Euro Area and US Recessions, 1970–2003

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1 Introduction

Many papers have analysed differences and similarities between the euro area and US business cycles (Artis *et al.*, 1997; Artis and Zhang, 1997; Canova and Ciccarelli, 2003; Del Negro and Otrok, 2003; Monfort *et al.,* 2002; Stock and Watson, 2003). Moreover, CEPR has recently produced dates of recessions in the euro area aggregate cycle since 1970 and these dates can now be compared with those established by the National Bureau of Economic Research (NBER) for the US cycle. Knowledge about the euro area cycle is building up and the time is perhaps ripe to model the interaction between the US and the euro area cycle and to try understand differences and similarities between business fluctuations in the two economies.

The literature has focused on a variety of concepts of business cycle and stressed similarities to rather than differences from the US. The comparison shows that euro area and US recessions are mostly synchronous, they are both rare events and shorter than expansions which are the 'normal state' of both economies.

This paper starts with the observation that, although level cycles are strikingly similar in the two economies, the growth rate of output in the euro area is less volatile than in the US and more persistent. Persistence implies that the effect of an exogenous shock in the euro area is longer than in the US and, as a consequence, the ratio between the long-run variance and the total variance of output growth is larger.

How can the differences between growth cycles be reconciled with the similarities in level cycles?

We argue that a simple statistical model of joint US-euro output behaviour that is able to produce these characteristics has the following features. First, euro area and US output have a common trend, but US output grows at an average rate one-quarter higher than euro area output. Second, the euro-US output gap, defined as the difference between the euro output and the common euro-US output trend, does not Granger-cause (and it is not Granger-caused by) US output growth. Third, the shock generating the common trend has a larger contemporaneous impact but less of a persistence effect on US output than on euro area output.

By definition, the shock generating the common trend has long-run effects on the output of both economies and can therefore be interpreted as a technology shock. The model described above implies that in the US the technology shock is rapidly absorbed, but it takes longer to work its effect through European economies. The shock can be interpreted either as the world shock, immediately absorbed in the US, or as a shock originating in the US which spreads to the euro area with a lag. The two hypotheses are empirically indistinguishable.

The immediate effect of the shock is a divergence between the level of economic activity in the US and the euro area. The divergence seems to reach its maximum in the middle of the cycle (roughly five years). Europe eventually catches up, but the catching up lasts about ten years.

The model suggests that the leading-lagging relation between the two cycles is explained by the different rates of absorption of the technology shock. This feature also explains the different profile of output volatility in the two economies, with the US showing larger volatility at high than at low frequencies and the euro area showing more persistence.

Beside estimating the model and testing for cointegration and Granger causality, we use the constraints implied by the characteristics described above to define a hypothetical data-generating process that we then use to generate artificial data. When using standard techniques to identify peaks and troughs in the cycles of the generated data, we find features which are insignificantly different from those identified on output data. These features are also very similar to those implied by CEPR and the NBER dating. This suggests that our simple model is able to capture the essential characteristics of cyclical output in the two economies.

The same model fits consumption data.

The model and the CEPR-NBER 'fact' that classical recessions are rare events while expansions are the normal state of the economy can be assembled to draw some conclusions for the welfare implications of fluctuations in both economies. Even assuming that there are no long-run differences in trend, Europe loses welfare because, after a technology shock, it reaches its steady state later than the US. In other words, the US enjoys all the advantages of growth immediately while Europe has to wait much longer. In Europe, losses in terms of both output and consumption during recessions are not as drastic as in the US and they are distributed over a long period of time. Recessions are less sharp, but recoveries are very slow. Given that expansions are the normal state of affairs in the economy (the mean of the shock is positive) and recessions are rare, at realistic real interest rate values, the larger loss of welfare that the US incurs on impact is more than compensated for by the rapid recovery.

2 Stylized facts

2.1 Classical cycles: NBER and CEPR dating

The NBER and CEPR provide a chronology for, respectively, the US and the euro area business cycle. In both cases, the chronology is established by informal inspection of a variety of key macroeconomic time series and it is not just based on GDP. The dates refer to what is typically called the classical cycle, i.e. the turning points in the level of economic activity. Figure 1 plots quarterly US and euro area GDP since 1970 (the first date for which aggregate euro statistics are available) and the dates established by CEPR and NBER.

