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Business cycle stylized facts and inventory behaviour: new evidence for the Euro area

by

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ABSTRACT

In recent years a number of studies have investigated stylised facts concerning the most important US macroeconomic time series (Stock and Watson, 2002; McConnell and Perez-Quiros, 2000; Blanchard and Simon, 2001; Arias, Hansen, and Ohanian, 2006). One of the main results of the analysis concerns a marked volatility reduction emerging from the data since the early eighties. In this respect, the aim of this paper is twofold. Firstly, it analyzes the Euro Area business cycle stylised facts in order to gain better understanding of the European economy as compared with that of the US. Secondly, it explores the technological innovation hypothesis as an explanation of the 'Great Moderation', focusing on the advances in inventory management techniques due to computerisation.

Keywords: Business cycle stylized facts, Inventory behaviour, European survey data.

JEL codes: C32, E32.

CONTENTS

1 INTRODUCTION

In recent years a number of studies have investigated stylized facts concerning the most important US macroeconomic time series (Blanchard and Simon, 2001; Stock and Watson, 2002; Ahmed, Levin and Wilson, 2004). The main findings concern the volatility reduction registered by the US economic indicators, as well as changes in the main features of business cycle fluctuations. Various explanations have been put forward for the 'Great Moderation'. For example Blanchard and Simon (2001) attribute it to changes in monetary and fiscal policy. Stock and Watson (2002) show that the US volatility reduction should be attributed not only to monetary policy improvements but also to a decrease in the volatility of productivity shocks (the so-called 'good luck' hypothesis), whereas McConnell and Perez Quiros (2000) propose an explanation based on better inventory management practice. More recently, Arias, Hansen and Ohanian (2006) have used a Real Business cycle model to investigate the causes of decline in business cycle volatility after 1983.

Whereas numerous analyses of US business cycle stylized facts are available, to our knowledge there are no systematic studies relative to Europe. The majority of the existing papers on the Euro Area only deal with particular aspects such as the synchronicity of national cycles with respect to the Euro area business cycle (see for example Camacho, Perez Quiros and Saiz, 2005), and its increase after monetary union (see for example Mink, Jacobs, De Haan, 2007), convergence (Carvalho and Harvey, 2004 and Canova, Ciccarelli, Ortega, 2004), and dating of cyclical chronology (Artis, Krolzig and Toro, 2002, Giannone and Reichlin, 2005). Furthermore, international comparisons of business cycle properties often concern the US and individual European countries. For example, Backus, Kehoe and Kydland (1992) compare the international business cycle's properties (cross correlations, standard deviations etc.) with those obtained using dynamic general equilibrium models. Their analysis focuses on GDP components, terms of trade, etc., of the US, the UK and the most important European countries (IT, FR, GER etc). Analogously, Hearn and Woitek (2001) analyze business cycle fluctuations in the US, Canada and the main European economies (UK, IT, DE, FR, NDL etc) during the period 1865-1913. According to their findings, the industrial output of the North Atlantic economies has been characterised by a long cyclical component of 7-10 years. Furthermore, the long cycle fluctuations are clearly synchronised in those economies.

Agresti and Mojon (2001) also compare stylized facts concerning the Great Moderation in Europe and United States . They find that the Euro Area and the US are similar with respect to the magnitude of fluctuations in the main macroeconomic time series, and in the persistence of GDP and prices. They

also find that the pattern of cross correlations of GDP components, prices and interest rates with respect to GDP is very similar between Europe and the US. Furthermore, they provide evidence of the synchronicity of national cycles and the Euro Area aggregate cycle for GDP and its main components and for short term interest rates. More recently, Giannone, Lenza and Reichlin (2008) have sought to explain the causes of the Great Moderation in Europe exploring the good policy hypothesis as an explanation for European GDP and inflation volatility reduction. In particular, they use VAR models to evaluate, in pre-Great Moderation and Great Moderation samples, the role of shocks on the observed output volatility decline.

In this paper we investigate the Euro Area economic activity movements in order to gain better understanding of the European business cycle stylised facts compared with those of the US economy and UK over the period 1963-2007 focusing on business cycle volatility reduction. We introduce a number of innovations with respect to the existing literature.

Firstly, we focus on the reduction of volatility that has already been observed in a number of papers, mostly referred to the US economy considering the Euro Area as whole. More in detail, in order to inspect the European business cycle properties, we use a Euro Area business cycle indicator obtained by combining data from Italy, France and Germany. These three countries can be considered as representative of the Euro Area as a whole in terms of their value added shares.

Secondly, we concentrate on the volatility of business cycles, providing evidence of Great Moderation for the Euro Area and the main industrialized countries focusing on both whole economy and industrial business cycle movements. Whereas the majority of papers evaluate business cycle co-movements by examining the economy's demand side components (Stock and Watson, 2002; Agresti and Mojon, 2001), here we adopt a different point of view by looking at the supply side. This approach will enable us to detect possible discrepancies in whole economy and industrial sector business cycle stylized facts; furthermore, as already stated by Camacho, Perez-Quiros and Saiz (2005) the use of industrial production yields higher statistical reliability in terms of availability both across countries and over time.

Thirdly, we investigate the technological innovation hypothesis as an explanation for the Great Moderation in the Euro Area and in its most industrialized countries (Italy, France, Germany and the UK). We do so by focusing on the advances in inventory management techniques brought about by computerization, and by examining business survey data. In fact, unlike in the US, inventory data in Europe are not directly derived from specific quantitative surveys but are instead obtained either as a residual from National Accounts or from qualitative surveys on the industrial and retail sectors. In our

analysis we use inventory data from harmonised business surveys at the European level carried out by the European Commission. These data are qualitative in the sense that firms are not asked to provide quantitative information on the stock or the rate of change of their inventories, but rather to state whether inventory levels are above or below “normal” levels generally interpreted as desired levels of stocks. Since business survey data are commonly considered to be strongly correlated with economic activity and industrial production, qualitative data on inventories can be used to make inferences about the role of inventories at the aggregate level. In particular, in our view, the volatility reduction in economic activity can be explained by a decrease in inventories volatility due to their better management. To this end, we try to determine whether the findings concerning the volatility reduction of Euro Area economic activity can be mainly attributed to a change in the persistence of shocks to inventories accumulation dynamics, or rather to a change in the shocks hitting the inventories optimisation process (i.e. in sales), interpreting the latter as exogenous.

The paper is structured as follows: section 2 describes the data set used, the methodology employed to construct the Euro Core business cycle indicator, and it conducts a preliminary data analysis. Section 3 reports the main stylized facts concerning the Euro Area business cycle and includes an analysis of volatility patterns over time. Section 4 then focuses on business cycle volatility reduction, looking in particular at qualitative data coming from business tendency surveys and try to disentangle the causes of volatility reduction. Section 5 concludes.

2 DATA DESCRIPTION

The data analysed cover the period 1963:1 – 2008:1 and were obtained from OECD statistical data base. For the real economy we use quarterly, seasonally adjusted values of the logarithm of the real GDP and industrial production index (IPI) for the United States, the United Kingdom, the three main Euro area countries (France, Germany and Italy) and a Euro Core indicator built by aggregating data from France, Germany and Italy. The data set also includes cyclical indicators drawn from qualitative surveys such as those on inventories, current production and production expectations in European countries. Furthermore, all the data available on monthly bases (i.e. Industrial production, as well as business survey data), were collapsed to quarterly frequency simply by averaging out monthly observations.

Some explanation is required of our decision to use industrial production besides GDP as a business cycle indicator and to focus only on three Euro Area countries. In fact, cyclical economic activity is generally measured in terms of GDP. However, the agriculture and service sectors do not usually display a well defined cyclical pattern[1] (see Ulrich and Woitek, 2001). The use of GDP may therefore yield misleading signals on underlying cyclical fluctuations, since economy-wide cyclical patterns are mainly driven by the industrial sector. Our choice of using a Euro Area aggregate based on data from Germany, France and Italy was due to the unavailability of a long time horizon data set for the Euro area. In fact, Europe-wide indicators are only available from 1995 and 1975 respectively for GDP and Industrial Production. In order to overcome this drawback in the study of cyclical movements, we chose to elaborate "Euro Core" indicators obtained by aggregating country specific data weighted with the respective value added shares. These indicators are strongly representative of the Euro aggregate, given that Euro Core industrial value added accounts for roughly 70% of the Euro Area and the correlation between Euro Core and Euro Area business cycle indicators in the period for which data are available is very high (0.99 for both GDP and industrial production).

Since our goal was to analyze changes in the economic fluctuations, we removed the secular component from the data using four quarter growth rates and cyclical components of both GDP and IPI extracted with a Band-Pass filter. More specifically, following Stock and Watson (2005), we employed the Baxter-King (1999) filter, with eight leads/lags and a pass-band of 6-32 quarters.

The Euro core, the UK and the US. Figure 1 shows the yearly growth rates for GDP and Industrial production, considering the US, the Euro Core countries taken as a whole, and the UK. The average yearly growth of GDP and industrial activity is higher in the US (3.3% and 3.2% respectively) than in the Euro Core (2.8% and 2.3%) and the UK (2.5% and 1.3%). Similarly to what Agresti and Mojon (2001) have already found when looking at GDP data, the timing of cyclical patterns also seems to be quite close: in all the countries considered, both industrial activity and GDP lapse into a deep recession after the first oil shock, followed by a recovery and a "double dip" at the beginning of the eighties. The subsequent recovery appears to be much steeper in the US than in Europe, especially when GDP data are considered.

