.062)	

Notes: In the bottom triangle with two regimes and in the upper right angle with three regimes. P-value in brackets.

Table 4: Summary of syncronization measures

	?s	*C2*	*Q2*	*C3*	*Q3*	*I*	*?*	t-tesHP
AND	0.47	0.179	0.500			0.548	0.126	0.364
ARA	0.83	0.292	0.875	0.443	0.750	0.668	0.108	0.698
AST	0.58	0.202	0.500	0.352	0.667	0.589	0.123	0.447
BAL	0.71	0.249	0.687	0.383	0.833	0.633	0.122	0.530
CAN	0.70	0.239	0.687			0.632	0.153	0.526
CANT	0.84	0.272	0.625	0.411	0.750	0.661	0.079	0.510
CYL	0.66	0.224	0.688	0.423	0.750	0.623	0.108	0.482
CLM	0.25	0.125	0.250			0.435	0.105	0.226
CAT	0.73	0.316	0.938	0.489	0.912	0.664	0.101	0.637
CVAL	0.85	0.138	0.313	0.340	0.583	0.635	0.103	0.426
EXT	0.37	0.173	0.375			0.508	0.111	0.309
GAL	0.59	0.298	0.750	0.500	1.000	0.627	0.148	0.552
MAD	0.75	0.189	0.438	0.333	0.500	0.627	0.069	0.565
MUR	0.80	0.242	0.625	0.399	0.750	0.653	0.076	0.482
NAV	0.80	0.314	0.750	0.492	0.917	0.673	0.126	0.603
PVAS	0.70	0.166	0.438	0.317	0.583	0.611	0.101	0.395
LAR	0.57	0.177	0.438	0.328	0.583	0.577	0.103	0.378

Notes: $m_{S_{it}}$ is the mean of S_{it}. The other indicators show the average of their values for each region. C_2 and C_3 display the contingency coefficient with 2 and 3 regimes respectively; Q_2 and Q_3 are the corresponding test of Pearson; I is the index of concordance of Harding and Pagan; ? ?is the correlation coefficient and, finally, t-tesHP its corresponding t-test.



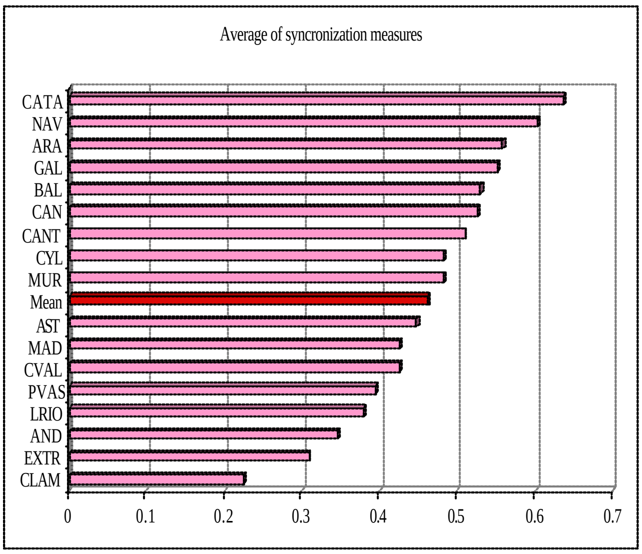


Table 5a: Estimation results of the MS-VAR model by groups of regions

	ARA	BAL	CAN	CYL	CATA	CVAL	MAD	MUR	NAV	LRIO
Regime-dependent intercepts										
Regime 1	-1.37	-2.34	-0.70	-0.97	-0.75	-2.21	-2.48	-1.36	-1.39	0.00
Regime 2	0.10	0.58	0.03	0.07	0.07	0.07	0.41	0.40	0.09	0.05
Regime 3	1.68	1.28	1.11	1.36	0.76	0.20	1.77	0.68	1.87	0.02
Autoregressive parameters at lag 1										
ARA	0.21	0.23	0.01	0.01	0.08	0.10	0.29	-0.06	-0.03	-0.03
BAL	-0.03	-0.31	0.02	-0.04	0.01	0.09	-0.05	-0.00	-0.05	0.00
CAN	-0.48	-0.65	-0.02	-0.27	-0.20	-0.30	-0.32	-0.27	-0.23	-0.03
CYL	0.14	0.11	-0.14	0.22	0.01	0.21	0.18	-0.07	-0.08	-0.02
CAT	0.12	-0.06	0.10	0.27	0.30	0.75	0.12	0.31	0.08	0.01
CVAL	-0.09	-0.30	-0.08	-0.13	-0.13	-0.97	-0.50	-0.17	-0.09	-0.01
MAD	-0.07	-0.15	-0.01	-0.09	-0.02	-0.22	-0.73	-0.02	-0.09	0.00
MUR	-0.03	0.06	0.07	0.02	-0.06	-0.34	-0.33	0.07	0.23	0.01
NAV	-0.04	-0.04	-0.10	-0.16	0.04	0.00	0.36	0.01	-0.03	0.01
LRIO	1.88	2.76	1.87	2.28	1.23	2.55	3.53	1.79	1.83	1.52
Autoregressive parameters at lag 2										
ARA	-0.09	0.14	-0.04	-0.06	0.13	0.03	0.15	0.16	0.14	0.02
BAL	0.01	-0.29	-0.01	0.00	0.03	0.23	-0.05	-0.00	-0.02	0.00
CAN	0.00	0.11	-0.05	0.04	0.10	0.03	0.01	-0.07	0.06	-0.02
CYL	-0.22	-0.20	-0.12	-0.12	-0.03	0.16	0.22	-0.11	-0.14	-0.00
CAT	-0.08	0.59	-0.24	0.08	-0.18	0.67	0.63	0.35	-0.14	-0.01
CVAL	-0.11	-0.37	-0.02	-013	-0.05	-0.86	-0.60	-0.08	-0.11	-0.001
MAD	0.01	-0.05	-0.01	-0.02	-0.02	-0.13	-0.31	-0.01	-0.02	-0.01
MUR	0.18	0.17	0.09	0.19	-0.05	-0.07	-0.23	0.06	0.24	0.03
NAV	0.21	0.25	0.20	0.07	-0.04	0.25	0.44	0.01	-0.00	-0.03
LRIO	-0.84	-1.93	-1.06	-1.24	-0.49	-1.55	-2.68	-1.46	-0.63	-0.56
SE	0.024	0.001	0.010	0.002						

Log-likelihood 5485.85 (vs. linear 5441.02)

AIC -61.84 (-61.62) HQ -59.65 (-59.62) SC -56.43 (-56.69) LR linearity test 89.66 (0.000)

	p_{1i}	p_{2i}	p_{3i}	Duration	Ergod.prob.	Observations
Regime 1	0.45	0.35	0.20	1.81	0.24	39.6
Regime 2	0.10	0.78	0.12	4.53	0.56	95.2
Regime 3	0.37	0.21	0.42	1.74	0.20	33.2

Notes: The intercepts are expressed in $^0/_{00}$.

Table 5b: Estimation results of the MS-VAR model by groups of regions

	AND	CLM	GAL	EXTR
Regime-dependent intercepts				
Regime 1	-0.10	-0.09	-0.03	-0.06
Regime 2	0.91	0.20	0.31	0.09
Autoregressive parameters at lag 1				
AND	-0.63	-0.01	-0.11	-0.02
CLM	3.11	1.21	1.29	0.06
GAL	-0.20	-0.02	0.01	-0.02
EXTR	1.28	-0.01	0.59	1.37
Autoregressive parameters at lag 2				
AND	-0.30	-0.01	-0.02	-0.01
CLM	-2.47	-0.71	-0.53	-0.02
GAL	0.10	0.01	0.07	-0.02
EXTR	-1.49	0.10	-0.78	-0.53
SE	0.024	0.001	0.010	0.002

Log-likelihood 2569.19 (vs. linear 2550.62)
AIC -29.97 (-29.82) HQ -29.57 (-29.47) SC -29.00 (-28.96) LR linearity test 37.14(0.000)

	p_{1i}	p_{2i}	Duration	Ergod.prob.	Observations
Regime 1	0.92	0.08	12.23	0.62	104.2
Regime 2	0.14	0.86	7.40	0.38	63.8

Notes: The intercepts are expressed in $^0/_{00}$.

Table 5c: Estimation results of the MS-VAR model by groups of regions

	AST	CANT	PVAS
Regime-dependent intercepts			
Regime 1	-1.47	-0.34	-0.36
Regime 2	0.13	-0.17	0.00
Regime 3	0.29	0.78	0.39
Autoregressive parameters at lag 1			
AST	-0.62	-0.06	-0.02
CANT	-0.07	-0.09	-0.08
PVAS	3.05	1.34	1.23
Autoregressive parameters at lag 2			
AST	-0.36	0.02	-0.00
CANT	0.05	0.09	-0.03
PVAS	-2.35	-1.53	-0.74
SE	0.028	0.009	0.010

Log-likelihood 1687.60 (vs. linear 1652.00)
AIC -19.62 (-19.35) HQ -19.33 (-19.14) SC -18.90 (-18.84) LR linearity test 71.20 (0.000)

	p_{1i}	p_{2i}	p_{3i}	Duration	Ergod.prob.	Observations
Regime 1	0.57	0.31	0.12	2.35	0.13	21.4
Regime 2	0.09	0.81	0.10	5.28	0.48	80.5
Regime 3	0.02	0.13	0.84	6.44	0.39	66.1

Notes: The intercepts are expressed in $^0/_{00}$.

Table 6: Spanish regional business cycle

	SPAIN
Regime-dependent intercepts	
Regime 1	-0.87
Regime 2	0.30
Regime 3	0.91
Regime-dependent variances	
σ^2_1	0.004
σ^2_2	0.002
σ^2_3	0.006

	Log-likelihood 554.23		(vs. linear 536.35)
AIC –6.76 (-6.66)	HQ -6.60 (-6.58)	SC -6.37 (-6.46)	LR linearity test 35.75 (0.000)

	p_{1i}	p_{2i}	p_{3i}	Duration	Ergod.prob.	Observations
Regime 1	0.38	0.62	0.00	1.61	0.30	47.7
Regime 2	0.23	0.43	0.34	1.76	0.33	52.0
Regime 3	0.30	0.00	0.70	3.30	0.37	58.3

Notes: The intercepts are expressed in $^0/_{00}$.

Table 7: Comparison of Spanish and regional business cycle

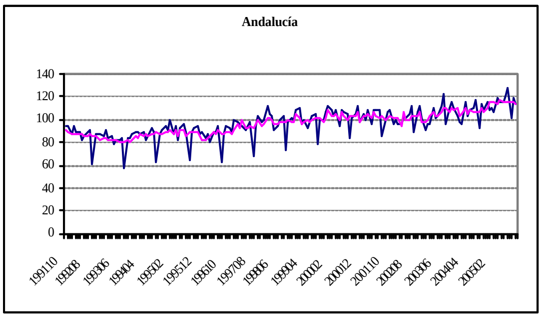
	G1	G2	G3
C_2	0.54	0.46	0.17
Q_2	26.73 (0.000)	18.23 (0.000)	2.27 (0.132)
C_3	0.63	-	0.58
Q_3	39.79 (0.000)		31.75 (0.000)
I	0.77	0.61	0.70
r	0.40	0.32	0.01
t-tesHP	4.53 (0.000)	5.04 (0.000)	0.35 (0.805)

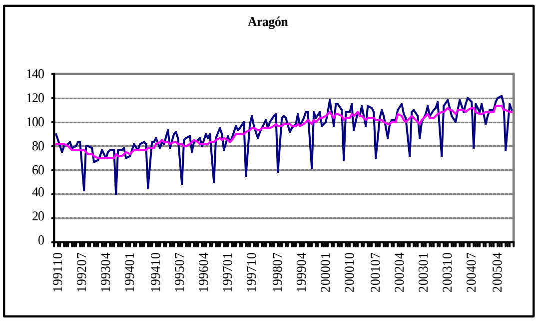
	Regimes probabilities			Regimes duration		
	Regime 1	Regime 2	Regime3	Regime 1	Regime 2	Regime3
Spain	0.30	0.33	0.37	1.61	1.76	3.30
G1	0.24	0.56	0.20	1.81	4.53	1.71
G2	0.62	0.38		12.23	7.40	
G3	0.13	0.48	0.39	2.35	5.28	6.44

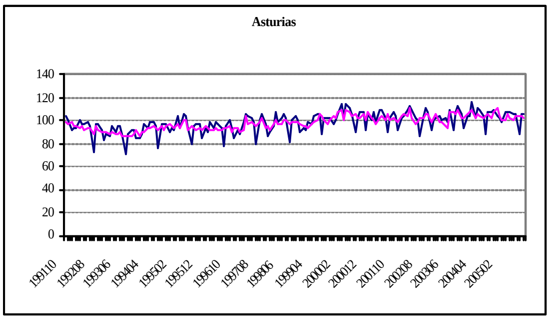
Notes: p-values in parenthesis. The group G1 is formed by ARA, BAL, CAN, CYL, CAT, CVAL, MAD, MUR, NAV and LRIO; G2 by AND, CLM, GAL, EXTR and G3 by AST, CANT and PVAS..