NBER and CEPR dating illustrate striking similarities between the cyclical characteristics of the two economies. In both economies, recessions are rare and of short duration if compared with expansions and they are roughly synchronized.

The dates produced by CEPR and NBER, based on informal data analysis, can also be compared by dates for peaks and troughs identified by the automatic algorithm designed by Bry and Boschan, 1971 (BB). The latter is a non-parametric procedure devised to identify local maxima and minima and it is widely used in business cycle analysis.[1] Table 1 reports results.

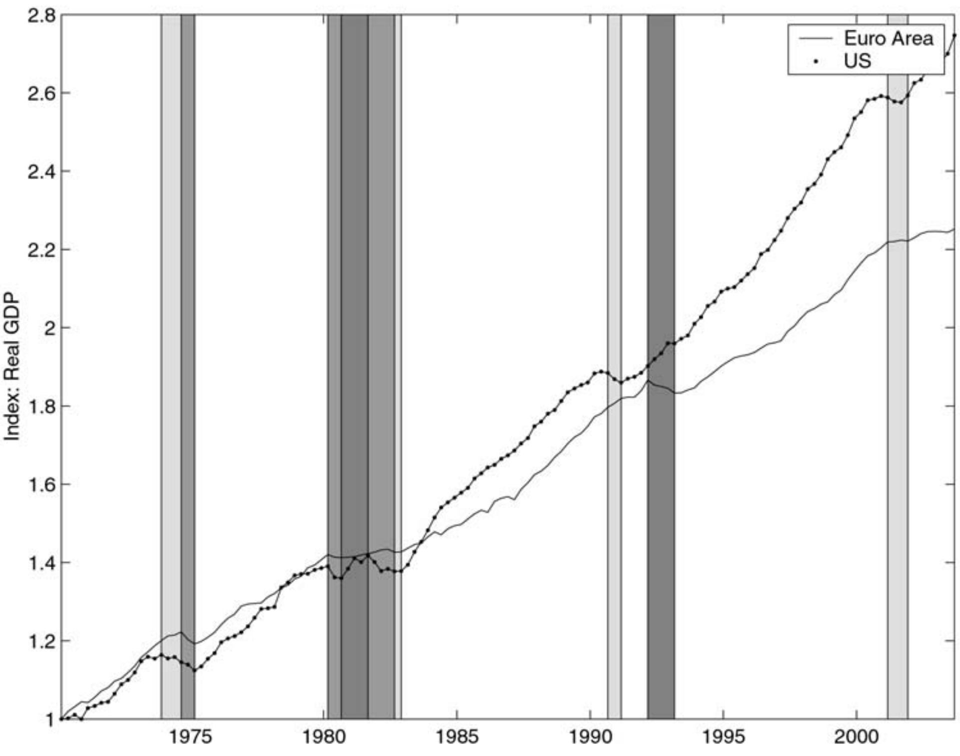
Notice that the informal CEPR and NBER procedures give similar results to the BB procedure. There are two exceptions, both pertaining to the euro area: the early 1980s and the recent slowdown. The differences are explained by the fact that CEPR (as NBER) dating is not exclusively based on GDP and both in the 1980s and in the recent slowdown, euro area GDP dynamics is not clearly correlated to labour market variables, industrial production and investment (on this point, see the discussion by the CEPR dating committee at *www.cepr.org*).

Table 1 Dating algorithm

Euro area		US	
P^{EU}	T^{EU}	P^{US}	T^{US}
1974:3	**1975:1**	**1973:4**	**1975:1**
(1974:3)	(1975:1)	(1973:4)	(1975:1)
		1980:1	**1980:3**
1980:1	**1982:3**	(1980:1)	(1980:3)
(1980:1)	(1980:3) + 8q	———	———
		1981:3	**1982:4**
		(1981:3)	(1980:3) + 1q
1992:1	**1993:1**	**1990:3**	**1991:1**
(1992:1)	(1993:1)	(1990:2) + 1q	(1991:1)
?	?	**2001:1**	**2001:4**
(2002:4) + ?q	(2003:2) + ?q	(2000:4) + 1q	(2001:3) + 1q

Notes: Both the CEPR and NBER dates for the peaks and troughs appear in bold. We show between parentheses the date computed by the dating algorithm. The numbers of quarters of mismatch appears after the + sign.

Figure 1 GDP since 1970



Note: The light shadow corresponds to a recession in the US, the dark one to a recession in the euro area; overlapping recessions are shown by an intermediate shade.