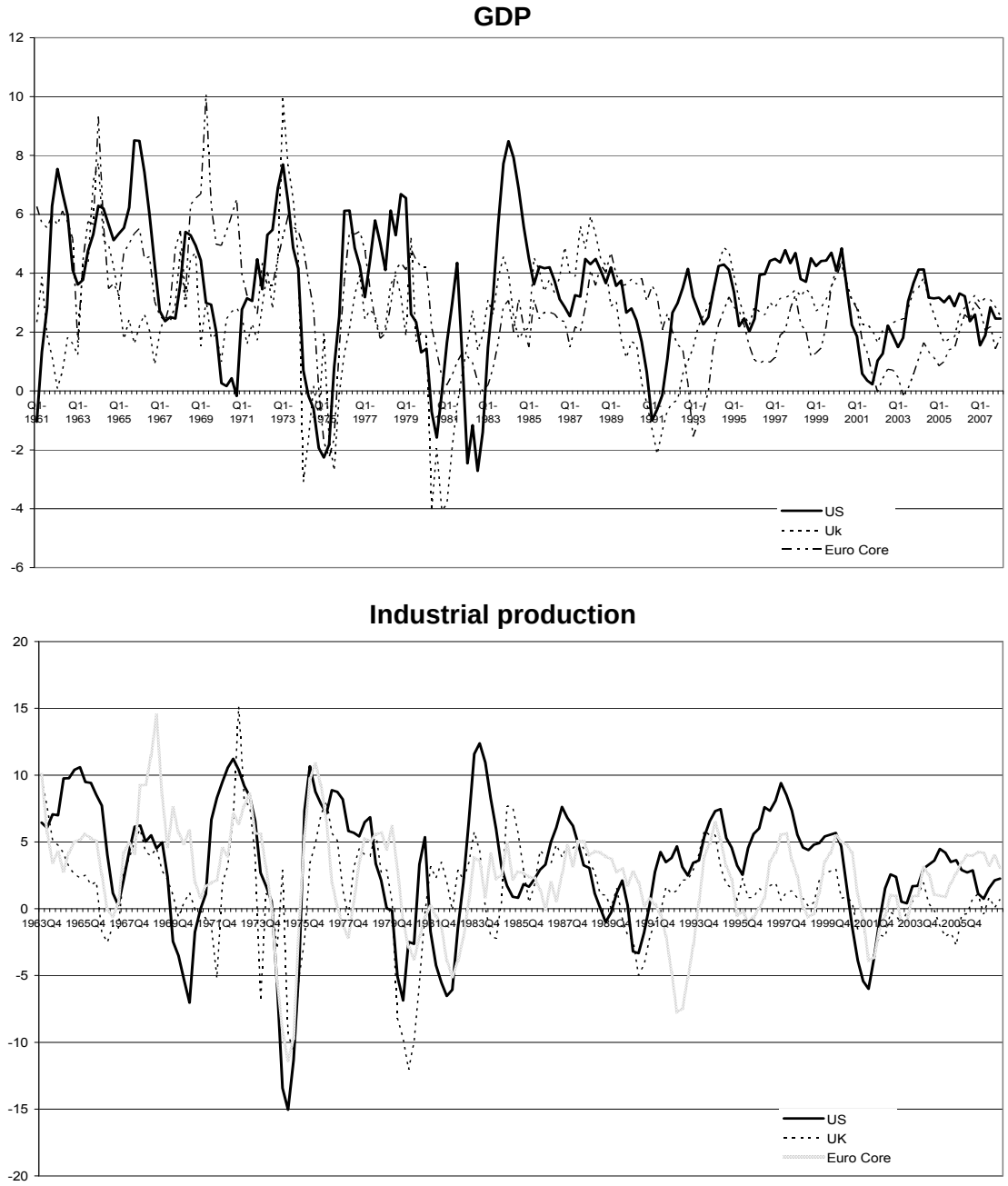
Another important divergence emerges in the early nineties, when a recession took place in the US as a consequence of the Gulf War, but not in Europe, amongst other things because of the fiscal stimulus following German reunification. In the first half of the last decade, GDP and IPI growth was higher in the US than in Europe. However, European growth was catching up with that of the US in the last years of the sample, as a result of both a slowdown in the

[1] In the case of agriculture, cyclical fluctuations are mainly determined by environmental factors.

US and the resilience of growth in Europe. Over the entire period, US activity seems to be leading with respect to European fluctuations; the lead is much more evident when GDP rather than Industrial production data are considered. On average, the volatility of business cycles seems to be higher in the US than in Europe, although it seems to slow down in all the countries towards the end of the sample.

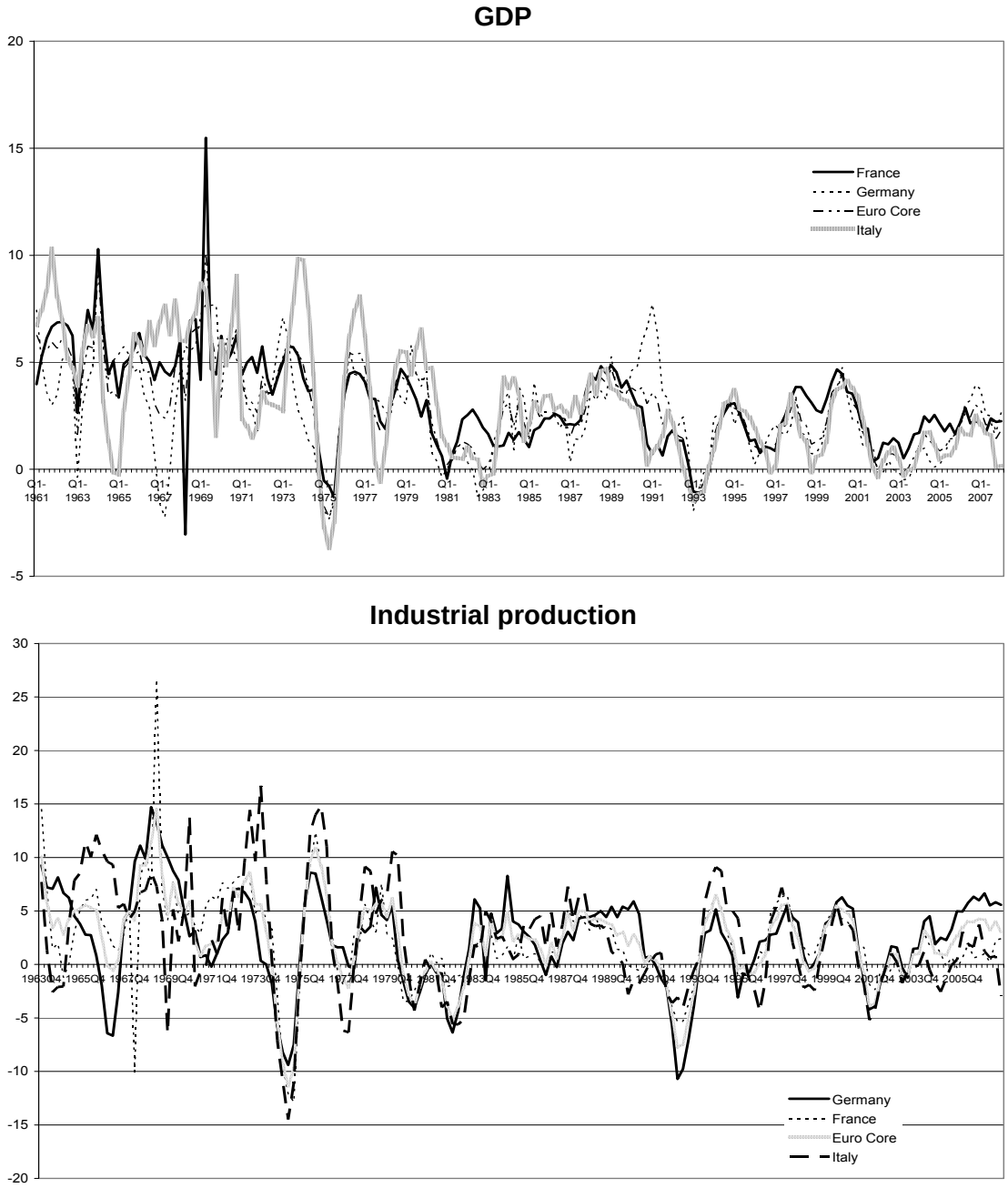
Fig. 1 **GDP and Industrial production growth**

Euro Core, UK and US



***continue* Fig. 1 GDP and Industrial production growth**

Euro core Countries (IT, FR, DE)



Euro Core countries. Figure 1 also displays the same analysis conducted on the three countries of the Euro Core. GDP and industrial production growth are on average remarkably similar among the three countries (2.6% and 2.2% in Germany, 3% and 2.4 % in France and 2.8% and 2.2% in Italy for GDP and industrial production respectively). France shows a highly distinctive growth episode at the end of the sixties, which resulted from the political turmoil associated with the "French May" in 1968, when a wave of strikes hit the French economy and gave rise to severe contraction of both GDP and industrial

production in 1968:2, followed by a large “rebound” in the following year. Germany is also characterised by a country-specific cyclical episode at the beginning of the nineties, when as a result of the policy stimulus following reunification, the economy grew at a faster pace than in the rest of Europe. Italy instead exhibits a different cyclical pattern towards the end of the sample, with a stagnation of both GDP and Industrial activity which began at the end of 2000 and protracted for more than 3 years thereafter, contrasting with a (moderate) growth registered in the rest of the Euro core. Cyclical patterns, however, seem largely consistent among the three countries considered. On average, the volatility of business cycles also seems to be quite similar in the three countries (without considering the sharp cyclical episode in France during the sixties). Finally, in this case too, towards the end of the sample volatility appears to slow down in all the countries considered in the analysis.

3 STYLISED FACTS ABOUT THE EURO AREA BUSINESS CYCLE

In this section, we examine the main business cycle characteristics for the Euro Core, the US and the UK, as well as for Italy, France and Germany. More specifically, section 3.1 presents an analysis of the duration, amplitude, steepness and shape of the cyclical phases, section 3.2 looks at the cross-correlations of business cycles, while section 3.3 investigates business cycles volatility changes.

3.1 Main Business cycle characteristics

In order to gain better understanding of the business cycles characteristics on the two sides of the Atlantic, we calculated the business cycle reference dates. To do so, we used the methodology proposed by Harding and Pagan, 2002 and 2006). The dating algorithm is based on the “classical” business cycle definition and considers the (log) levels of both GDP and Industrial production. For each country, Table 1 provides various business cycles statistics, including the average duration of complete cycles, the periods of expansions and contractions, their amplitude and steepness (i.e. the amplitude divided by the duration). It also reports a measure of asymmetry of the fluctuations – the excess of cumulated movements (E) – which shows the deviation of the economy from a constant expansion/contraction. A value of E close to zero

indicates that the cyclical fluctuation is (almost) linear in its behaviour: during an expansion, a negative sign implies a non linear behaviour, with a progressive intensification of gains (concave expansions), while a positive sign instead indicates a convex expansion, with a slowing down of output gains towards the end of the fluctuation. On the other hand, during a recession, a positive sign of E is interpreted as indicating a "convex recession", where output losses are particularly intense at the beginning of the fluctuation. Conversely, a negative sign is an indicator of a "concave recession", where losses are particularly intense towards the end of the fluctuation. Furthermore, turning points for each series are reported in the appendix.

The Euro core, the UK and the US. First we compare the main cyclical features for the aggregate Euro Core, the UK and the US. Industrial production is found to fluctuate more than total GDP in all the countries considered in terms of the number of turning points located by the Harding-Pagan procedure, confirming that industrial activity is the most cyclical component of industrialised economies. Moreover, considering IPI, the duration of cycles is higher in the US than in the Euro Core and the UK; in particular, the duration of expansionary phases is much longer in the US than in Europe. The graph of the series (see the statistical appendix) shows that this is mainly due to the long expansion in the US during the nineties. For GDP data, on the other hand, the duration of cycles is fairly similar among the three areas. In all the countries, expansions are much longer than contractions, although this result is partly due to the use of "classical" definition of cycle in the algorithm. What most distinguishes the Euro Core from the two English-speaking countries, however, is the amplitude and the steepness of the fluctuations, which are much lower in the Euro Core during both recessions and expansions. As a consequence, also the cumulative gains/losses are higher in the US and the UK than in the Euro Core, both when GDP and industrial production data are considered. The wider scope of fluctuations in UK and US with respect to the core European countries has already been documented in the literature (see for instance Forni and Reichlin, 2001), even if a reduction of the difference has been found for the last part of the sample (Agresti and Mojon, 2001). Finally, measures of excess expansion/recessions show that GDP recessions are close to linear in the Euro Core, and also the US, but instead show a tendency towards a slowdown of output losses towards the end of the fluctuation in the UK. For IPI, the positive sign of E(expansions) exhibits a similar shape of the fluctuations for all the areas considered. On the other hand, during expansions, strong evidence emerges of "concave" fluctuations, with a progressive intensification of output gains towards the end of the fluctuation.