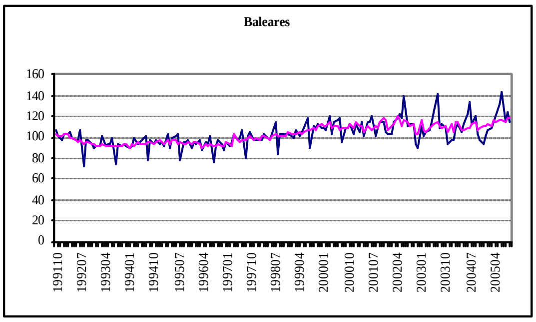
A. 2: Figures

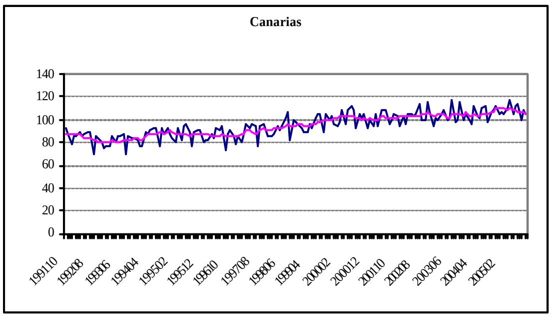
Figure 1: Industrial production index by regions

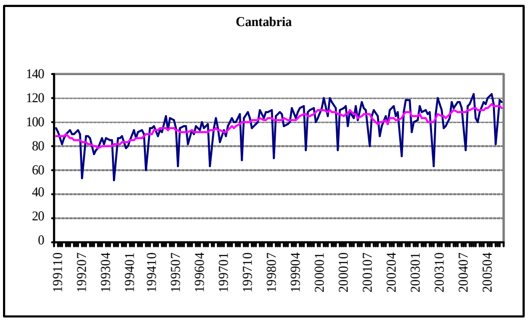


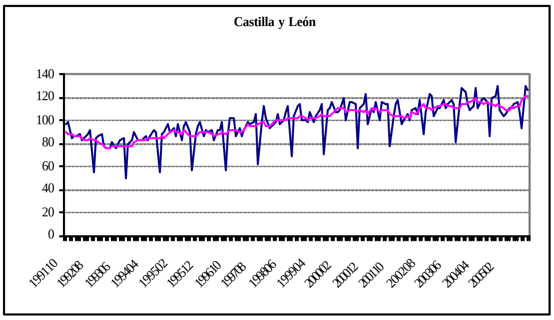


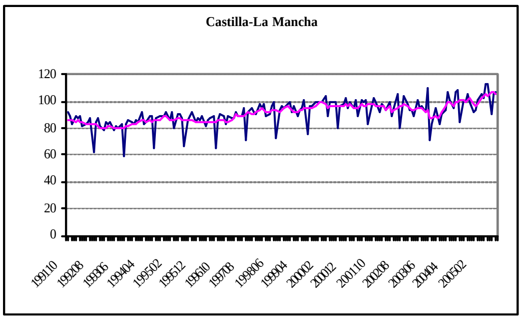


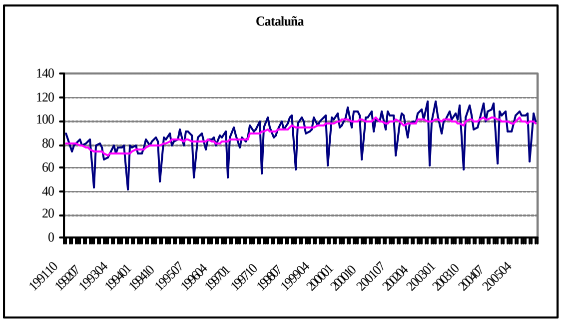


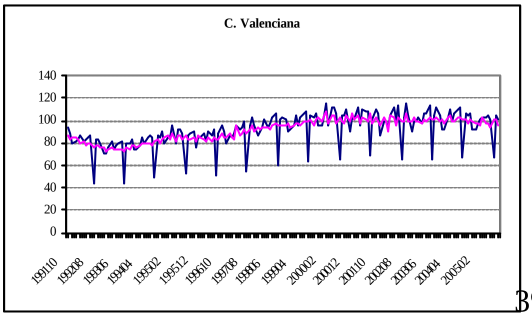


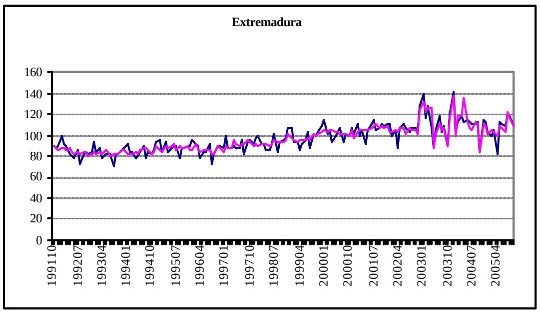


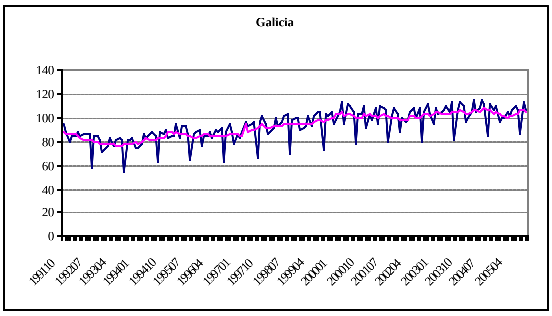









Extremadura
160
140
120
100
80
60
40
20
0
199110 199207 199304 199401 199410 199507 199604 199701 199710 199807 199904 200001 200010 200107 200204 200301 200310 200407 200504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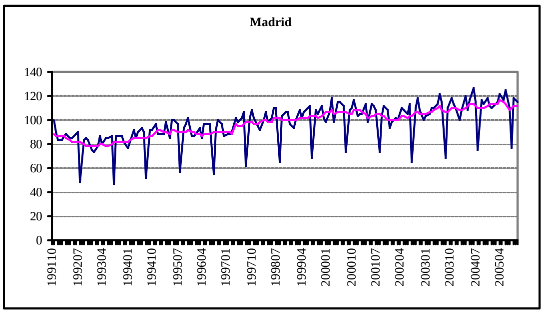
140
120
100
80
60
40
20
0


Madrid
140
120
100
80
60
40
20
0
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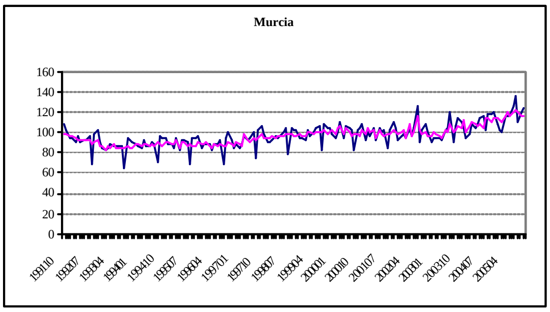
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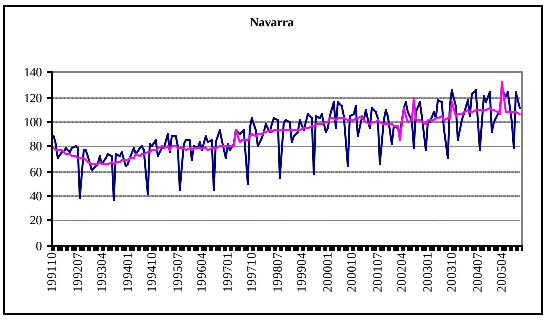
100
80
60
40
20
0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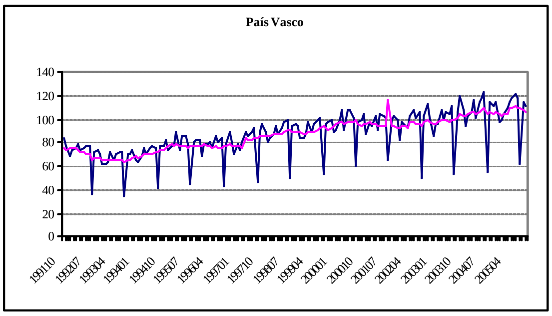
120
100
80
60
40
20
0
199110 199207 199304 199401 199410 199507 199604 199701 199710 199807 199904 200001 200010 200107 200204 200301 200310 200407 200504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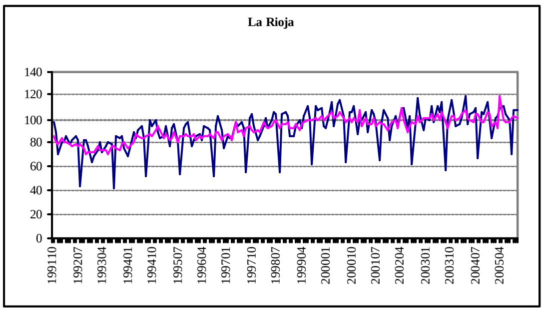
120
100
80
60
40
20
0


La Rioja
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120
100
80
60
40
20
0
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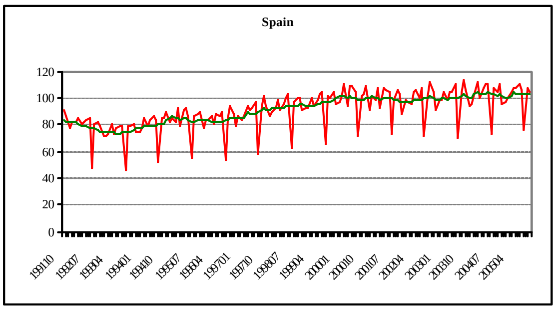
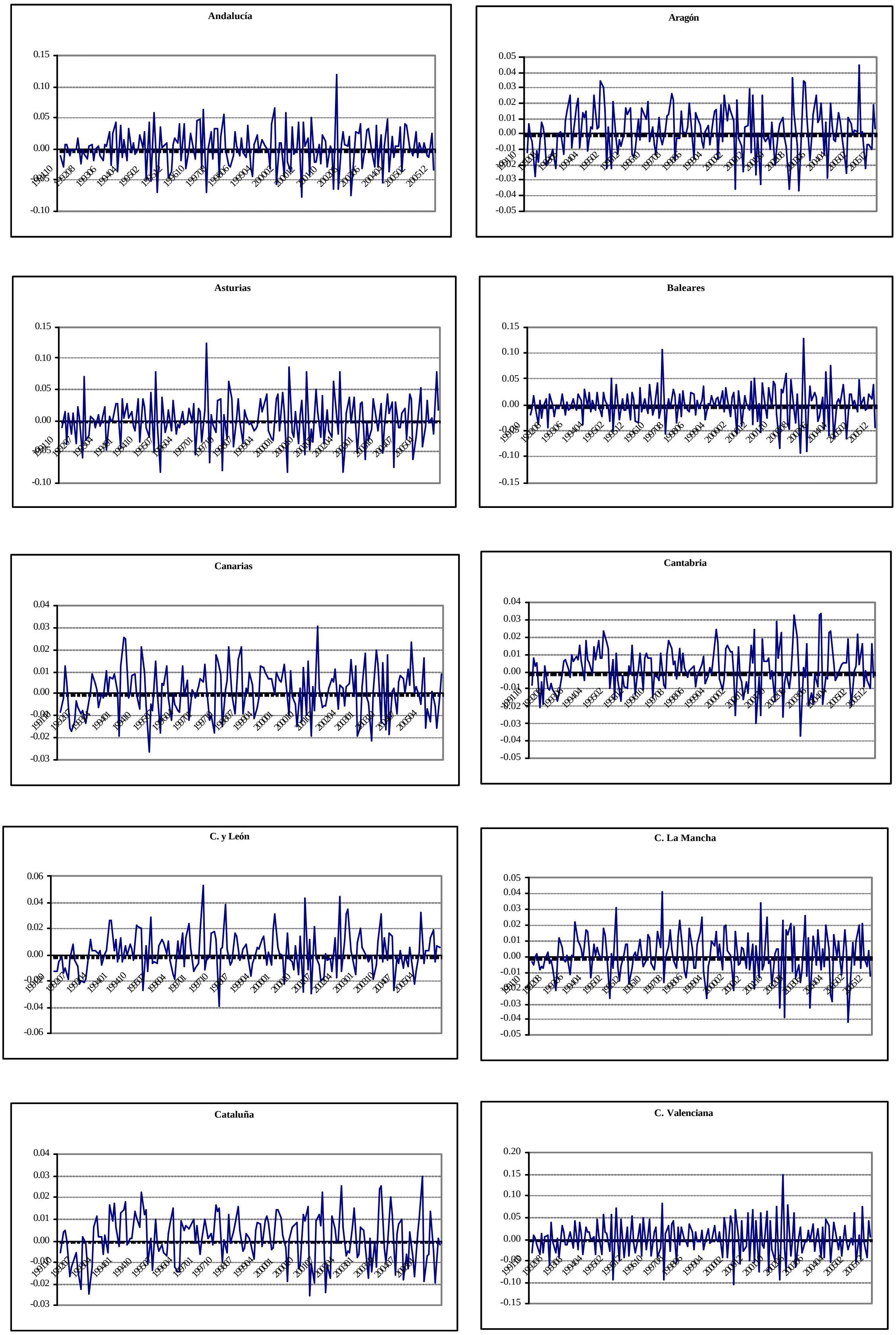
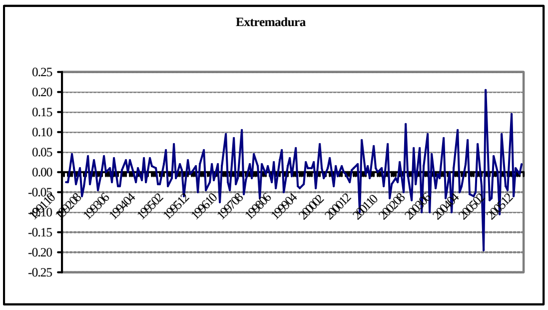