We will now compute some descriptive statistics on duration, amplitude and synchronization of cycles to document further similarities and differences between the two business cycles. Table 2 reports statistics for the two classifications of peaks and troughs: the informal CEPR and NBER classification (bold figures) and the dating resulting from the application of the BB algorithm to quarterly GDP (in parenthesis). Amplitude is measured as the quarterly average growth rate of GDP during the subperiod, duration is measured in quarters and the concordance index is a measure of synchronization developed by Harding and Pagan (2002b.) Calling the log of US GDP as y_t^{US} and the log of euro area output y_t^{EU}, the concordance index is defined as:

$$C_{ij} = \frac{1}{T}\sum_{t=1}^{T}[S_{y_t^{US}}S_{y_t^{EU}} + (1 - S_{y_t^{US}})(1 - S_{y_t^{EU}})]$$

where $S_{y_t^j}$ is a binary random variable that takes the values unity during recessions and zero during expansions. The concordance index ranges between 0 and 1.

Table 2 shows that, as suspected by inspection of Figure 1, there is high concordance between the two cycles. However, cyclical amplitude in the US is larger than in the euro area, while recessions are shorter. In general, the euro area cycle seems to be smoother than the US one.

Table 2 Business cycle statistics

	US	Euro area
Peak to trough amplitude	**-0.5658**	**-0.2433**
	(-0.6294)	(-0.4979)
Trough to peak amplitude	**0.9445**	**0.7653**
	(0.9589)	(0.6254)
Peak to trough duration	**3.4000**	**5.3333**
	(3.4000)	(2.5000)
Trough to peak duration	**23.25**	**29.00**
	(23.50)	(35.00)
Concordance index	**0.8593**	
	(0.8222)	

Notes: The buseinss cycle statistics corresponding to the NBER and CEPR dating are in bold. We show in parenteses the same statistics, produces by the BB dating alogrithm.

2.2 Growth cycles

The problem with the definition of the cycle in terms of level of economic activity is that it depends on the underlying trend growth rate, so that in a period of sustained growth one may be led to never detect a business cycle. An alternative is to refer to the growth cycle and define a recession as a period of deceleration of the growth rate, an event which may occur even when the GDP growth rate is positive (clearly, growth cycles exhibit more frequent turning points than classical cycles).

The analysis in terms of growth rates brings further insights on differences and similarities between business cycles. Since the growth of output is typically stationary, growth cycle characteristics can be illustrated by looking at volatility, persistence and dynamic correlations.

Volatility is typically measured by the variance of the growth rate of the series. This is an average of the variance at all frequencies and therefore captures short-run, long-run and business cycle variance. Persistence can be measured in different ways.

We will here define it as the variance of that component of the growth rate of output corresponding to cycles of eight years or longer. This roughly corresponds to the variance of the Hodrick and Prescott (HP) trend with smoothing parameter equal to

1600 (HP trend). Table 3 reports the variance of the growth rates of output, the variance of the HP trend and the ratio between the latter and the former for both the euro and the US economy. We can observe the following characteristics. Output volatility is higher in the US than in the euro area and persistence, as measured by the ratio between the variance of the HP trend and the total variance, is larger in the euro area.