Tab. 1 Business Cycle Characteristics - Euro Core, UK and US

	Euro Core		UK		US	
	GDP	IPI	GDP	IPI	GDP	IPI
			Duration			
Recessions	3.00	3.67	4.75	4.64	3.20	4.25
Expansions	19.40	9.91	18.00	10.36	17.50	15.14
			Amplitude			
Recessions	-0.91	-3.57	-3.77	-5.15	-2.04	-6.69
Expansions	13.13	10.87	15.22	9.33	18.07	21.90
			Steepness			
Recessions	-0.30	-0.97	-0.79	-1.11	-0.64	-1.57
Expansions	0.68	1.10	0.85	0.90	1.03	1.45
			Excess			
Recessions	0.15	0.81	1.09	1.47	0.38	1.77
Expansions	-5.89	-4.34	-6.76	-3.76	-8.00	-9.50

	Germany		France		Italy	
	GDP	IPI	GDP	IPI	GDP	IPI
			Duration			
Recessions	3.00	4.80	2.67	5.67	3.11	4.33
Expansions	18.29	11.33	33.50	13.00	16.22	7.07
			Amplitude			
Recessions	-1.44	-5.35	-1.25	-5.07	-1.32	-4.79
Expansions	14.61	13.57	21.63	15.43	14.25	11.38
			Steepness			
Recessions	-0.48	-1.11	-0.47	-0.89	-0.42	-1.11
Expansions	0.80	1.20	0.65	1.19	0.88	1.61
			Excess			
Recessions	0.24	1.56	0.16	1.64	0.23	1.29
Expansions	-6.50	-5.59	-10.17	-6.53	-6.25	-4.08

Euro Core countries. Turning to Euro Core countries, Germany and especially Italy exhibit a lower average duration of expansions and recessions. In the case of Italy, this is mainly due to short fluctuations towards the end of the sample. This finding is at odds with previous studies on the Italian manufacturing sector (see for instance ISAE, 2006), according to which the Italian economy entered a long phase of stagnation after a peak at the end of 2000. Accordingly, the trough identified by the Harding-Pagan procedure applied to quarterly data at the end of 2001 (followed by new peaks and troughs quite close to each other in 2002-2005) may be interpreted as merely a “false start” and not as a proper cyclical fluctuation. If this is the case, the number of fluctuations for Italy is closer to what has been found for the other two countries of the Euro core. As for the amplitude and the cumulative gains of expansionary phases, these are larger in France with respect to Germany and Italy. Recessions are generally mildly convex, meaning that they are quite close to the linear approximation representation, with output losses that are generally slightly larger at the beginning of the fluctuation. Expansions are also convex, which indicates that also output gains are larger at the beginning of the fluctuation.

3.2 Cross Correlations

In order to assess the degree of synchronicity of business cycles among countries, table 2 provides an analysis of cross-correlations of both GDP and IPI cyclical components extracted with the Band-Pass filter of each country with respect to the US business cycle.

Tab. 2 Correlation with the US business cycle. Period: 1965 - 2006

					Cross correlation with US GDP (t+k)				
	k	-4	-3	-2	-1	0	1	2	3	4
Germany		0.11	0.28	0.42	0.48	0.44	0.28	0.06	-0.16	-0.31
France		0.32	0.46	0.52	0.47	0.32	0.09	-0.14	-0.32	-0.38
Italy		0.35	0.46	0.50	0.43	0.27	0.03	-0.22	-0.42	-0.51
Euro core		0.28	0.45	0.56	0.55	0.42	0.19	-0.09	-0.33	-0.47
Uk		0.10	0.26	0.40	0.48	0.48	0.41	0.30	0.17	0.06
US		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
					Cross correlation with US Industrial Production (t+k)				
	k	-4	-3	-2	-1	0	1	2	3	4
Germany		0.01	0.20	0.38	0.50	0.51	0.39	0.19	-0.06	-0.27
France		0.02	0.28	0.52	0.65	0.64	0.47	0.20	-0.10	-0.33
Italy		0.06	0.28	0.47	0.57	0.54	0.37	0.12	-0.14	-0.36
Euro core		0.03	0.27	0.49	0.61	0.60	0.45	0.19	-0.10	-0.34
Uk		0.20	0.38	0.52	0.57	0.52	0.39	0.22	0.06	-0.06
US		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

The Euro core, the UK and the US. Contemporaneous cross-correlations between the Euro Core countries and the US are equal to .42 and to .6 for Industrial Production and GDP respectively. Similarly, the contemporaneous correlation coefficient between the US and the UK is equal to .5 (for both GDP and IPI). Cross correlations functions between the Euro Core and the US peak at lag 2 and at lag 1 respectively for GDP and industrial production, indicating that US GDP cycles lead the European cycles on average by two and one quarters. On the other hand, UK cycles are exactly synchronised with that of the US in the case of GDP, with the cross correlation function peaking at lag 0. However, UK industrial production leads that of the US by one quarter. The fact that IPI cycles appear to be more internationally correlated than those of GDP probably reflects the larger openness of the industrial sector with respect to total activity, which gives rise to a more direct transmission of shocks among countries.

Euro Core countries. Among Euro Core countries, on considering GDP, cross correlations with the US business cycles are generally quite low, ranging from .2 for Italy to .3 for Germany. Cross correlation functions again generally peak at lag 2 (lag 3 for Italy), confirming the leading properties of the US with respect to Euro core countries. Inspection of industrial production data shows that contemporaneous cross correlations with the US are generally around .4 in

the Euro Core countries, reaching a peak at lag 1 for both France and Italy. Interestingly, cross correlation between industrial production in Germany and US peaks at lag 0, which denotes a synchronicity between industrial activity fluctuations in Germany and the US in the period considered.

3.3 Volatility

A diminished business cycle volatility has been widely documented for the US. In what follows, we try to determine whether this is also a characteristic of the Euro zone. More specifically, we investigate whether volatility reduction can be attributed to the existence of structural breaks in the Data Generating Process (McConnell and Perez-Quiros, 2000) or to a long trend decline (Blanchard and Simon, 2001). In order to inspect the first hypothesis, table 3 reports standard deviations of the cyclical component (extracted again with the band pass filter) for both GDP and Industrial Production, in absolute terms and relative to the US over the period 1965-2006. As in Kim and Nelson (1999) we also split the sample considering a break in 1984. Each sub-period standard deviation is then reported relatively to the full sample, so that a value less than one indicates a period of relatively low volatility.

Tab. 3 Volatility of GDP and Industrial production, 1965-2006

	GDP				Industrial Production			
	Std Abs.	Relative to US	Standard deviation relative to 1965 - 2006		Std Abs.	Relative to US	Standard deviation relative to 1965 - 2006	
	1965:1 2006:1	1965:1 2006:1	1965:1 1983:4	1984:1 2006:1	1965:1 2006:1	1965:1 2006:1	1965:1 1983:4	1984:1 2006:1
Euro Core	0.82	0.73	1.25	0.73	2.59	1.13	1.25	0.72
Germany	1.00	0.88	1.23	0.75	2.27	0.99	1.22	0.77
France	0.71	0.63	1.15	0.84	2.94	1.28	1.30	0.64
Italy	1.16	1.03	1.34	0.59	2.36	1.03	1.31	0.62
U K	0.91	0.81	1.28	0.68	2.09	0.91	1.34	0.56
US	1.13	1.00	1.33	0.59	2.29	1.00	1.32	0.61

The GDP data over the period 1965-06 show that Italy experienced the highest volatility both in absolute terms and relatively to the US. Standard deviations relative to that of the US are quite similar in Germany and United Kingdom (.88 and .81), and are indeed lower in France (0.63). With respect to industrial production, relative volatility is generally higher, ranging from 0.91 for the UK to 1.28 for France. In fact, GDP volatility for France is the lowest among the European countries, whilst that of industrial production is higher than that calculated for the same countries. In all the countries considered, both GDP and Industrial production are much less volatile in the second part of the sample. The results also indicate that the volatility reduction is a widespread

phenomenon involving both the English-speaking countries and those of the Euro Core. Nevertheless, volatility is on average lower in the Euro Core countries than in the US and the UK, especially when considering cycles referred to GDP. Within the Euro Core, volatility is higher in Italy than in France and Germany. In light of the previous graphs, this finding seems to be mainly due to higher volatility at the beginning of the sample. This latter result may be considered a consequence of the fact that Italy was at that time "catching up" in terms of industrial structure.

We then investigate the second hypothesis of a long-term trend decline by calculating the rolling standard deviations of both GDP and Industrial Production. In this regard, figures 2 and 3 report rolling standard deviations of the cyclical components extracted with the band pass filter for both the Euro core, the UK and the US and the Euro core countries considered separately. For each geographical area, we analysed both the volatility of GDP and that of the industrial production index from 1969, using a window of five years (as in Blanchard and Simon, 2001).