Spain
120
100
80
60
40
20
0

Figure 2: Growth of Industrial production index by regions

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0.05
0.00
-0.05
-0.10
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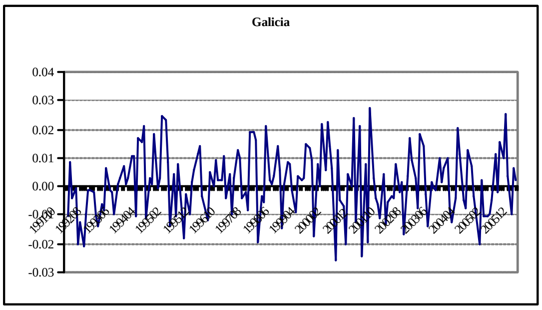
-0.25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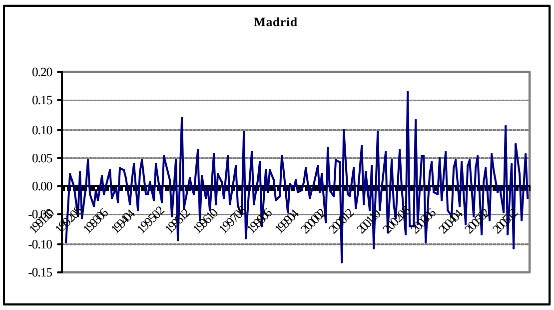
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03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0.15
0.10
0.05
0.00
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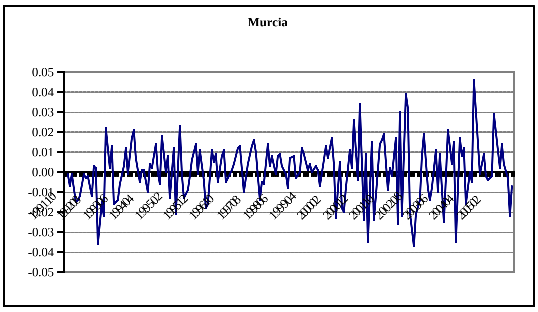
-0.10
-0.15


Murcia
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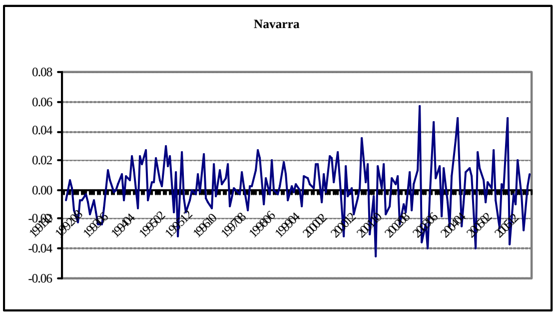
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05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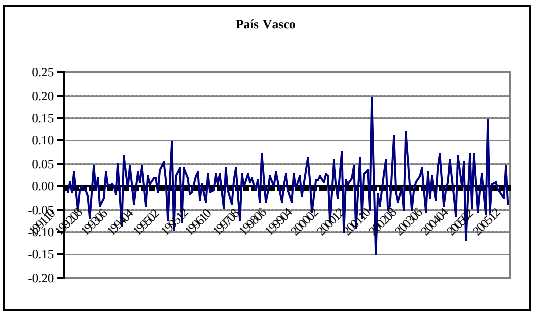
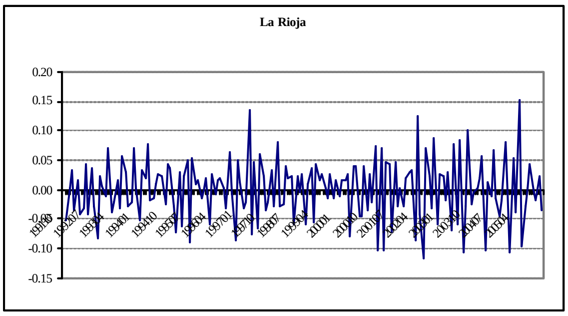
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06


País Vasco
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20


La Rioja
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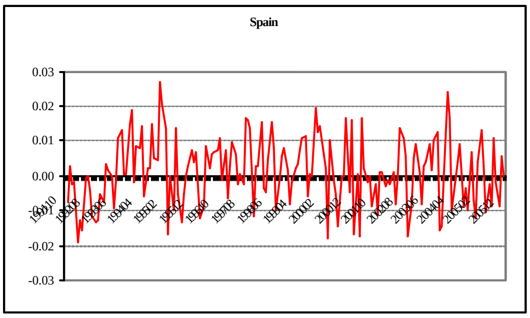
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15


Spain
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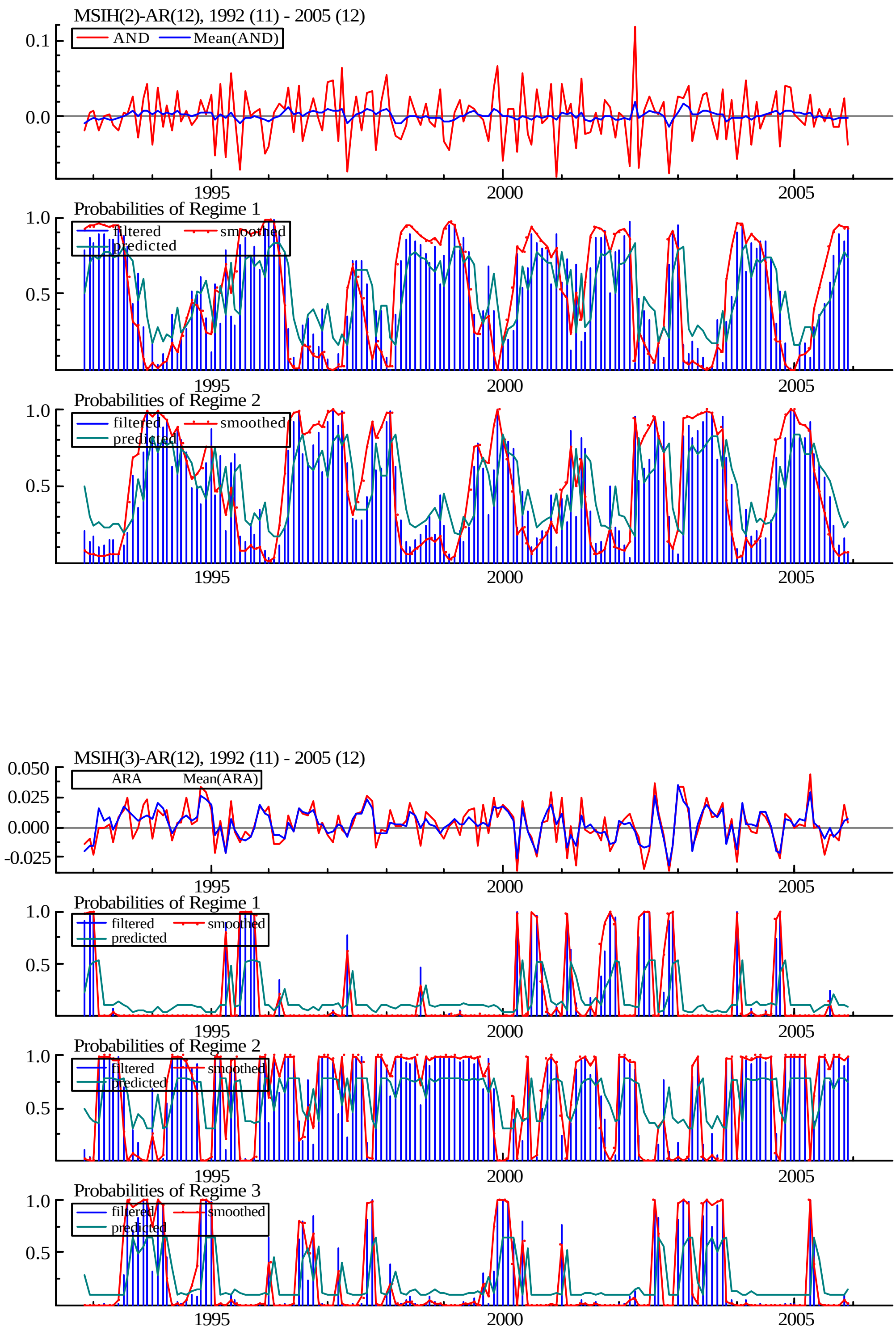
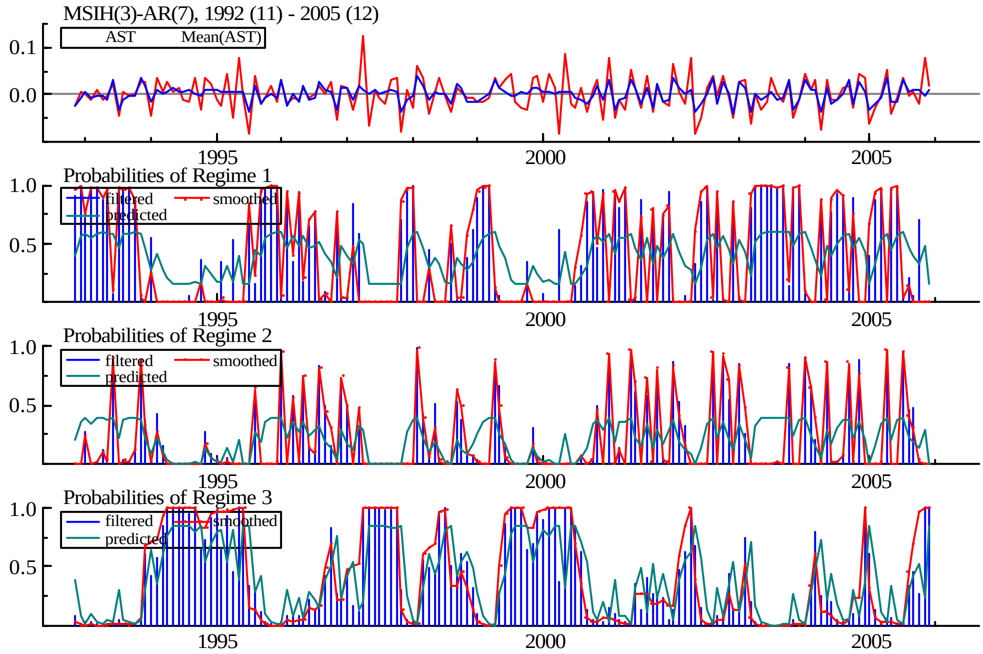
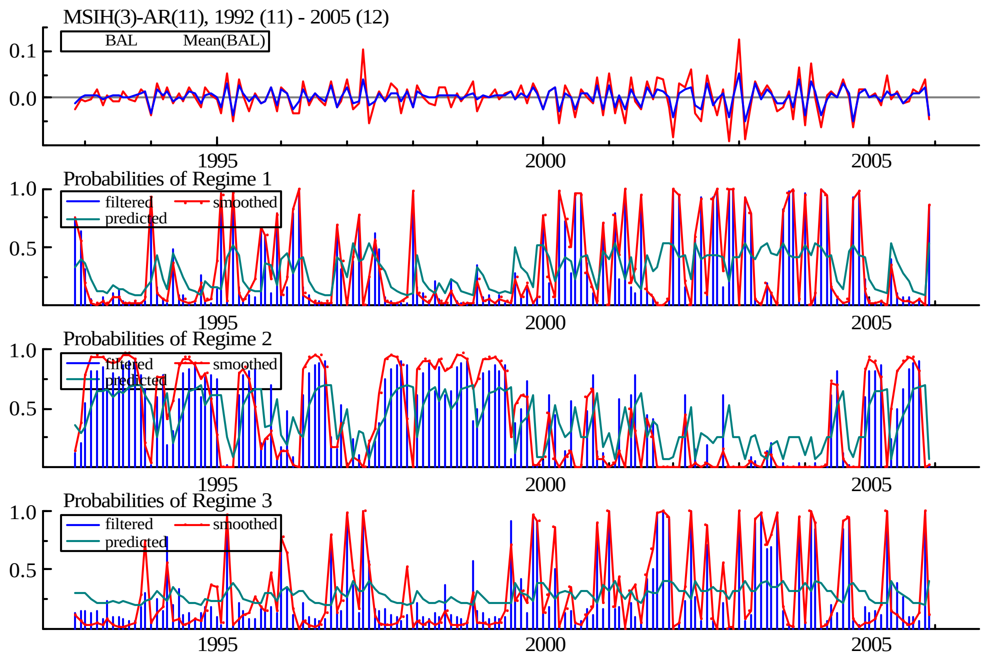
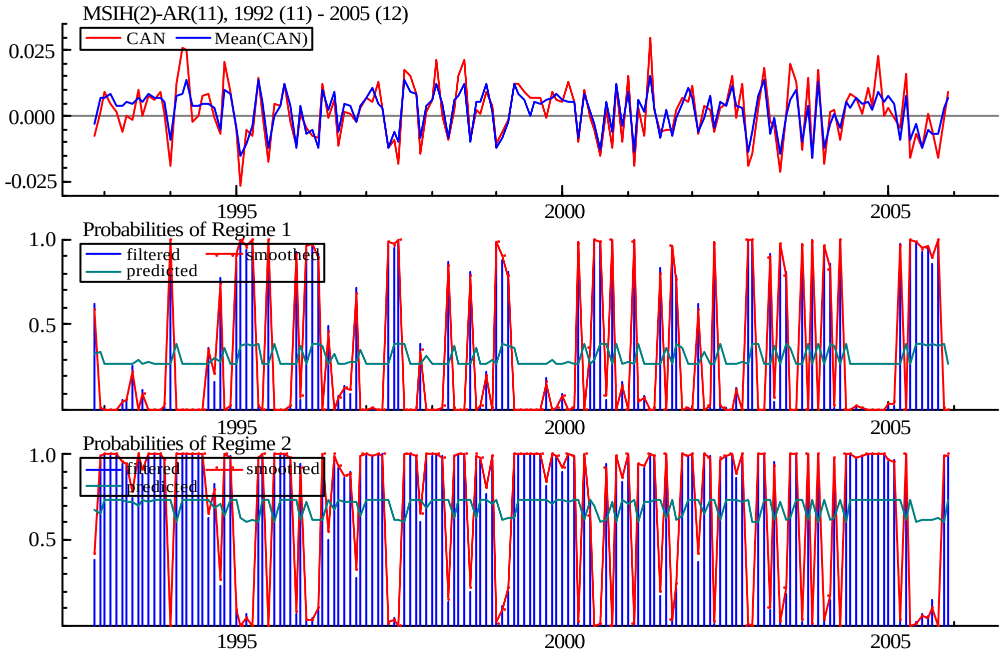
0.02
0.01
0.00
-0.01
-0.02
-0.03