Table 3 Standard deviation of the growth rate of output and of the HP trend

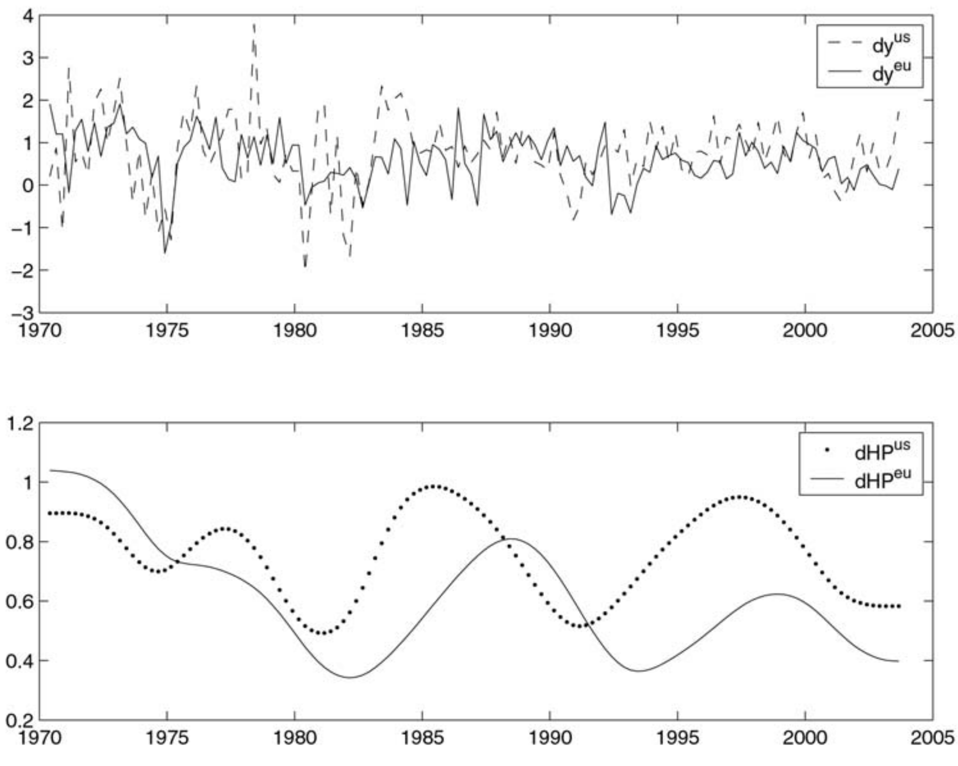
	US	Euro area
std (Δy)	0.88	0.60
std (ΔHP)	0.14	0.19
$\frac{std\ (\Delta HP)}{std\ (\Delta y)}$	0.16	0.31

Differences in volatility and persistence characteristics of growth cycles between the US and the euro area are the same as those observed for level cycles based on amplitude and duration statistics. Larger persistence in the euro area is not surprising, since recessions, as we have seen, are less pronounced, but last longer than in the US.

What about synchronization?

Figure 2 plots quarterly growth rates of GDP (upper quadrant) and HP cycles (lower quadrant) corresponding, as we have seen, to cycles eight years or longer. The plot shows that the persistent component of output growth in the euro area is lagging the US analog.

Figure 2 Growth rates and HP trends



3 Classical and growth cycles: reconciling the evidence

The descriptive statistics reported in the previous section show that, although level cycles are similar in the euro and US economies, the Euro area is characterized by lower volatility of output growth and larger persistence. This implies that shocks have a larger impact effect on the US economy but they are absorbed faster than in the euro area.[2] Moreover, the US growth cycle seems to lead the euro area cycle at medium- to long-term frequencies.

In this section we identify a statistical model of joint US-Euro area output dynamics which can account for these characteristics.

We will proceed as follows. We first test for cointegration to determine whether the two economies have a common trend. Then, we apply Granger causality tests to determine whether the euro area growth adjusts to the US's, as suggested by the lagging relation of its HP cycle illustrated in Figure 2.

Results from the Johansen cointegration test are illustrated in Table 4. They show that, at the 1% level, the hypothesis of cointegration cannot be rejected and that with cointegration coefficients are estimated to be [1, –3/4]. This implies that, during the sample period, the average rate of growth in the US has been three-quarters higher than in the euro area and that there is only one shock driving output in the long run in both countries (the world shock).

Table 4 Unresticted cointegration rank test

No. of coint. vectors	eigenvalue	trace statistics	5% cv	1% cv
None *	0.111818	15.56124	15.41	20.40
At most 1	0.001123	0.146078	3.76	6.65
Cointegration equation		$y^{eu} - 0.72y^{us}$ (0.01931)		

Let us now define

$$X_t = \begin{pmatrix} \Delta y_t^{US} \\ y_t^{EU} - 3/4 y_t^{US} \end{pmatrix}$$

where $GAP_t = y_t^{EU} - 3/4y_t^{US}$ is the output gap between the euro area and the US. The VAR augmented by an error correction term can be written as:

$$B(L)X_t = \varepsilon_t$$

The F-test rejects the hypothesis of the significance of GAP_t on Δy_t^{US}, implying that the gap does not Granger-cause (and is not Granger-caused by) the US rate of output growth (results are reported in Table 5).