Fig. 2 Rolling Standard Deviations – Euro Core, US and UK

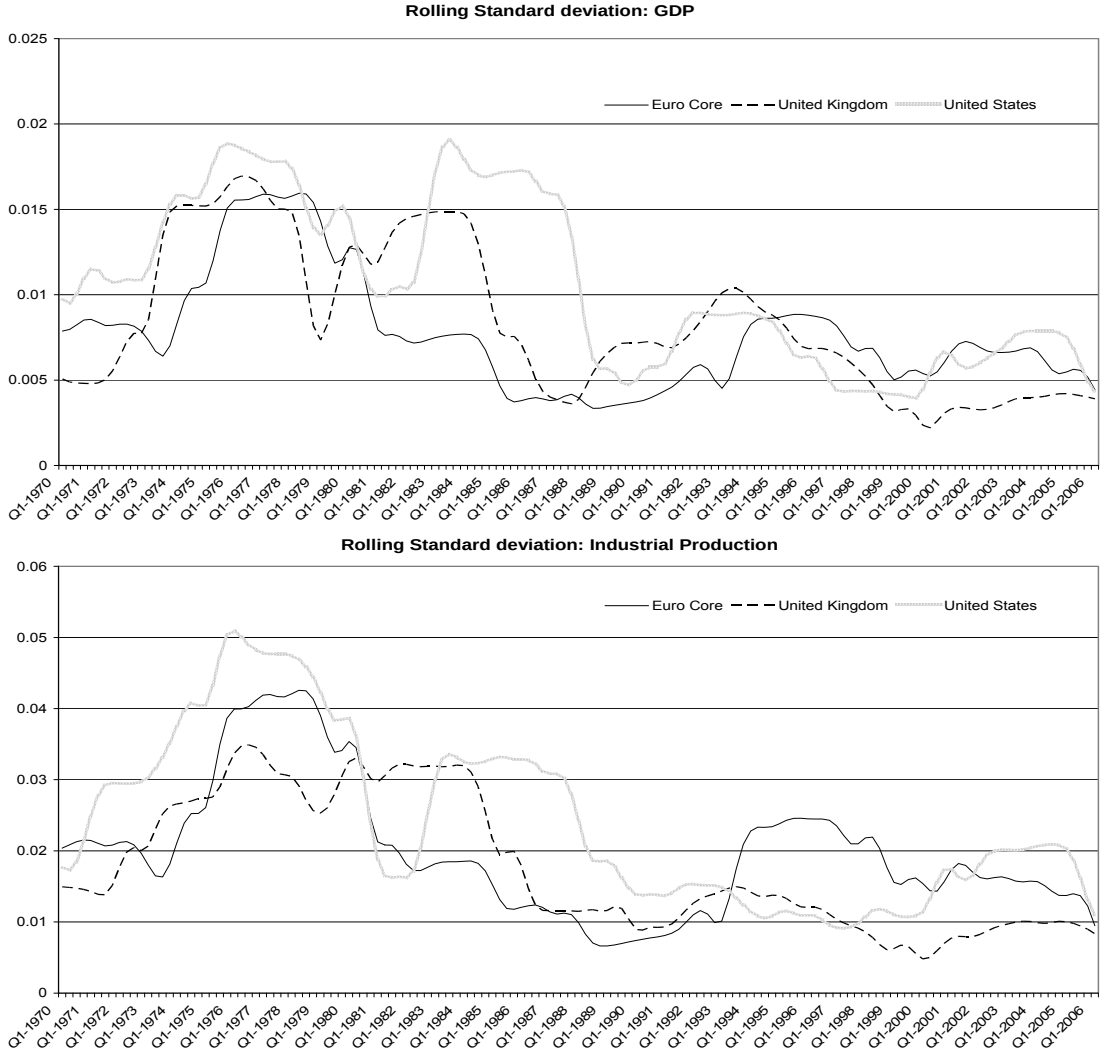
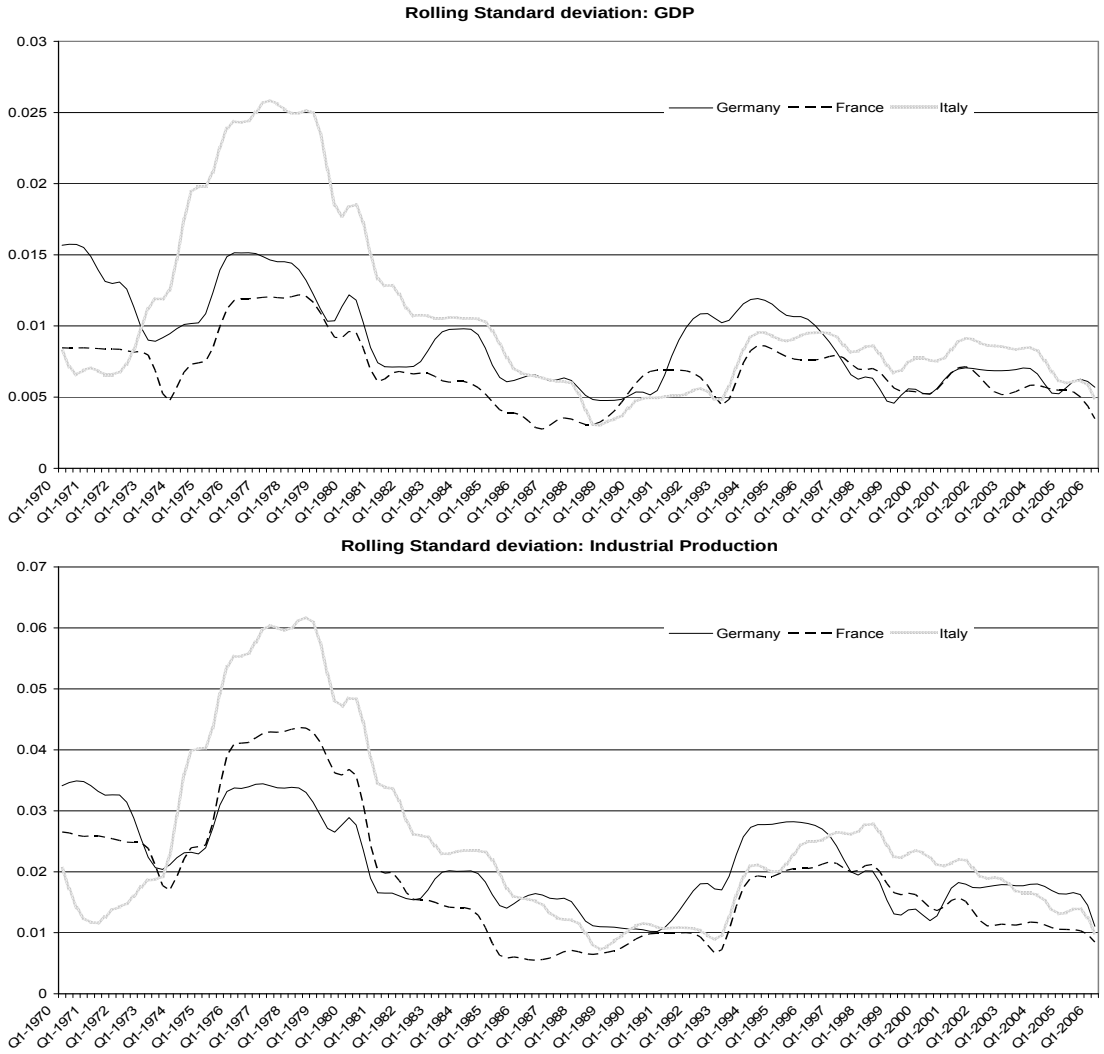


Fig. 3 Rolling Standard Deviations – Germany, Italy, France



The Euro Core, the UK and the US. The GDP data show that standard deviation started declining in the mid-seventies in all the areas considered, eventually picking again in the US at the beginning of the eighties. However, volatility decreased again after 1983, and more sharply in 1985, reaching its lowest levels at the end of the decade. Some signs of resilience appeared in Europe at the beginning of the nineties, with volatility, however, stabilising at its lowest level of the last 40 years towards the end of the sample. Similar results also emerge from the analysis based on industrial data: in this case too, the Euro Core seem to have been characterised by a significant rise in volatility at the beginning of the nineties, which eventually disappeared towards the end of the decade. In 2006, also for industrial production, volatility was at its lowest levels of the last 40 years in all the countries considered.

Euro Core countries. A possible explanation for the peculiar behaviour of business cycle volatility in Europe during the nineties is furnished by national data. In fact, after a decline in all the countries considered in the period 1969-

1992, volatility picked up in Germany (with possibly a break in the Data Generating Process) in the period 1992-1998, probably because of the shock associated with the reunification process. Indeed, standard deviation started to fall again from 1999 onwards, reaching its lowest levels at the end of the sample, with values almost 1/3 of those of the mid-seventies. Finally, among the countries considered, Italy exhibits the most marked decline, which is possibly explained by some of the considerations already advanced about the "catching up" of Italian economy in the first part of the sample and its prolonged stagnation during the last decade.

On the basis of the above statistical evidence, it is therefore not possible to discriminate clearly between the two different representations of the volatility decline observed, i.e. those alternatively associated with a structural break occurring somewhere in the mid-eighties or with a change in the slope of the volatility trend. Consequently, to shed light on this issue, we decided to take a step forward by investigating the economic determinants of the Great Moderation. In fact, different explanations have been advanced in the literature[2] as to the causes of volatility decline, alternatively linking it to structural breaks, changes in policy regimes or "good luck". More specifically, structural changes may have stemmed from technological innovation concerning inventory accumulation (McConnell and Perez-Quiros, 2000); whilst changes in policy regimes may have involved the functioning of the labour market (Gali and Gambetta, 2008) or the management of monetary policies (Clarida, Gali, Gertler, 2000). On the other hand, the "good luck" hypothesis argues that diminished output volatility is mainly due to the fact that smaller shocks have hit the international economy in the recent past (see Stock and Watson, 2002 and 2005; Ahemed, Levin and Wilson, 2004). This last approach has been recently criticised using Vector Autoregression Analysis (VAR): in particular, Giannone, Lenza and Reichlin (2008) have argued that the decline in volatility cannot be attributed to exogenous effects mainly linked to a reduction in volatility of shocks; instead, volatility reduction is, in their view, mainly due to a change in the propagation mechanism of the shocks, in turn linked to structural changes either in the structure of the economy or in policy regimes. In this regard, however, Canova and Gambetti (2008) have found that the transmission of policy shocks has been relatively stable over time, which rules out the possibility that structural changes may have stemmed mainly from a new monetary policy regime more aggressive and effective in controlling inflation. In their conclusions, the authors point out that the structural changes may have instead

[2] Early works include those of Kim and Nelson (1999) and McConnel and Perez-Quiros (2000); among the most recent contributions, see for instance Stock and Watson (2005) and Cecchetti, Flores Lagunes and Krause (2006).

involved private sector behaviour, leaving the field open for further study along this line of inquiry.

In the rest of the paper we concentrate on the hypothesis that large part of the 'Great Moderation may have been due to changes in industrial organisation, and involving, in particular, the use of information and communication technologies for inventory management. The so-called ICT revolution has brought more rapid and effective access to information. In turn, it may have helped firms change their production levels more quickly in response to external shocks. In other words, new technologies can be considered to have made it easier for firms to adjust production to demand, for example via shorter lead times in ordering or hiring decisions. A number of important consequences may ensue in this case. Firstly, if firms are able to adjust production rapidly to market needs, the accumulation/decumulation of undesired stocks of finished products become less probable; as a consequence, the volatility of stocks should decline more than that of output. Moreover, if the technological shocks affecting inventory behaviour have a major effect on overall volatility reduction, one can also expect that reduction in inventories volatility will give rise to that observed for production.

These assumptions can be empirically tested using consistent data on industrial production, sales and stocks of finished goods for the manufacturing sector. These data are available for the US, and they have been used by various authors to test the hypothesis that inventory accumulation plays a prominent role in shaping the main features of business cycles. In this regard, Kahn, McConnell and Perez-Quiros (2002) have used a small structural model for the US economy to show that improved information about final demand (because of technological innovation) has determined a reduction in output volatility. More recently, Maccini and Pagan (2008) have used a partial equilibrium (i.e. concentrating only on the goods sector) approach to the modelling of inventory holdings, and they have shown that changes in inventory management have scant effects upon GDP volatility in the goods sector. However, although European official statistical institutes disseminate data on industrial production and – to some extent – sales, they do not do so on inventory accumulation. In fact, Inventory data are available from national accounts, but they are not usually measured directly on firms, being instead calculated as a residual. Moreover, in the Eurostat (1999) definition they also include "acquisitions less disposal of valuables and of non-produced, non-financial assets". Consequently, no official data are available in Europe with which to assess the contribution of inventory behaviour to business cycles movements, unless qualitative information stemming from Business Tendency Surveys (BTS from now on) harmonised at the European level from the European Commission are taken into consideration.

4 CYCLICAL INDICATORS

Since the early sixties, the European Commission has used a harmonised system of monthly business surveys to track the cyclical fluctuations of the industrial sector in real time.[3] These surveys, which began in 1962, initially covered the larger member states and were then gradually extended to all the countries participating in the Union. Today, such surveys are autonomously conducted by partner institutes in each country on the basis of a harmonised questionnaire. The questions are qualitative, in the sense that firms are not asked to provide quantitative information on the phenomena of interest but instead to assess them "qualitatively" on a given variable. For instance, a question on the current level of production does not ask firms to indicate the amount or the value of production but to report whether it has "gone up", "stayed the same" or "gone down" with respect to the previous month. Questions usually allow 3 possible answers arranged on a Linkert scale. Firm-level data are then processed in terms of sample averages of survey answers, e.g. by calculating the percentages of replies that production has "gone up", "stayed the same" or "gone down". As a synthetic measure, for each question (q), the balance (B) of the replies is usually calculated as the difference between the percentages of positive (P) and negative (N) replies:

$$B_q = P_q - N_q \qquad (1)$$

The questionnaire asks, amongst other things, for information on present and expected levels of production and orders, and on inventories of finished goods. In particular, firms are asked to indicate whether inventories are above or below "normal" levels generally interpreted as the desired amounts of stocks. In what follows, we assess the degree of correlation of survey data with the industrial cycle, and we look more closely at survey data volatility, concentrating in particular on inventories volatility and its relationship with industrial activity fluctuations.