Figure 3: Probabilities and cycle dating of regimes




MSIH(3)-AR(7), 1992 (11) - 2005 (12)
AST
Mean(AST)
Probabilities of Regime 1
filtered
smoothed
predicted
Probabilities of Regime 2
filtered
smoothed
predicted
Probabilities of Regime 3
filtered
smoothed
predicted
1995
2000
2005


MSIH(3)-AR(11), 1992 (11) - 2005 (12)
BAL
Mean(BAL)
Probabilities of Regime 1
filtered
smoothed
predicted
Probabilities of Regime 2
filtered
smoothed
predicted
Probabilities of Regime 3
filtered
smoothed
predicted
1995
2000
2005


MSIH(2)-AR(11), 1992 (11) - 2005 (12)
CAN
Mean(CAN)
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0.000
-0.025
1995
2000
2005
Probabilities of Regime 1
filtered
smoothed
predicted
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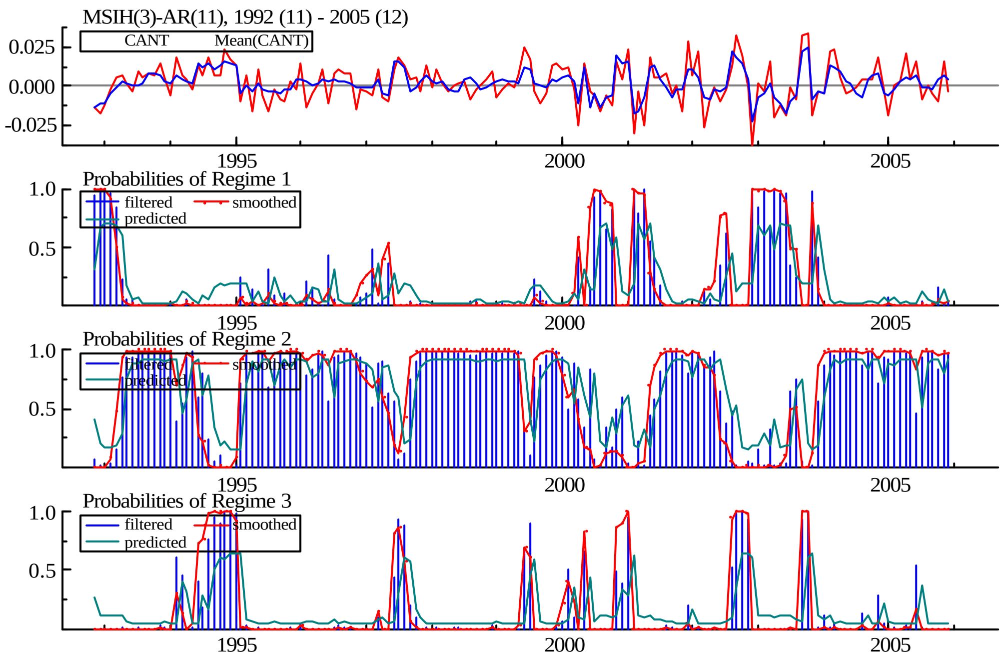
0.5
Probabilities of Regime 2


MSIH(3)-AR(11), 1992 (11) - 2005 (12)
CANT
Mean(CANT)
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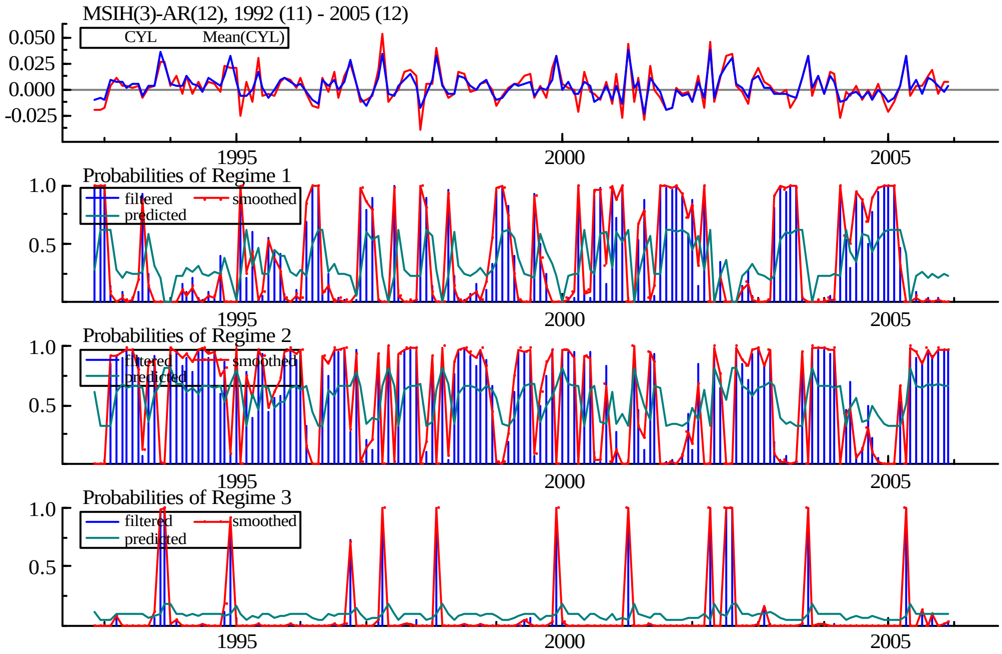
0.000
-0.025
1995
2000
2005
Probabilities of Regime 1
filtered
smoothed
predicted
1.0
0.5
Probabilities of Regime 2
Probabilities of Regime 3


MSIH(3)-AR(12), 1992 (11) - 2005 (12)
CYL
Mean(CYL)
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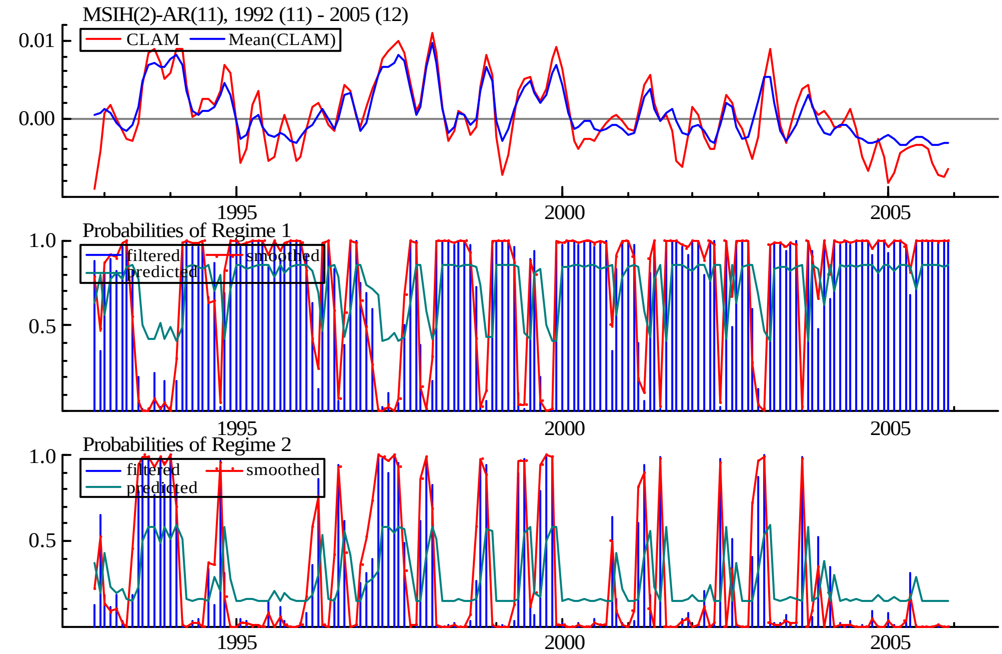
0.025
0.000
-0.025
1995
2000
2005
Probabilities of Regime 1
filtered
smoothed
predicted
1.0
0.5
Probabilities of Regime 2
Probabilities of Regime 3


MSIH(2)-AR(11), 1992 (11) - 2005 (12)
CLAM
Mean(CLAM)
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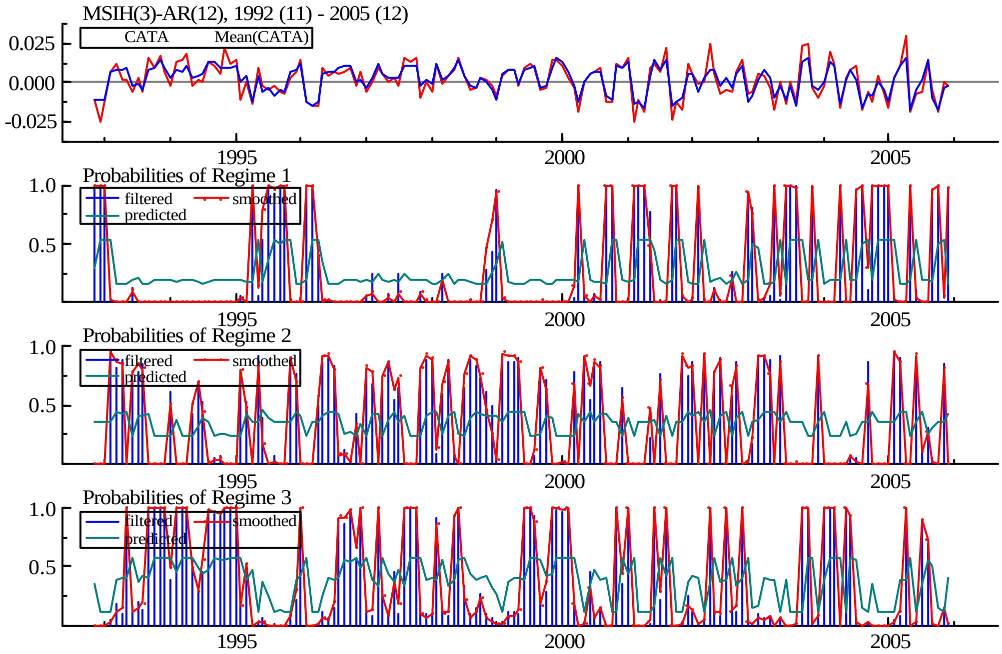
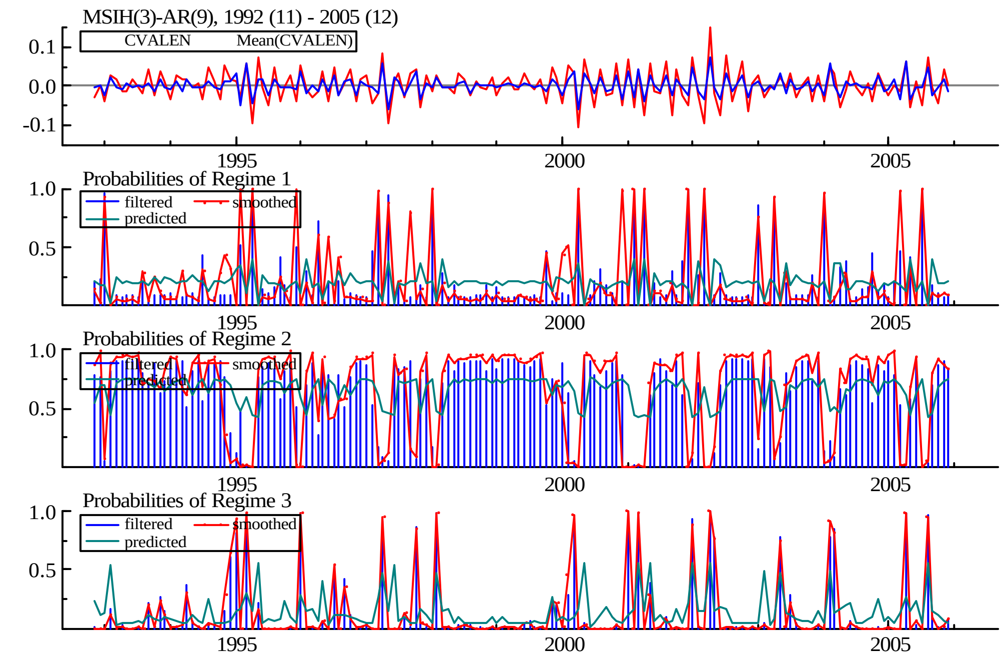
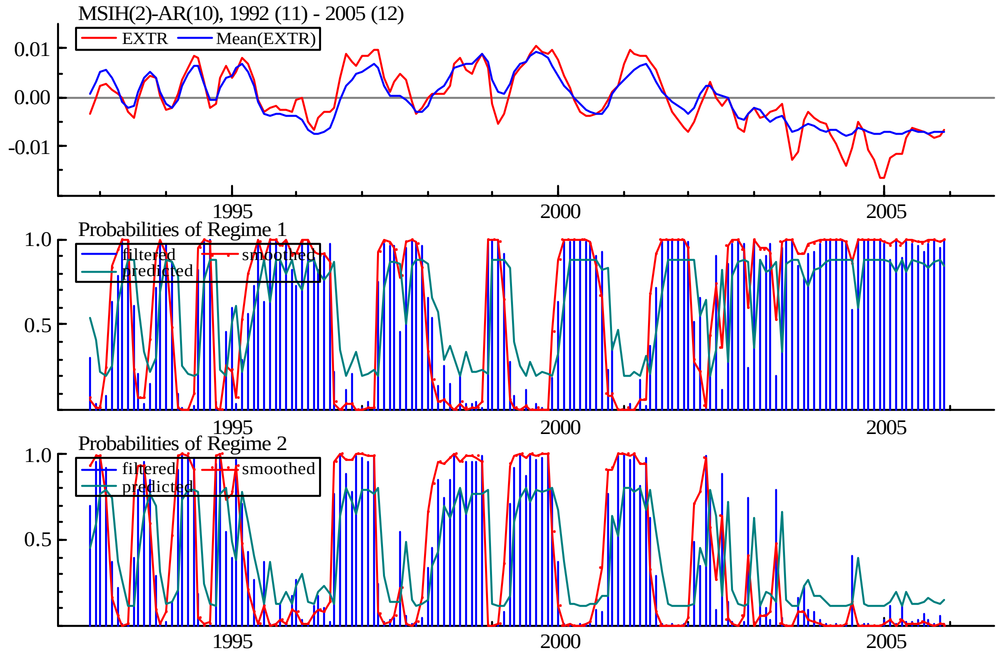
1995
2000
2005
Probabilities of Regime 1
filtered
smoothed
predicted
1.0
0.5
Probabilities of Regime 2


MSIH(3)-AR(12), 1992 (11) - 2005 (12)
CATA
Mean(CATA)
Probabilities of Regime 1
filtered
smoothed
predicted
Probabilities of Regime 2
Probabilities of Regime 3
1995
2000
2005


MSIH(3)-AR(9), 1992 (11) - 2005 (12)
CVALEN
Mean(CVALEN)
Probabilities of Regime 1
filtered
smoothed
predicted
Probabilities of Regime 2
Probabilities of Regime 3
1995
2000
2005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Mean(EXTR)
Probabilities of Regime 1
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smoothed
predicted
Probabilities of Regime 2
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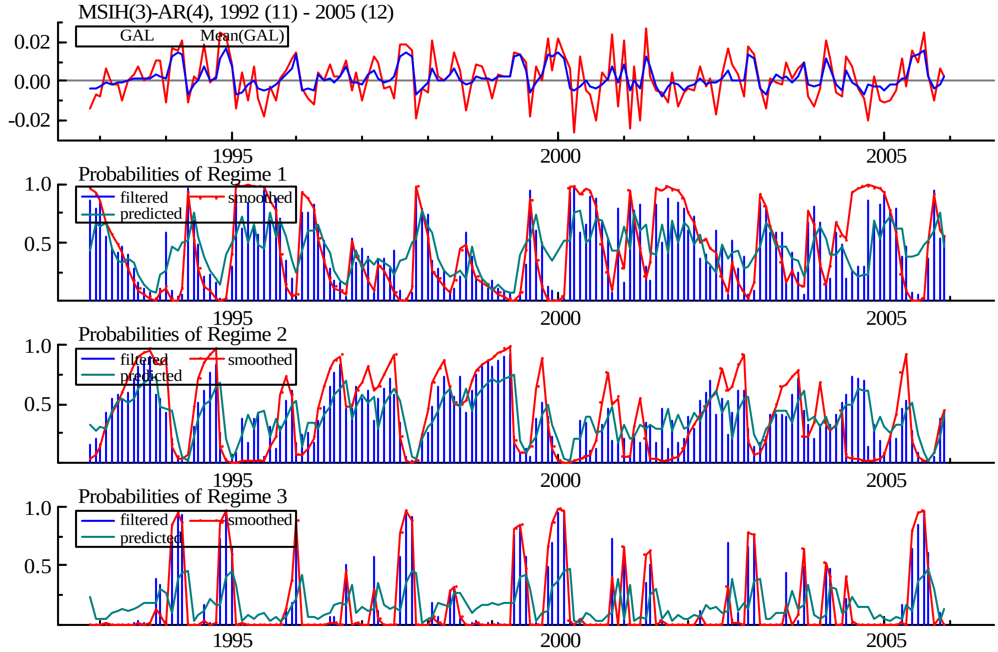
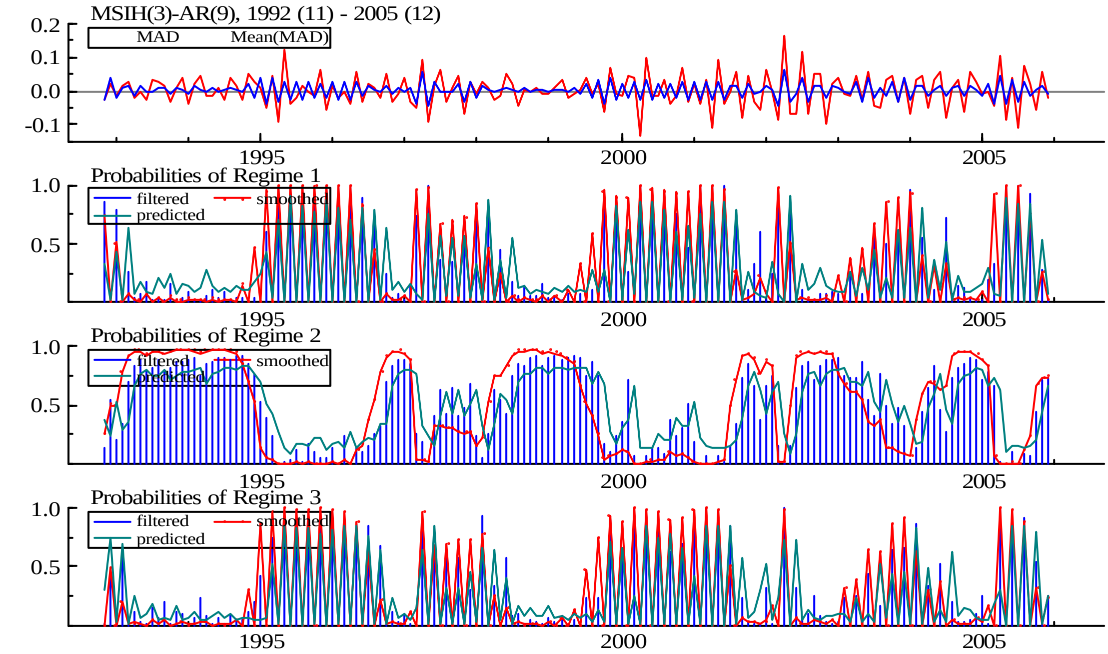
smoothed
predicted
1995
2000
2005


MSIH(3)-AR(4), 1992 (11) - 2005 (12)
GAL
Mean(GAL)
Probabilities of Regime 1
filtered
smoothed
predicted
Probabilities of Regime 2
filtered
smoothed
predicted
Probabilities of Regime 3
filtered
smoothed
predicted
1995
2000
2005



MSIH(3)-AR(9), 1992 (11) - 2005 (12)
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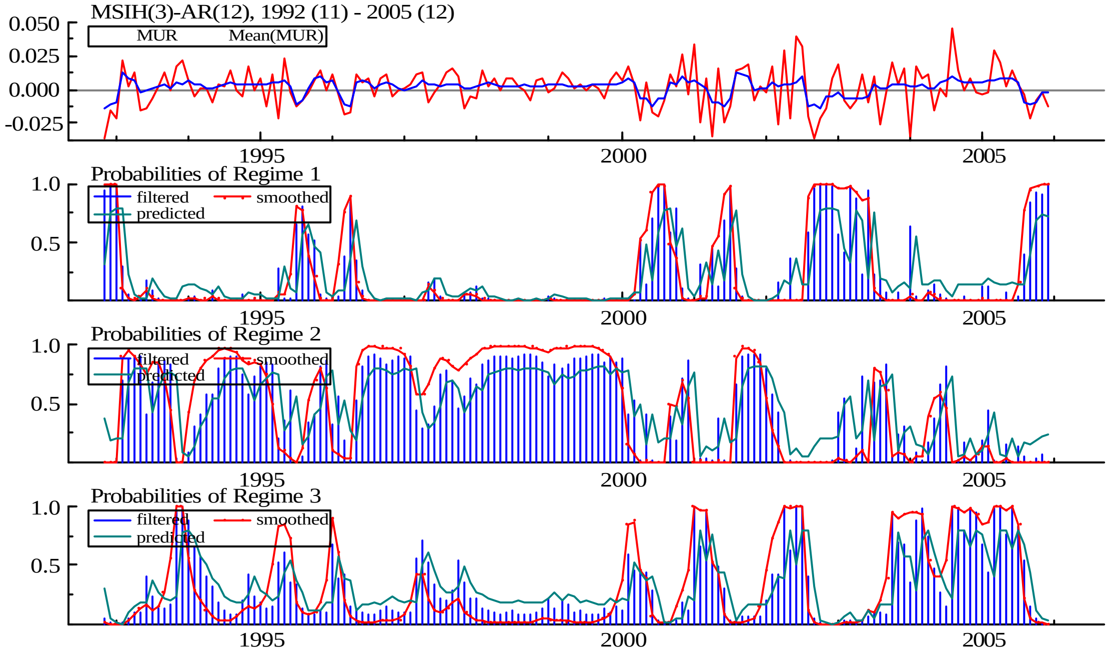
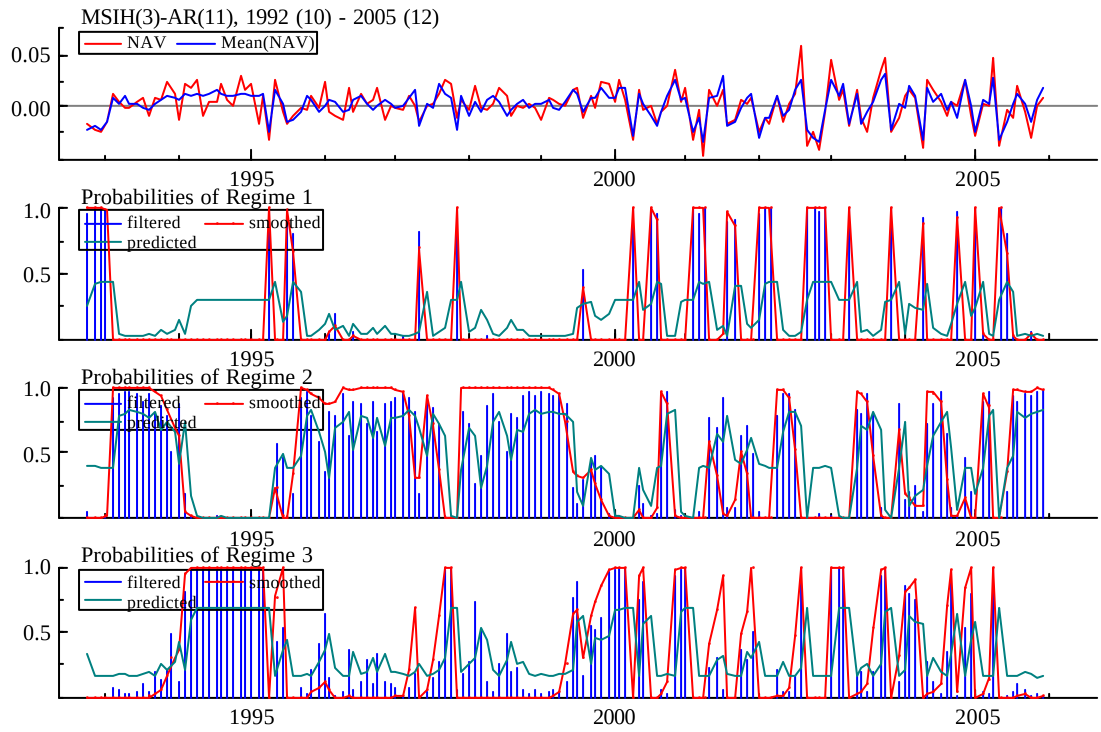
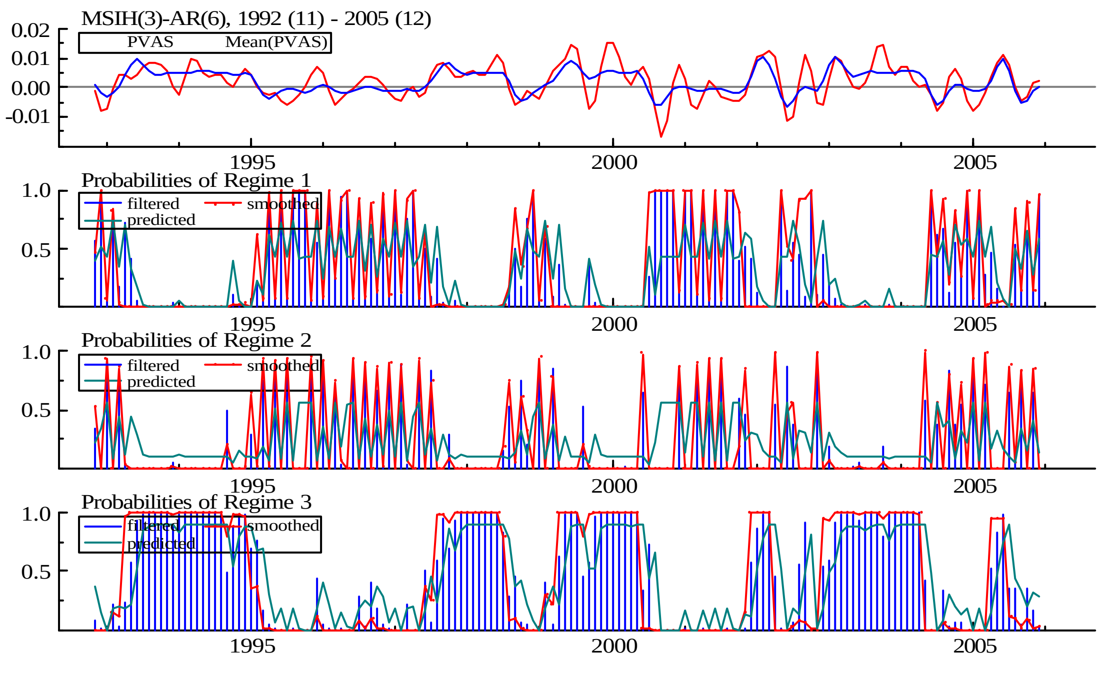
Mean(MAD)
Probabilities of Regime 1
Probabilities of Regime 2
Probabilities of Regime 3
filtered
smoothed
predicted
1995
2000
2005