4.1 Correlation with industrial activity

Business survey data are generally considered to be strongly correlated with economic activity, and as such they are widely used in Europe to evaluate business cycle evolution over time, especially for the industrial sector. In this respect, figure 4 compares the cyclical behaviour of industrial production with

[3] See European Commission, 2002.

Fig. 4 Industrial production and production assessments

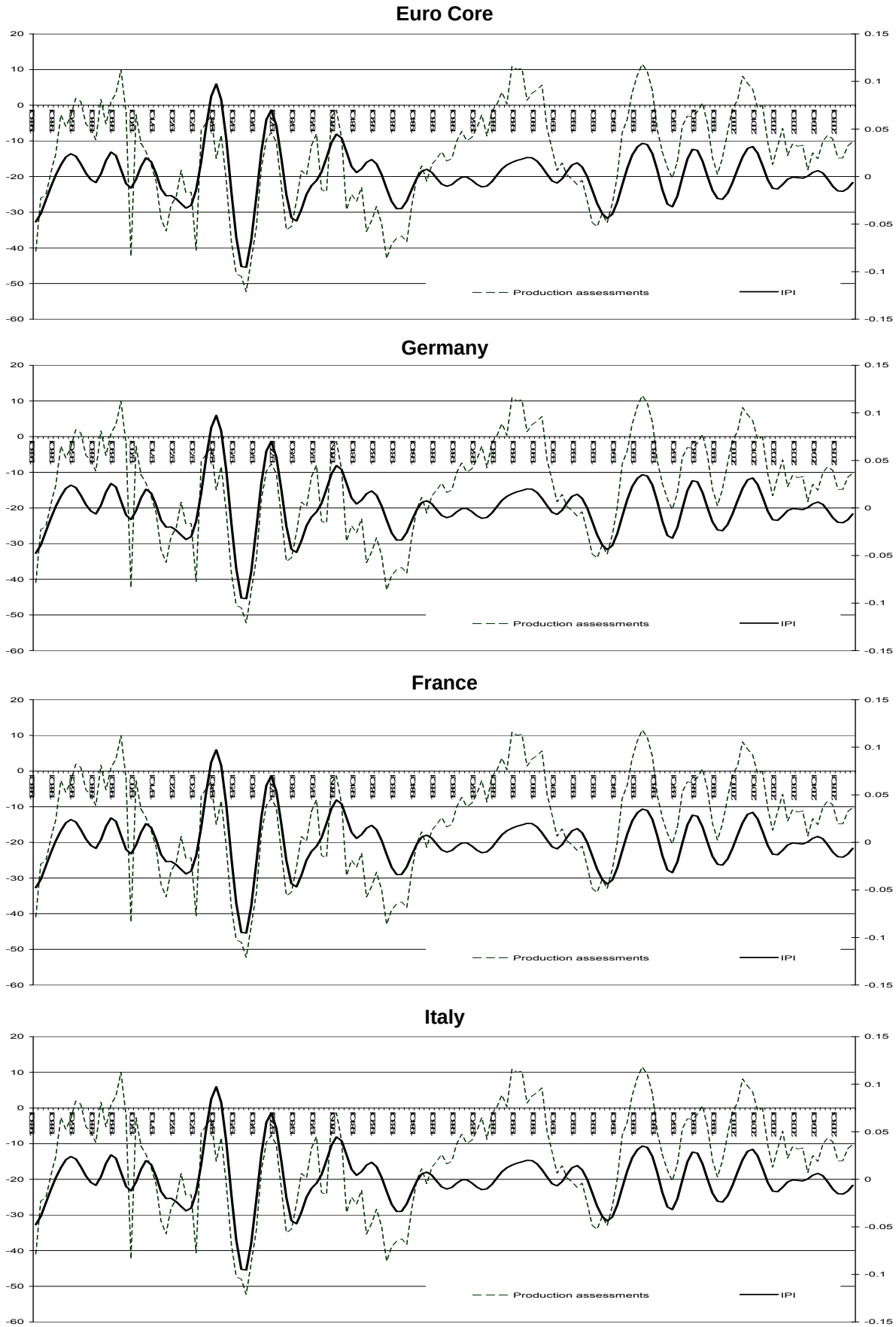
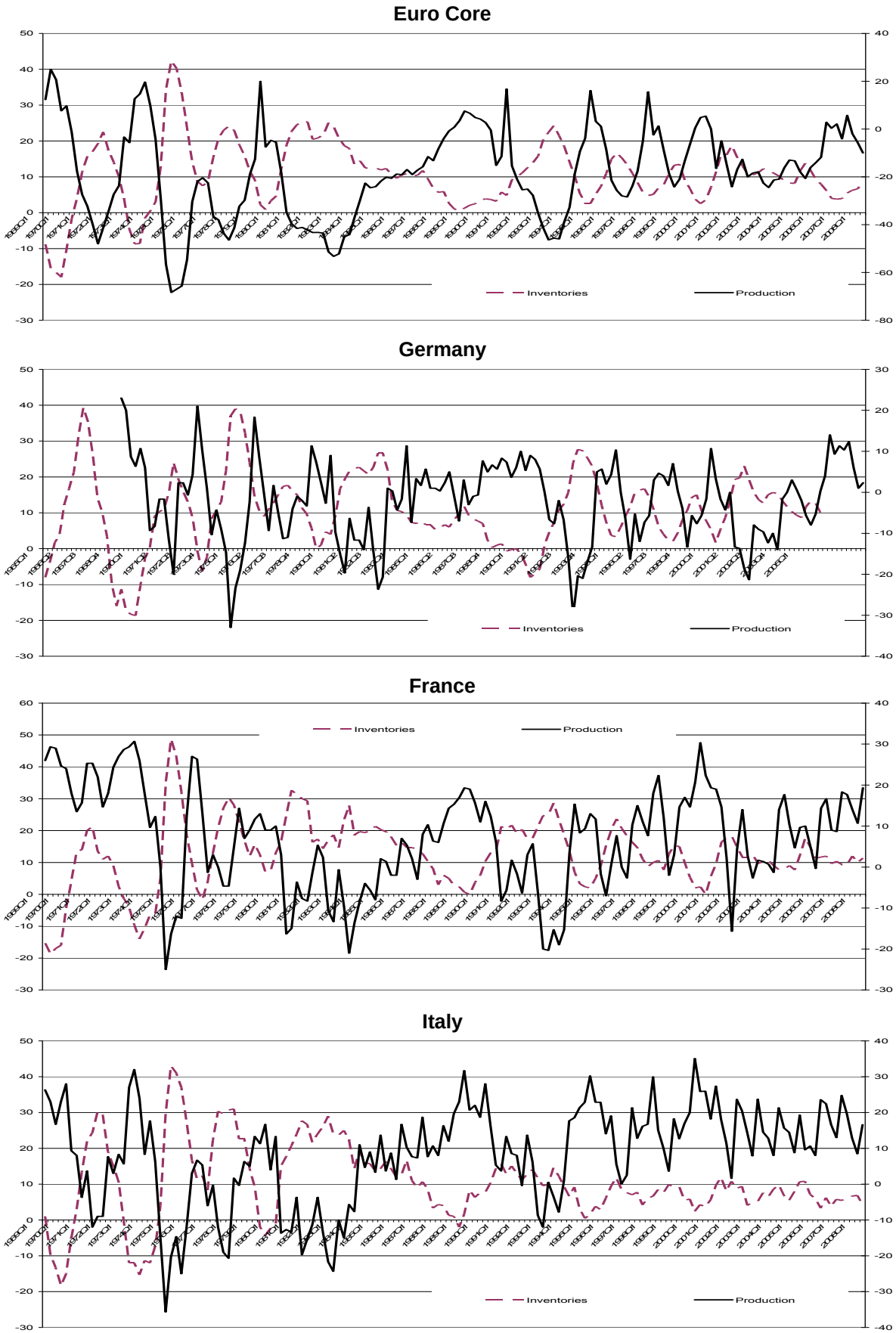


Fig. 5 **Inventories and production assessments**



that of current production assessments derived from European business surveys in Italy, France, Germany and in the Euro Core. The Euro Core indicator is, as always, obtained by combining the balances on production assessments in Italy, France and Germany using value added shares as weights.

Firm-assessments on production level and actual industrial production show a strong correlation throughout the sample, both for the Euro Core aggregate and for individual European countries. This finding is crucial for our analysis: if survey data are really able to match the real economy evolution, we can use them to investigate the "inventory hypothesis" as an explanation of the Great Moderation of European countries. Figure 5 separately reports the balance for the inventories question and those referred to current production assessments. Inventories balances are usually positive, a somewhat unexpected result given that one would expect inventories to be "normal" in the long run. Correlation of inventory movements with those of production assessments (which we have just shown to be strongly correlated with actual industrial activity) is quite high, albeit negative. That is, inventories move counter-cyclically, a finding in contrast with most studies in the literature but which can be easily explained by considering the exact nature of the question on inventory accumulation (see below).

Table 4 reports cross correlations among survey data and (the cyclical component of) industrial production. Besides data on firms' assessments concerning current production and inventories, here we also consider assessments on the current level of orders and expectations about future production trends.[4]

Cross correlations among industrial production and assessments on current orders, production and inventories generally peak at lead 1, indicating that survey variables lead actual industrial production by one quarter. Coefficients are generally rather high, being above .7 in absolute terms for assessments on production and inventories and slightly below that threshold for expected production. Inventories are confirmed to be counter-cyclical, a result already obtained by previous studies for the Italian economy (Cesaroni, 2007 and Malgarini, 2008). Overall, the results show that survey data are closely correlated with the cyclical behaviour of industrial production. The existence of common cyclical components among survey data and industrial production for Italy has, in fact, already been found using spectral methods (see on this

[4] The European Commission provides a "Confidence Indicator" for the Industrial Sector using the balances on the expected level of production and the assessments on the current level of orders and inventories. The choice of the series is based on considerations concerning the potential leading characteristics of the data and their performance in tracking industrial cyclical activity. See on this European Commission, 2002.

Cesaroni, 2007). Hence, a careful study of volatility of survey data may yield interesting insights into the role of inventories in the Great Moderation.

Tab. 4 Cross Correlations between business surveys data and industrial production, 1965-2006

					Current orders (t-k)				
	K	-4	-3	-2	-1	0	1	2	3	4
Germany		0.30	0.50	0.67	0.74	0.70	0.53	0.28	-0.02	-0.29
France		0.19	0.34	0.49	0.57	0.55	0.42	0.19	-0.06	-0.30
Italy		0.17	0.40	0.59	0.66	0.60	0.38	0.10	-0.18	-0.39
Euro core		0.21	0.45	0.63	0.72	0.66	0.47	0.19	-0.12	-0.37
					Current production (t-k)				
	K	-4	-3	-2	-1	0	1	2	3	4
Germany		0.44	0.61	0.69	0.64	0.44	0.12	-0.21	-0.46	-0.59
France		0.14	0.35	0.55	0.67	0.63	0.45	0.17	-0.13	-0.40
Italy		0.00	0.20	0.42	0.58	0.60	0.45	0.20	-0.08	-0.30
Euro core		0.17	0.42	0.63	0.73	0.68	0.48	0.20	-0.10	-0.34
					Expected production (t-k)				
	K	-4	-3	-2	-1	0	1	2	3	4
Germany		0.50	0.63	0.67	0.58	0.36	0.04	-0.28	-0.52	-0.63
France		0.31	0.49	0.58	0.53	0.36	0.10	-0.16	-0.36	-0.44
Italy		0.25	0.43	0.53	0.51	0.39	0.15	-0.09	-0.30	-0.40
Euro core		0.43	0.59	0.66	0.59	0.38	0.08	-0.22	-0.46	-0.57
					Inventories (t-k)				
	K	-4	-3	-2	-1	0	1	2	3	4
Germany		-0.41	-0.61	-0.75	-0.77	-0.66	-0.43	-0.12	0.20	0.45
France		-0.12	-0.42	-0.65	-0.74	-0.63	-0.36	-0.01	0.32	0.54
Italy		-0.16	-0.40	-0.57	-0.62	-0.53	-0.31	-0.04	0.21	0.38
Euro core		-0.26	-0.51	-0.70	-0.76	-0.65	-0.41	-0.08	0.24	0.49

4.2 Volatility of business survey data

In the previous section we found that survey data are strongly correlated with industrial activity and that survey-based information on inventory accumulation moves counter-cyclically. Table 5 analyses the volatility of survey data, again splitting the sample into two sub-periods with a break in 1984. Volatility reduction is also apparent in qualitative data stemming from the harmonised system of business surveys coordinated by the European Commission. For the Euro Core taken as a whole, and for all the series considered in the analysis, volatility is lower in the second part of the sample. The same results are also found when looking at the data for each country, the

only exception being current assessments of production and orders in France – for which, however, the sample starts at a later date (January and March 1976 respectively).

Tab. 5 **Volatility of business survey data**

	Current orders			Current Production		
	Standard deviation	Standard deviation relative to 1963-2006		Standard deviation	Standard deviation relative to 1963-2006	
	1963-2008	1963-1983	1984-2008	1963-2008	1963-1983	1984-2008
Euro Core	17.35	1.13	0.82	19.26	1.26	0.70
Germany	19.13	1.15	0.83	9.93	1.16	0.88
France	16.66	0.67	1.04	13.17	0.87	1.04
Italy	19.48	1.23	0.66	14.15	1.10	0.75
	Production Expectations			**Inventories**		
	Standard deviation	Standard deviation relative to 1963-2006		Standard deviation	Standard deviation relative to 1963-2006	
	1963-2008	1963-1983	1984-2008	1963-2008	1963-1983	1984-2008
Euro Core	10.47	1.18	0.79	9.24	1.34	0.54
Germany	11.22	1.21	0.78	10.69	1.28	0.67
France	12.58	1.15	0.64	10.88	1.33	0.59
Italy	14.05	1.10	0.64	10.73	1.37	0.39

Figure. 6 provides the usual analysis of the evolution of volatility over time, calculating rolling standard deviations on a window of five years. In this case too, the results obtained on survey data confirm those already derived by looking at variables more commonly used to measure cyclical fluctuations. For all the series considered, volatility decreased in the eighties, picked up again during the nineties and then fell in the last decade. Volatility reduction is stronger for inventories, and as a result the standard deviation of inventory assessments is clearly at its lowest level in the last part of the sample for all the countries considered and for the Euro Core taken as a whole.

4.3 Possible interpretations of the results

According to our findings, inventory volatility reduced steadily in the period considered; in fact, the survey data show that volatility reduction was stronger than observed for current and expected production and orders. However, it is not clear at this stage whether the reduction in inventory volatility may be simply

Fig. 6 **Rolling Standard deviations of survey data**

a consequence of a reduced volatility of demand and industrial activity in general, or whether it should be considered an autonomous factor directly influencing (and not being influenced by) business cycle volatility. In fact, inventory balance indicates the extent to which – according to firms – inventories diverge from their "normal" levels. No further indication is given in the survey about the exact meaning of "normal" inventory levels. However, in 2006, ISAE, the Institute which carries out BTS in Italy, asked its sample of Italian firms to indicate whether a "normal" level of inventories could be interpreted as a level "adequate to the current needs of the firm". More than 95% of the sample responded in the affirmative to the question, confirming that the "normal" level can be interpreted as the "desired" level of stocks. Using respectively N_t and N^* to denote the current and desired level of stocks, we can therefore state that if $\frac{N_t}{N^*} > 1$ firms will report that inventories are above "normal"/desired levels: hence, the balance of the question on inventories holdings can be interpreted as a qualitative measure of the divergence between the actual and desired level of stocks. Accordingly, considering the simple identity among production, inventories and sales,[5] and assuming that the desired level of inventories will depend positively on the level of sales,[6] we have that the $\frac{N_t}{N^*}$ ratio will be higher, the higher is the level of current stocks and the lower the level of sales. In its turn, the volatility of the above ratio (i.e., the volatility of the inventory balance) will depend upon:

- Volatility of sales: the more sales are volatile, the more the desired level of stocks is volatile;
- Ability of firms to adjust the desired level of stocks to the current level of sales: the more firms are able rapidly to adjust their production levels to the current level of sales, the less they need to adjust the current to the desired level of stocks, resulting in a decreasing volatility of the $\frac{N_t}{N^*}$ ratio.
- Ability of firms to adjust the actual to the desired level of stocks: the more firms are able to obtain the desired level of stocks, the less they need to "fine tune" the current to the desired level of inventories, resulting again in a decreasing volatility of the $\frac{N_t}{N^*}$ ratio

5 In t, production (Y) equals sales (X) plus/minus accumulation/decumulation of stocks (N), i.e. $Y_t = X_t + \Delta N_t$.

6 For a discussion of the model, see Maccini and Pagan, 2008.

Hence the observed lower volatility of the actual/desired inventory ratio may be due either to:

1) lower standard deviation of shocks hitting the inventory optimisation process (i.e. shocks pertaining mainly to the behaviour of sales)
2) a change in the dynamic process through which the shocks affect the current/desired inventory.

In the latter case, we may interpret this change as first evidence of technological change affecting the choice of the optimal level of stocks and /or of the process of adjusting the actual to the desired level of stocks. In order to disentangle the two hypothesis, we can assume that the actual/desired inventory ratio (i.e. the BTS balance) follows an autoregressive process (AR) given by:

$$\frac{N_t}{N^*_t} = \beta + a(L)\frac{N_{t-i}}{N^*_{t-i}} + \varepsilon_t \qquad (2)$$

Following Stock and Watson (2005), we estimated (2) using an AR(4) estimated on two different sample periods, again allowing for a discrete break in 1984 in order to capture possible variations over time in the AR coefficients and in the standard error of the regression. In fact, an increase/decrease in the sum of AR coefficients implies an increase/decrease in the persistence of shocks on the deviation of inventory accumulation from the desired level; similarly, an increase/decrease in the standard error of the regression (SER) implies an increase/decrease in the magnitude of exogenous shocks hitting the process of inventory accumulation. We also included a constant term in order to take account of the fact that on average the balance of the inventory question is greater than one. The order of the autoregressive process was chosen so as to maximise the likelihood function, provided that residuals were well behaved according to the usual tests.

Tab. 6 Autoregressive parameters for the current/desired inventory ratio

	Sum of AR coefficients		SER	
	1963-1983	1984-2008	1963-1983	1984-2008
Euro Core	0.82	0.86	3.71	1.60
Germany	0.82	0.87	4.20	2.05
France	0.73	0.80	5.51	2.57
Italy	0.76	0.83	5.19	2.49

The results (Tab. 6) show that, during the Great Moderation, innovations to the current/desired inventory ratio decreased substantially in all the countries considered. On the other hand, the persistence of shocks increased slightly in the period 1985-2008 with respect to the previous decades. According to these findings, the impact of external shocks (stemming from a reduced volatility of sales) has played a major role in reducing the volatility of the current/desired inventory ratio. Moreover, an increase in the persistence of shocks shows that exogenous innovations have – *ceteris paribus* – a greater impact on inventory volatility with respect to the first part of the sample.

5 CONCLUSIONS

The analysis conducted in the first part of the paper on stylized facts concerning the business cycle confirmed that fluctuations have been on average longer, more ample and steeper in the US and the UK with respect to the main countries of the Euro Area (Germany, France and Italy). This result is consistent on considering both aggregate activity (GDP) and industrial sector. As expected, the US cycle leads that of the Euro Core, whereas it appears to be almost synchronised with that of the UK. Moreover, synchronisation of business cycles is much higher for industrial activity than for total GDP. Nevertheless, the US, the UK, as well as the main countries of the Eurozone, all display a remarkable reduction of business cycle volatility from the mid-eighties onwards.

The second part of the paper has been devoted to analysis of one of the possible explanations of the Great Moderation, namely the explanation associated with the better inventory management made possible by the use of more advanced technologies. This issue has been often addressed in the literature with reference to the US, but it has been seldom considered for Europe, mainly because of a lack of official and reliable data on inventory accumulation. In this regard, our contribution has been that of introducing into this kind of literature the use of qualitative data drawn from Business Tendency Surveys harmonised at the European level by the European Commission. The strength of using this kind of data in short term analyses of the European economy is well known. Nevertheless the novelty of the work consists in the analysis of the cyclical properties of such data, in the findings concerning the existence of a strong correlation with underlying business cycle movement, and in the use of their signal for drawing inferences on structural issues such as that of the Great Moderation.

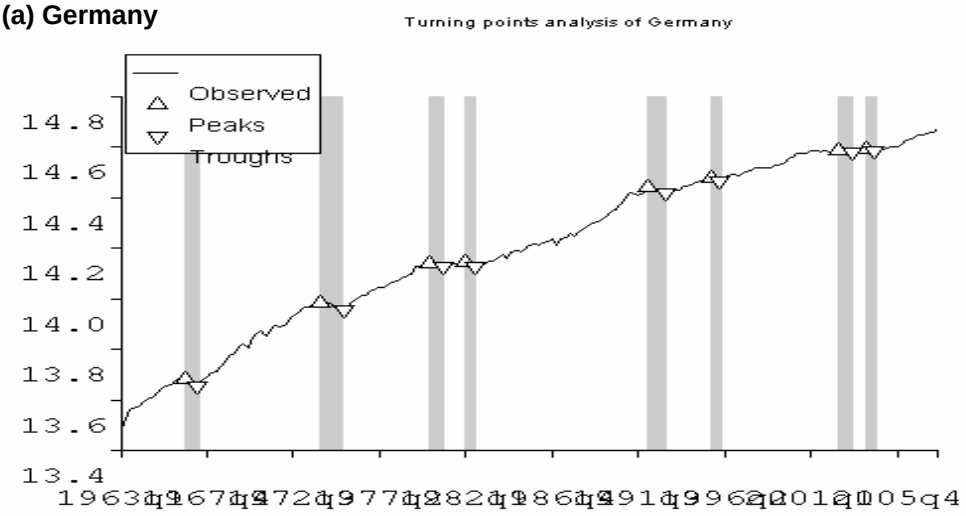
In particular, a possible interpretation of BTS data on inventories is that they represent the divergence between the actual and the desired level of stocks. The latter is usually found to depend upon the level of sales and the technology used to adjust stocks to their desired level. Hence, the volatility of inventories is influenced by both exogenous and endogenous factors: the former are mainly linked to the volatility of sales, and therefore to factors that may influence volatility on the demand side of the economy; the latter are instead linked to technology used in the inventory accumulation process, including those which enable the better forecasting of sales (with the consequent adjustment of the desired level of stocks to that of sales) and the better adjustment of the actual to the desired level of stocks. In this regard, our analysis has shown that the reduction in volatility occurring in the actual/desired inventory ratio is mainly linked to a reduction of volatility in innovation, with the persistence of shocks actually increasing during the Great Moderation.