MSIH(3)-AR(12), 1992 (11) - 2005 (12)
MUR
Mean(MUR)
Probabilities of Regime 1
Probabilities of Regime 2
Probabilities of Regime 3
filtered
smoothed
predicted
1995
2000
2005


MSIH(3)-AR(11), 1992 (10) - 2005 (12)
NAV
Mean(NAV)
0.05
0.00
1995
2000
2005
Probabilities of Regime 1
filtered
smoothed
predicted
1.0
0.5
Probabilities of Regime 2
Probabilities of Regime 3


MSIH(3)-AR(6), 1992 (11) - 2005 (12)
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Mean(PVAS)
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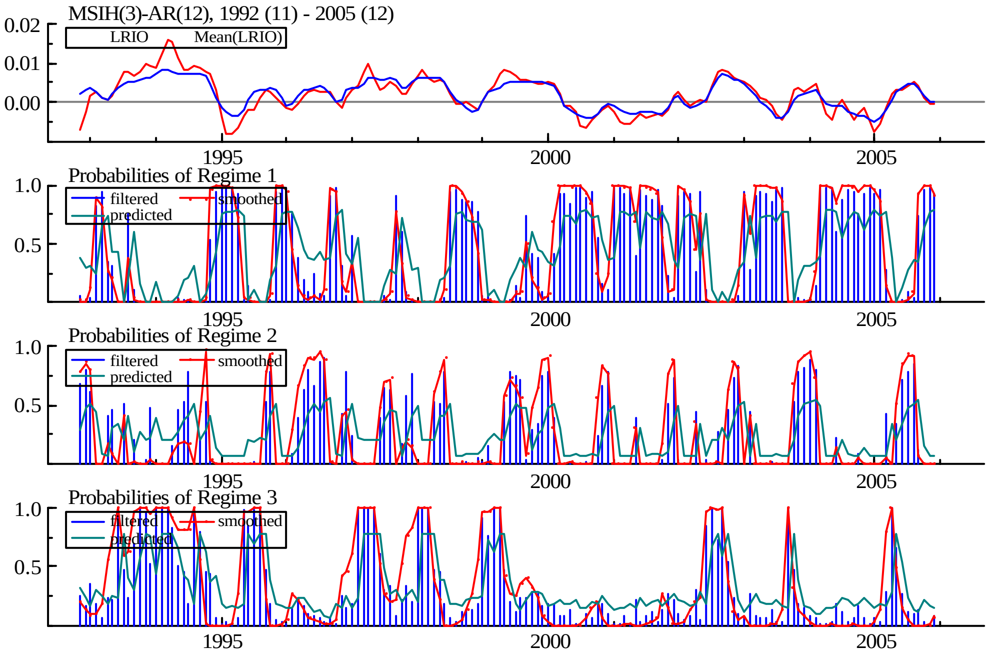
0.00
-0.01
1995
2000
2005
Probabilities of Regime 1
filtered
smoothed
predicted
1.0
0.5
Probabilities of Regime 2
Probabilities of Regime 3


MSIH(3)-AR(12), 1992 (11) - 2005 (12)
LRIO
Mean(LRIO)
0.02
0.01
0.00
1995
2000
2005
Probabilities of Regime 1
filtered
smoothed
predicted
1.0
0.5
Probabilities of Regime 2
Probabilities of Regime 3

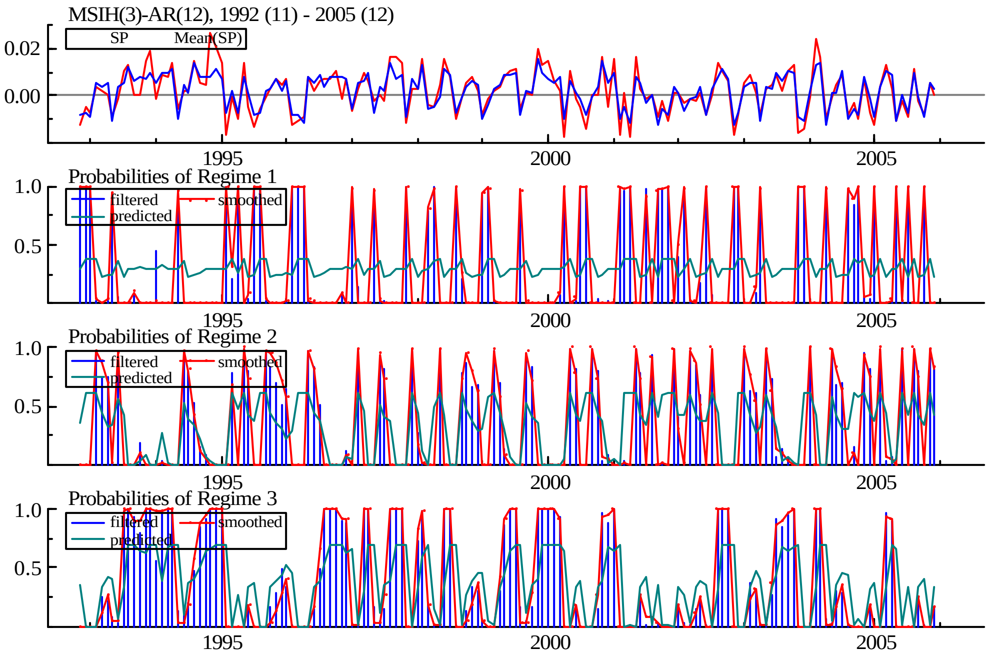
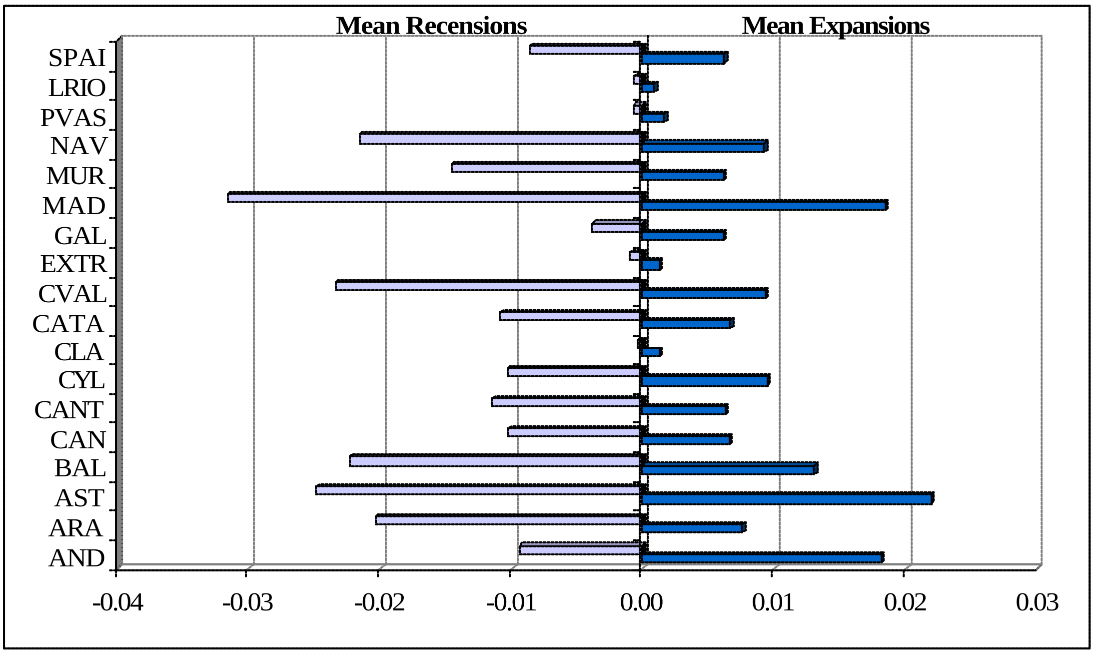
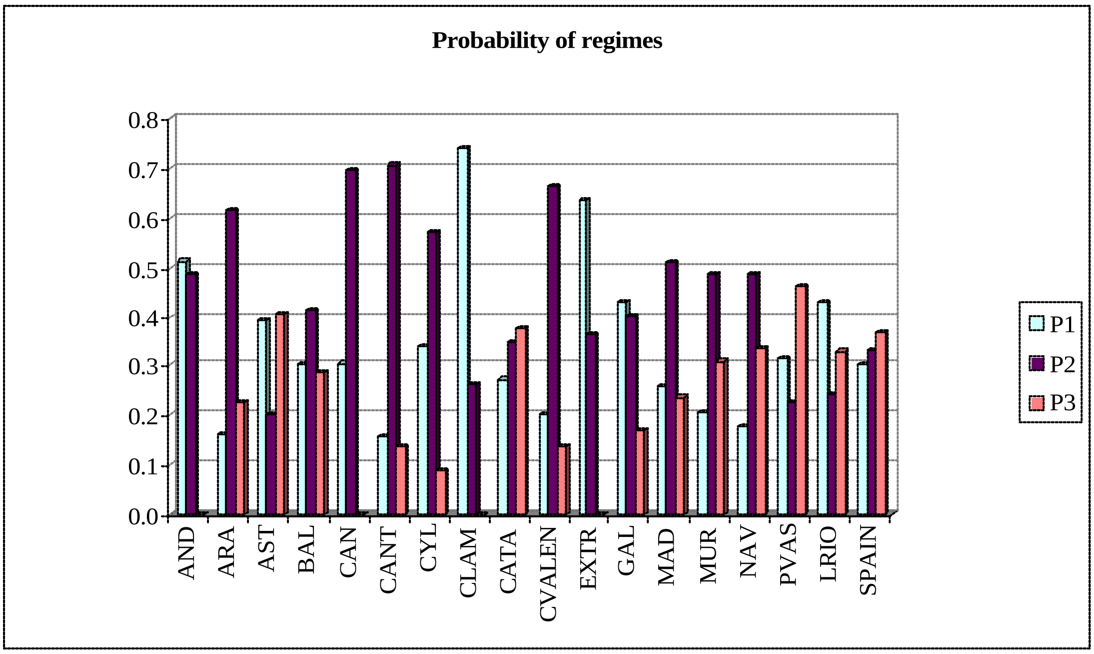

MSIH(3)-AR(12), 1992 (11) - 2005 (12)
SP
Mean(SP)
0.02
0.00
1995
2000
2005
Probabilities of Regime 1
filtered
smoothed
predicted
1.0
0.5
Probabilities of Regime 2
Probabilities of Regime 3

Figure 4: Features of business clycle by regions





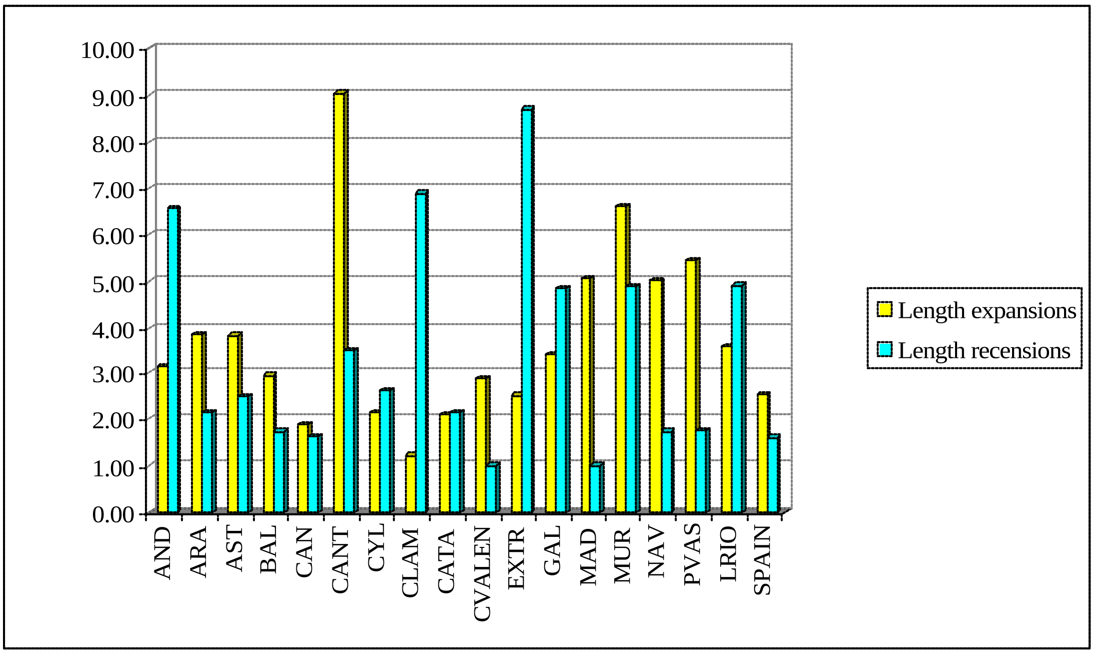

10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
AND
ARA
AST
BAL
CAN
CANT
CYL
CLAM
CATA
CVALEN
EXTR
GAL
MAD
MUR
NAV
PVAS
LRIO
SPAIN
Length expansions
Length recensions

Figure 5: Dendogram of Hierarchical Cluster Analysis

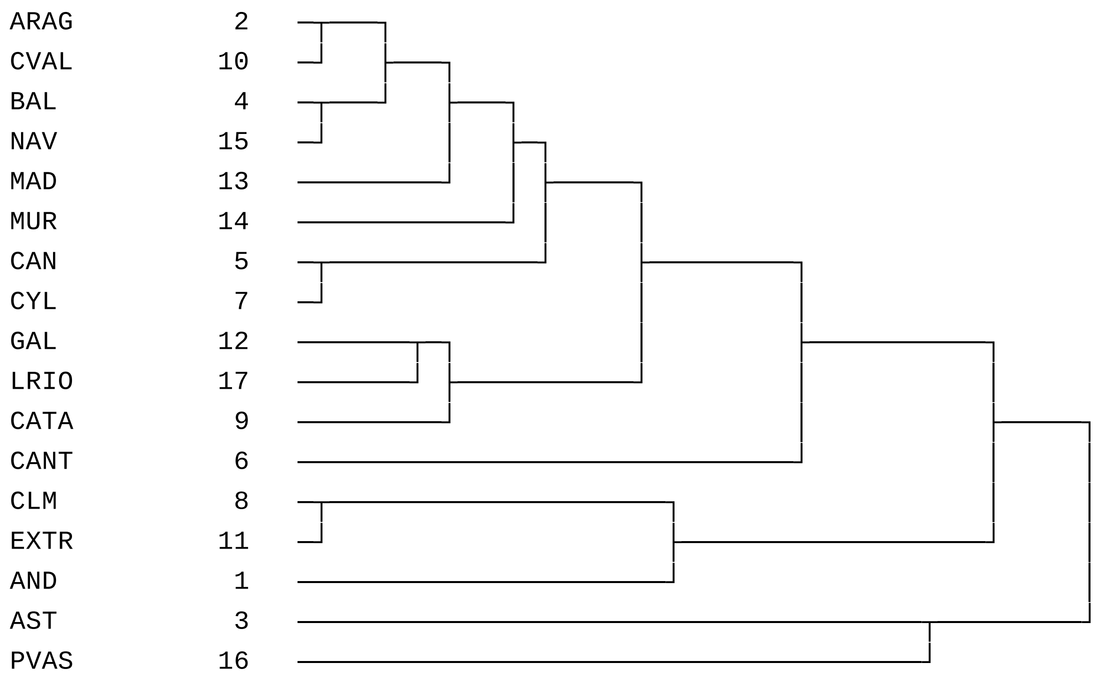


Figure 6: Groups formed by the K-means cluster method

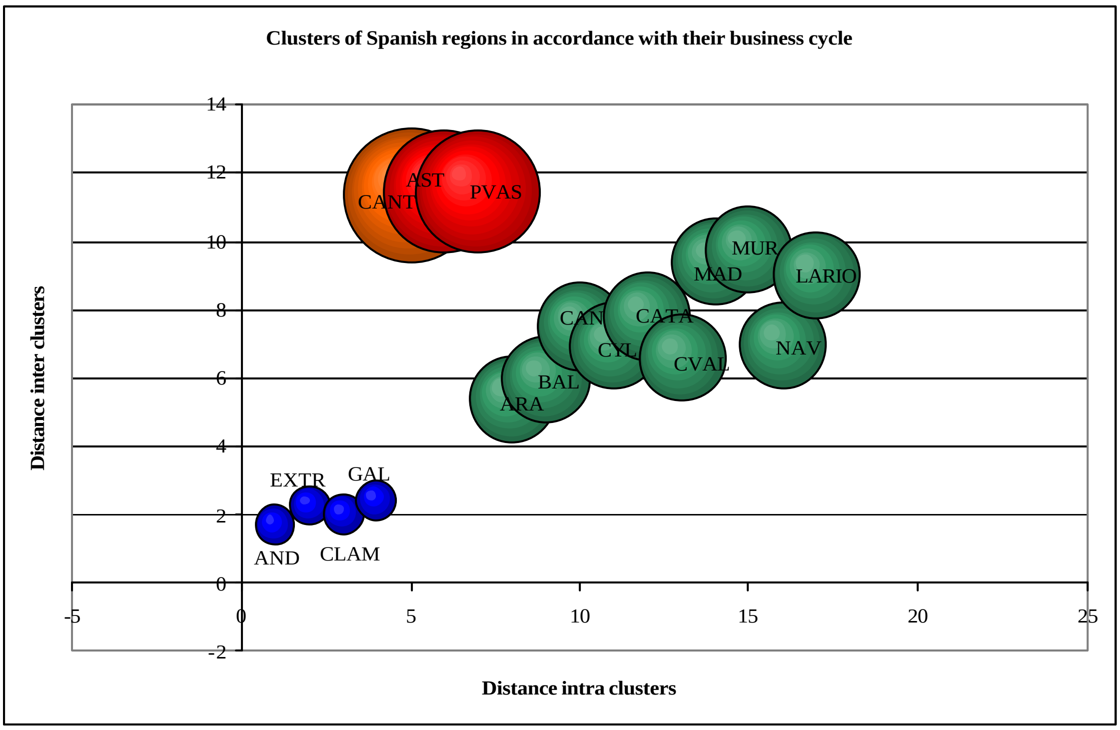
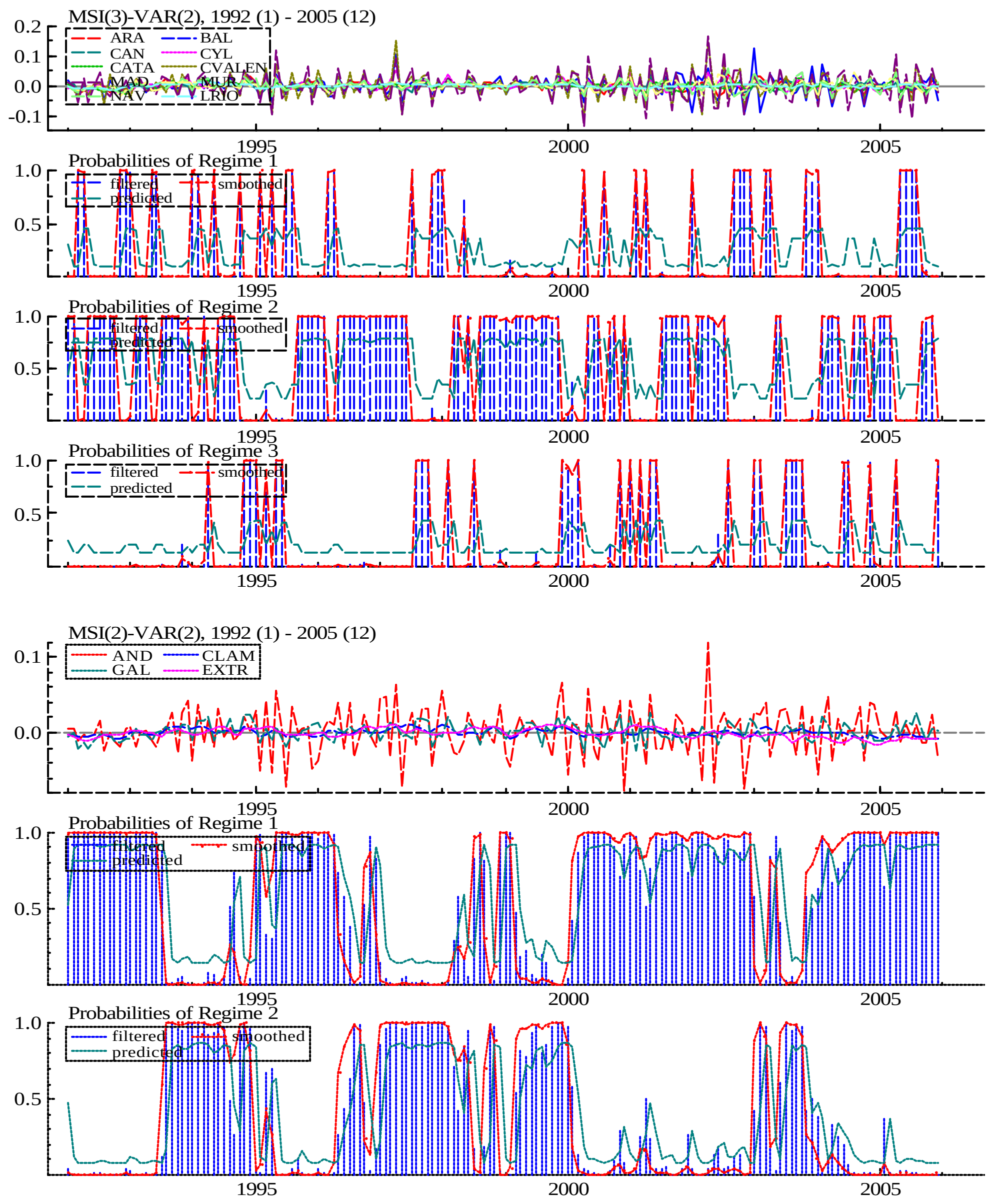


Figure 7: Probabilities and cycle dating by regimes and groups of regions



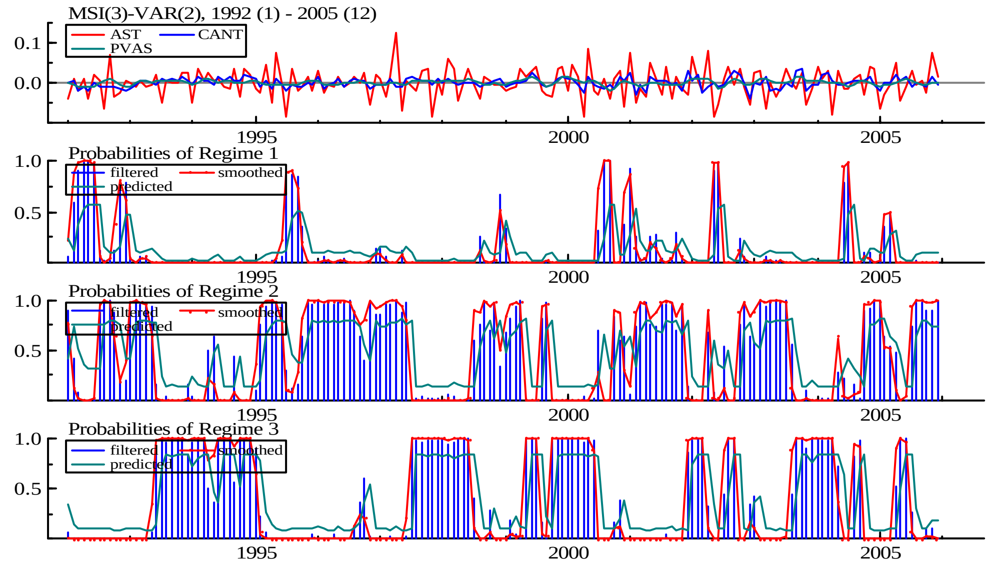
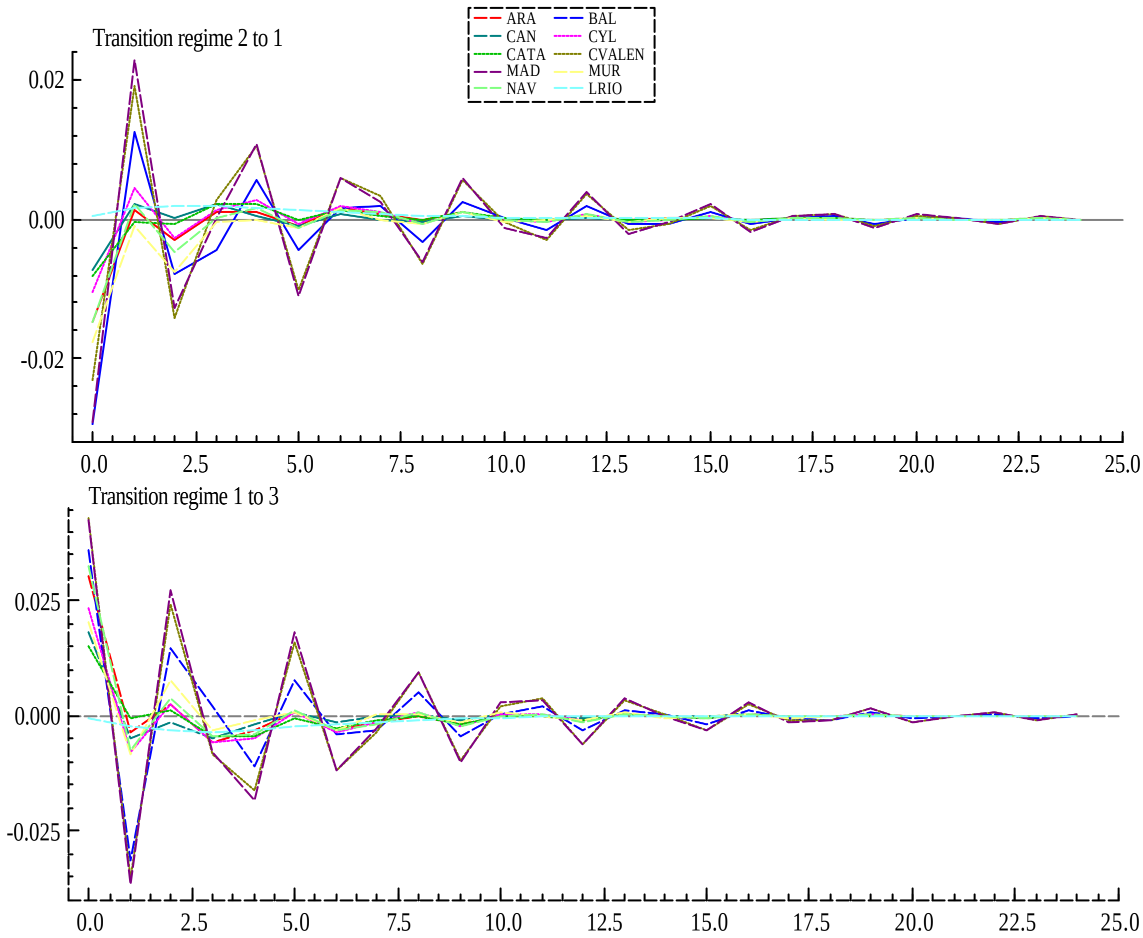