Consequently, our results do not support the view that inventories have played a major role in explaining the Great Moderation. However, nor do we interpret these findings as providing support for the “good luck” hypothesis. In this regard, in line with the findings of a recent study by Giannone, Lenza and Reichlin (2008), we believe that it is likely that the role of exogenous shocks has been overstated due to the fairly simplistic specification of the model that we have adopted to explain inventory movements. Accordingly, the main contribution of this paper is that it has introduced the use of survey data into the Great Moderation literature, having shown that the hypothesis of an autonomous role of inventory accumulation in explaining Euro Area volatility reduction is not clearly supported by the data. However, further research is advisable, possibly making more thorough use of BTS data, including those on the expectations of economic agents concerning such key variables as orders, demand and production. In fact, this information is not available elsewhere and can be derived only by means of public opinion surveys such as the one carried out in Europe by the European Commission.

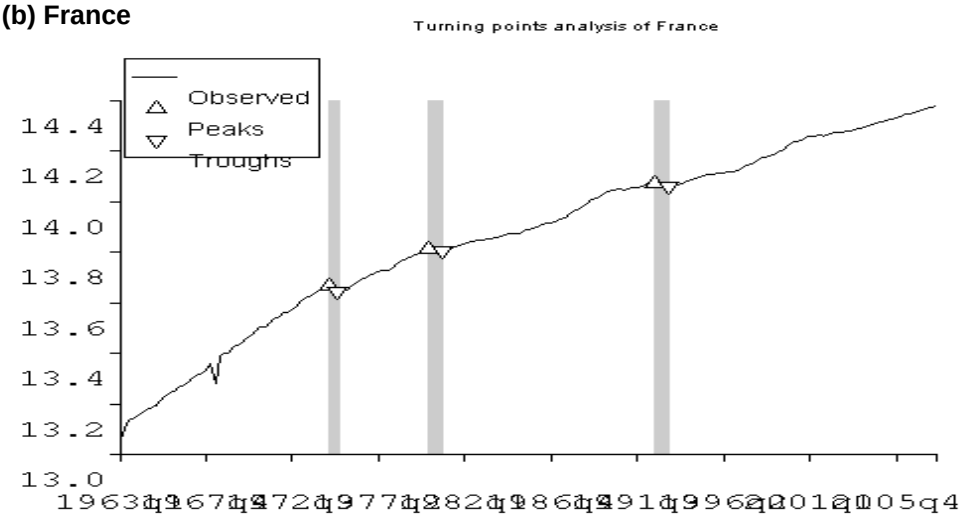
STATISTICAL APPENDIX

Figure A GDP, Harding and Pagan Turning Points analysis

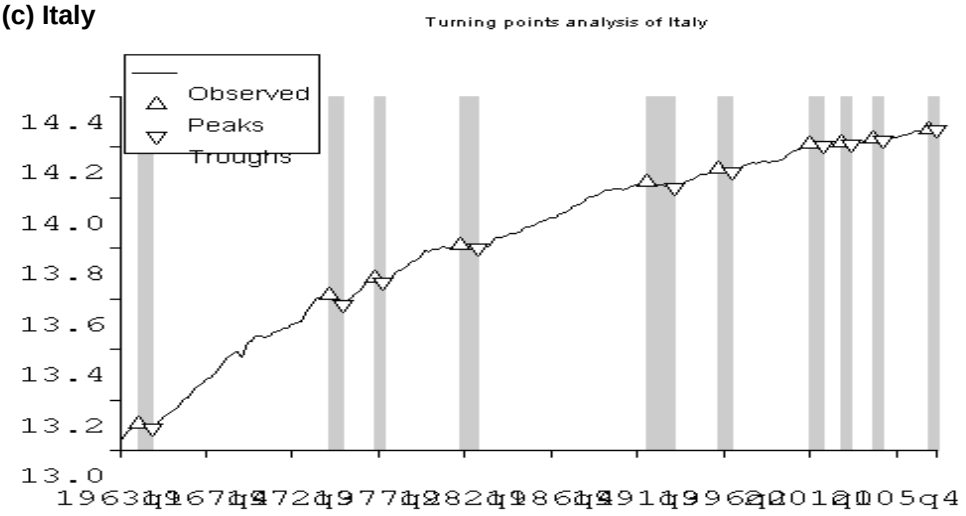
(a) Germany



(b) France

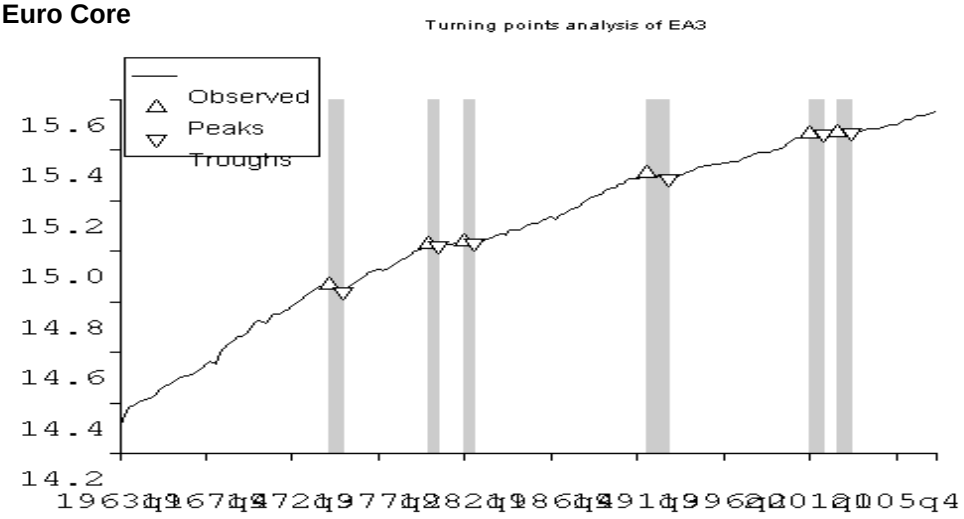


(c) Italy

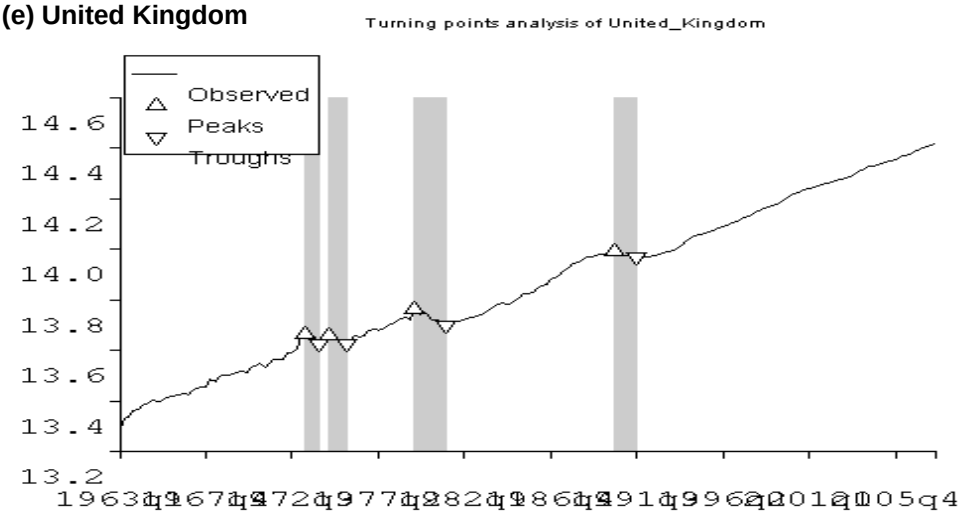


continue **Figure A**

Euro Core



(e) United Kingdom



(f) United States

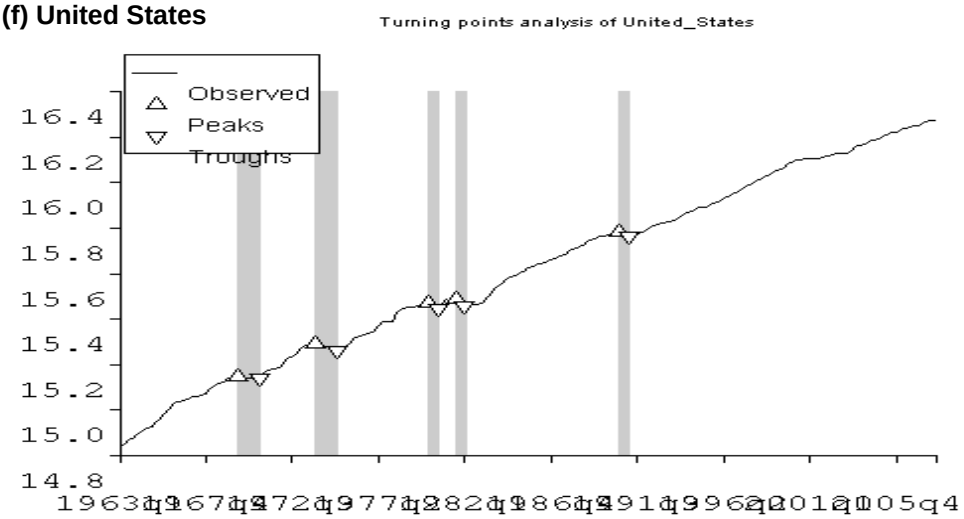
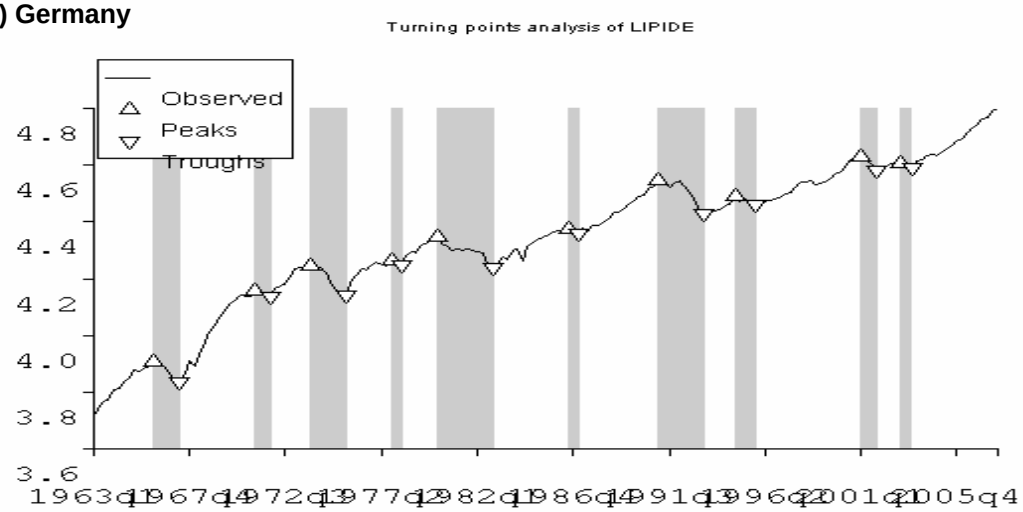
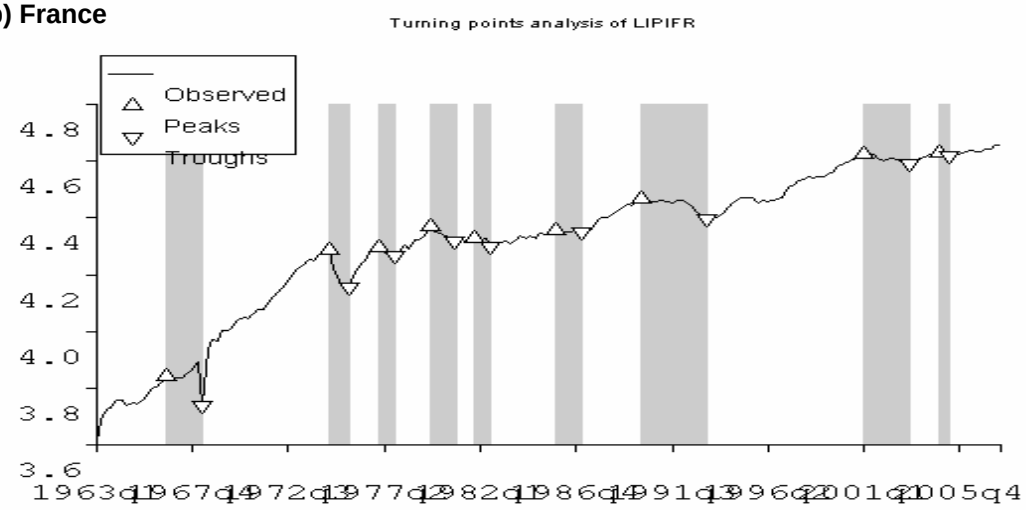