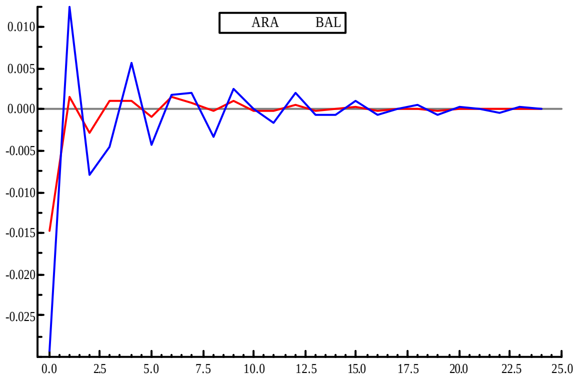
Figure 8: Impulse-Response Functions (Ms-Var)

Group 1

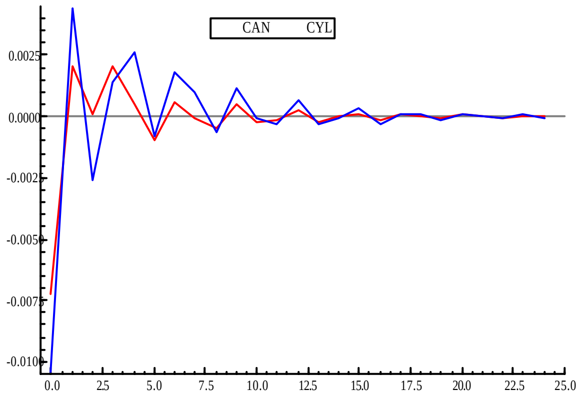


Transition regime 2 to 1

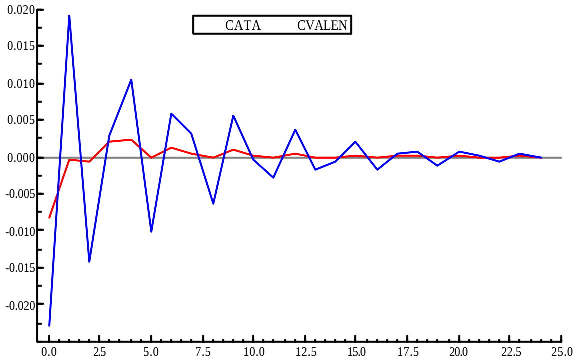
ARA and BAL



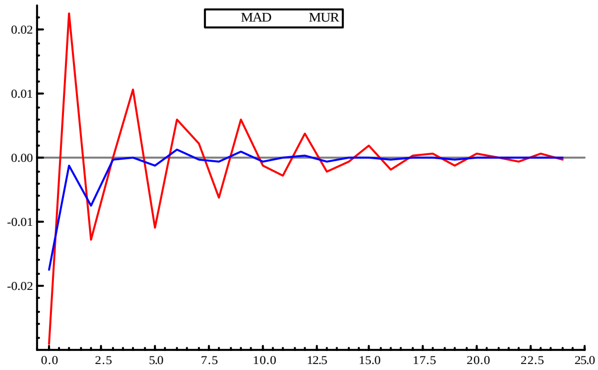
CAN and CYL



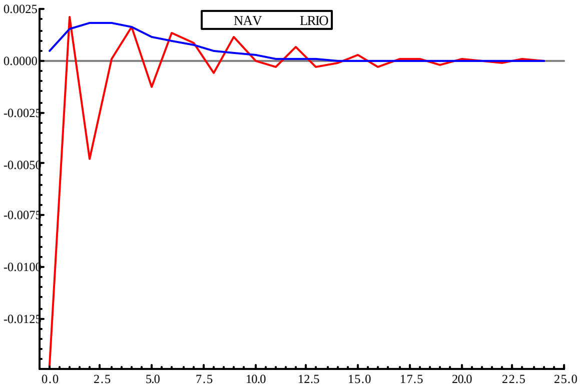
CAT and CVAL



MAD and MUR

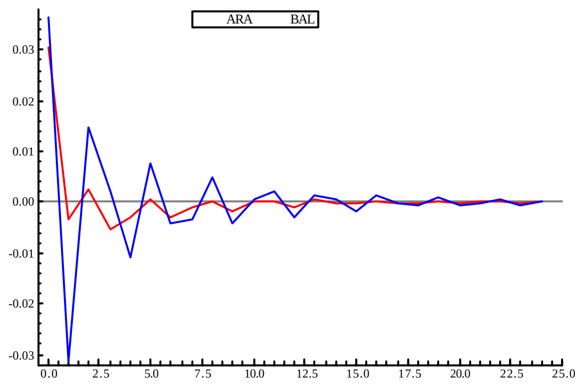


NAV and LAR

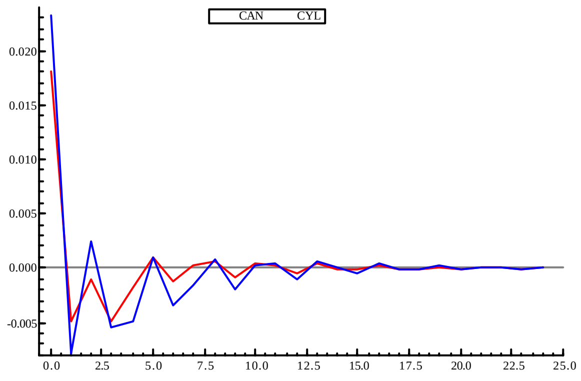


Transition regime 1 to 3

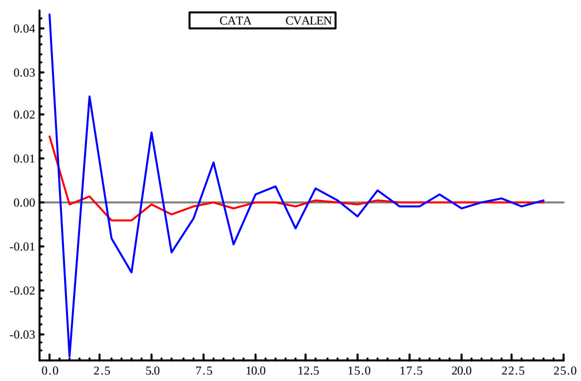
ARA and BAL



CAN and CYL



CAT and CVAL



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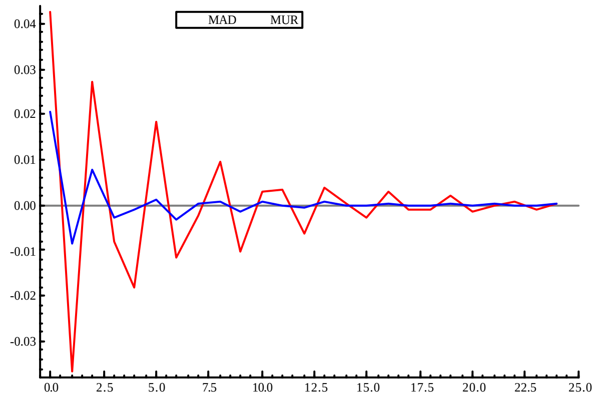

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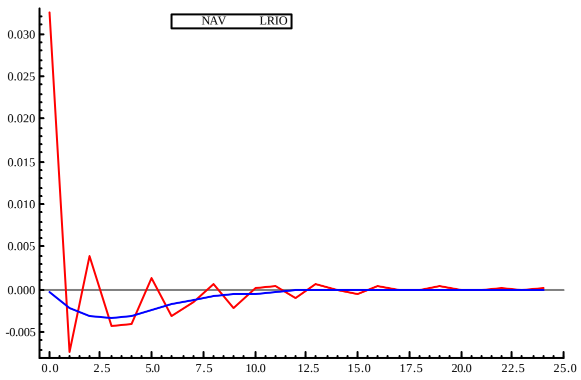
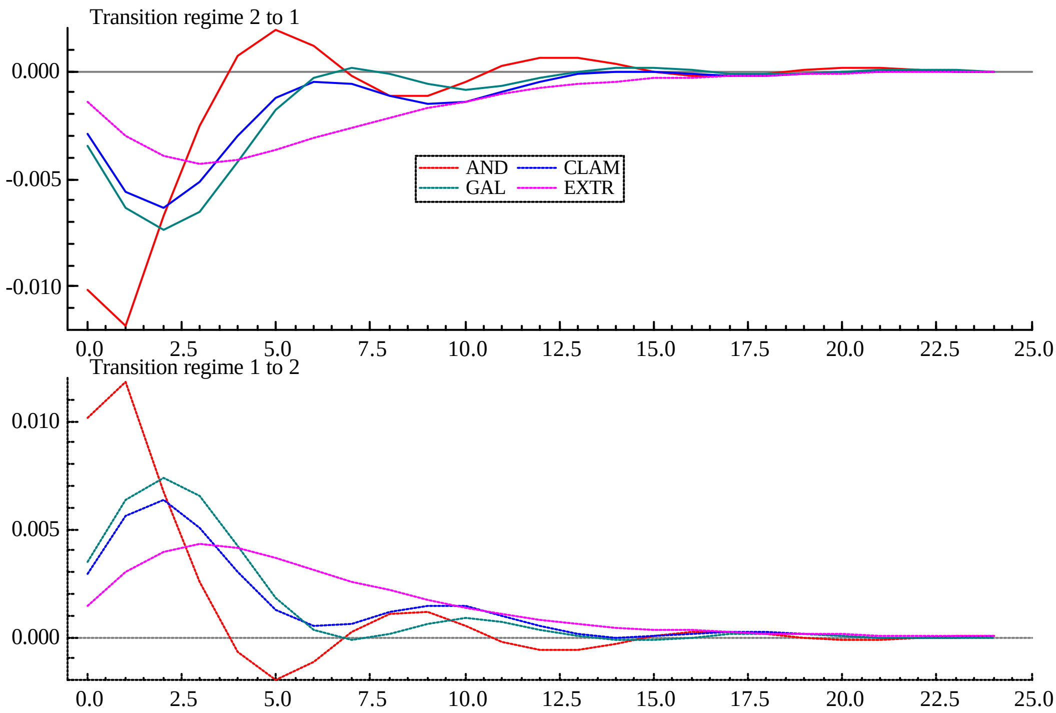
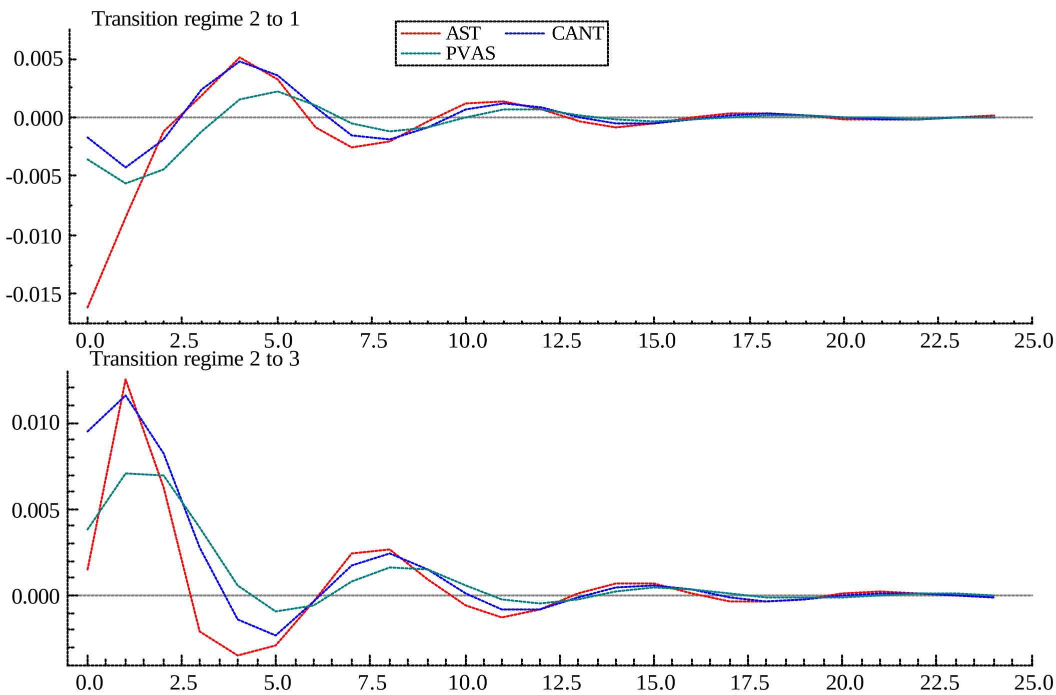


Group 2



Group 3



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- Elaborar estudios sobre economía aragonesa o sobre el territorio aragonés, por iniciativa propia o por encargo.
- Organizar y supervisar equipos de investigación solventes científicamente, que realicen trabajos sobre economía y de carácter territorial encargados a través de la Fundación.
- Promover un debate informado sobre las alternativas a que se enfrenta la economía aragonesa y la política de organización del territorio. En especial organizará periódicamente encuentros, seminarios o jornadas sobre temas relevantes.
- Publicar o dar difusión por cualquier medio a los trabajos que realice, las conclusiones de los seminarios así como otros trabajos de interés para Aragón.
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