Figure B Industrial Production, Harding-Pagan turning points analysis

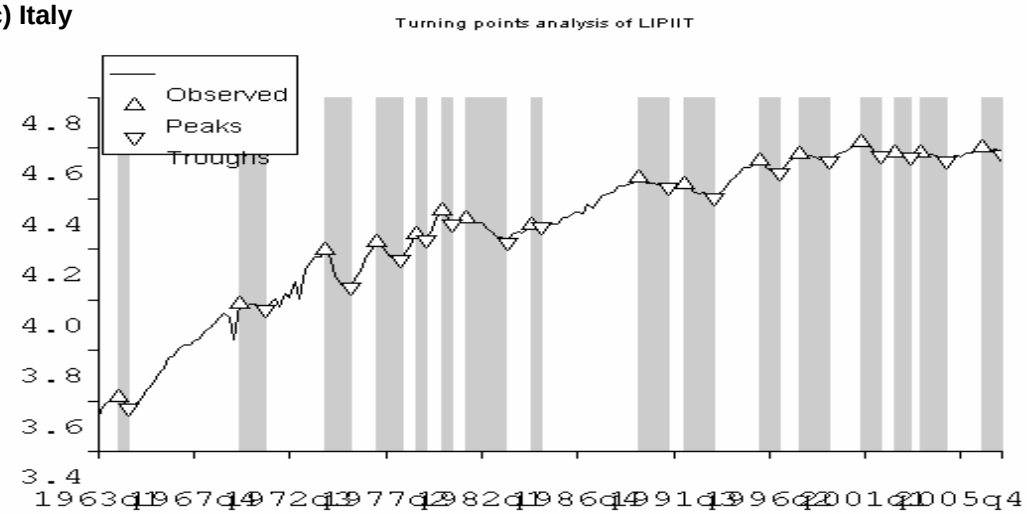
(a) Germany



(b) France

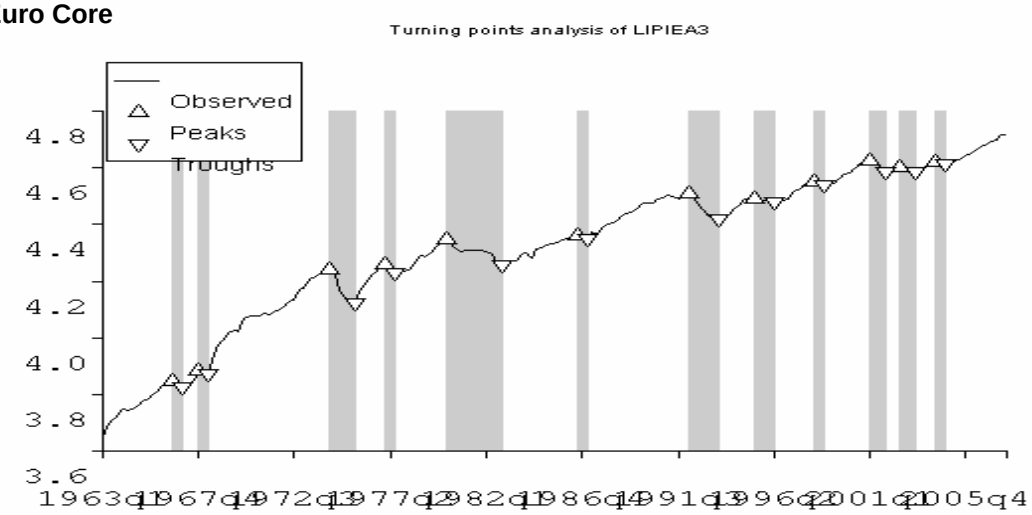


(c) Italy

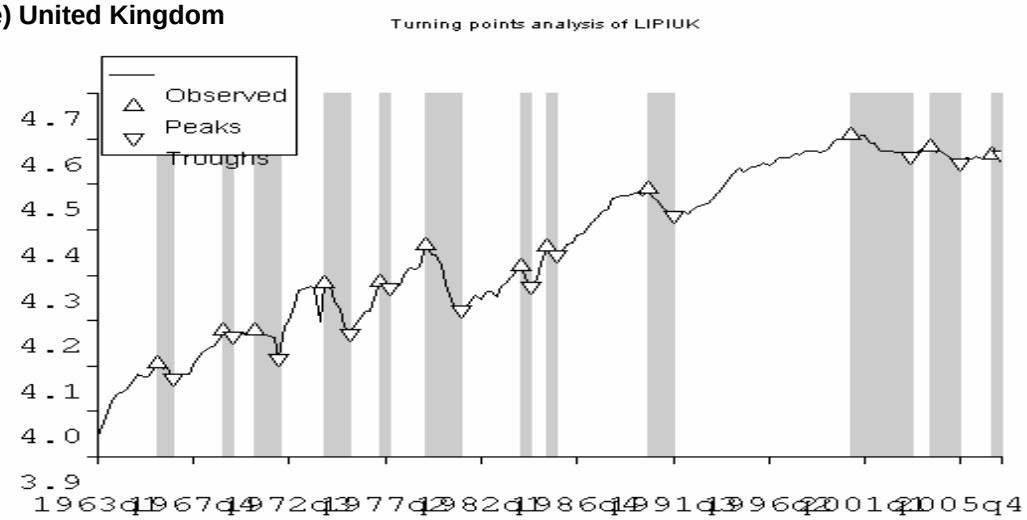


continue **Figure B**

Euro Core



(e) United Kingdom



(f) United States

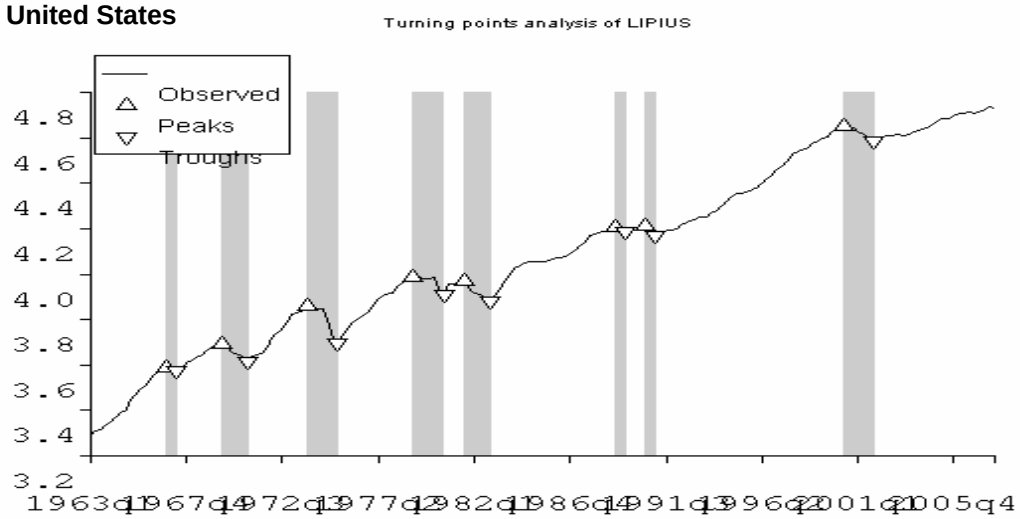


Table A Turning Points Analysis – Gross Domestic Product

Euro Core		Germany		France		Italy		United Kingdom		United States	
Peaks	Troughs	Peaks	Troughs	Peaks	Troughs	Peaks	Troughs	Peaks	Troughs	Peaks	Troughs
1974q3	1975q2	1966q3	1967q2	1974q3	1975q1	1964q1	1964q4	1973q2	1974q1	1969q3	1970q4
1980q1	1980q3	1974q1	1975q2	1980q1	1980q4	1974q3	1975q2	1974q3	1975q3	1973q4	1975q1
1982q1	1982q3	1980q1	1980q4	1992q3	1993q2	1977q1	1977q3	1979q2	1981q1	1980q1	1980q3
1992q1	1993q2	1982q1	1982q3			1981q4	1982q4	1990q2	1991q3	1981q3	1982q1
2001q1	2001q4	1992q1	1993q1			1992q1	1993q3			1990q3	1991q1
2002q3	2003q2	1995q3	1996q1			1996q1	1996q4				
		2002q3	2003q2			2001q1	2001q4				
		2004q1	2004q3			2002q4	2003q2				
						2004q3	2005q1				
						2007q3					

Table B Turning Points Analysis – Industrial Production

Euro Core		Germany		France		Italy		United Kingdom		United States	
Peaks	Troughs	Peaks	Troughs	Peaks	Troughs	Peaks	Troughs	Peaks	Troughs	Peaks	Troughs
1966q3	1968q2	1966q1	1967q2	1966q3	1968q2	1964q1	1964q3	1966q1	1966q4	1966q4	1967q2
1974q3	1975q3	1971q1	1971q4	1974q3	1975q3	1970q1	1971q2	1969q2	1969q4	1969q3	1970q4
1977q1	1977q4	1973q4	1975q3	1977q1	1977q4	1974q2	1975q3	1970q4	1972q1	1973q4	1975q2
1979q3	1980q4	1977q4	1978q2	1979q3	1980q4	1976q4	1978q1	1974q2	1975q3	1979q1	1980q3
1981q4	1982q3	1980q1	1982q4	1981q4	1982q3	1978q4	1979q2	1977q1	1977q3	1981q3	1982q4
1985q4	1987q1	1986q3	1987q1	1985q4	1987q1	1980q1	1980q3	1979q2	1981q1	1989q1	1989q3
1990q1	1993q2	1991q1	1993q2	1990q1	1993q2	1981q2	1983q2	1984q1	1984q3	1990q3	1991q1
2001q1	2003q2	1994q4	1995q4	2001q1	2003q2	1984q3	1985q1	1985q2	1985q4	2000q2	2001q4
2004q4	2005q2	2001q1	2001q4	2004q4	2005q2	1989q4	1991q2	1990q2	1991q3		
		2003q1	2003q3			1992q1	1993q3	2000q2	2003q2		
						1995q4	1996q4	2004q2	2005q4		
						1997q4	1999q2	2007q2			
						2000q4	2001q4				
						2002q3	2003q2				
						2003q4	2005q1				
						2006q4					

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