Table 5 Granger causality tests

Null hypothesis	F-statistic	Probablility
GAP does not Granger-cause y^{EU}	9.84170	0.00011
y^{EU} does not Granger-cause GAP	2.74502	0.06806
GAP does not Granger-cause y^{US}	0.43504	0.64820
y^{US} does not Granger-cause GAP	0.00992	0.99013

The restricted form of the model is:

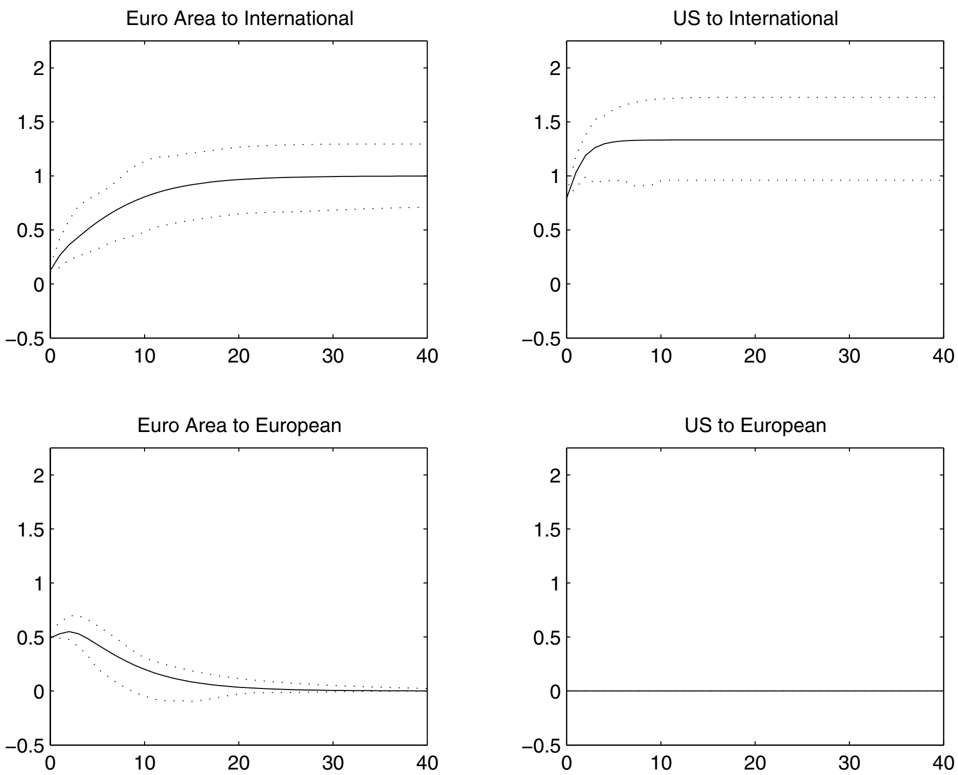
$$\Delta y_t^{US} = \alpha + \beta_1 \Delta y_{t-1}^{US} + \ldots + \beta_4 \Delta y_{t-1}^{US} + \varepsilon_{t1}$$

$$\text{GAP}_t = \rho_1 \text{GAP}_{t-1} \ldots + \rho 1 \text{GAP}_{t-4} + \varepsilon_{t2}$$

This triangular form implies that the euro area rate of growth adjusts itself to the US growth while the US does not respond to shocks specific to the euro area.

On the basis of the constrained model we can now compute impulse response functions to the non-neutral (world) shock (Figure 3 reports impulse responses and bootstrapped confidence intervals).

FIgure 3 Impulse response functions



Notice that a given shock has a larger impact in the US, but it absorbed less rapidly in the euro area than in the US. This is a consequence of the higher persistence in European output noticed above.

If the non-neutral common shock is interpreted as the world technology shock, this result implies that the US economy has a higher ability to absorb technology faster than the euro economy. The high rapidity with which technology is absorbed in the US seems to induce high short-term volatility. But in the euro area the bulk of the variance is in the long run because it takes longer to absorb shocks. An alternative interpretation is that the world shock is in fact the US shock. The two hypotheses cannot be distinguished statistically, but the economic implication of the two alternative interpretations is the same.

The result on Granger causality indicates that the world growth is led by the US, with the euro area following with a lag. This should explain why turning points of the euro cycle lag those of the US cycle.

The restricted model can now be used to simulate levels of output to verify whether we can reproduce the BB dating described above.

The model is simulated using 2,000 drawings. On the generated output series we apply the BB algorithm and compute the same statistics on duration and amplitude as in Table 2. Table 6 reports true values and simulated values with bands and shows that true values are in the bands in all cases.

Table 7 reports the simulated and true concordance statistics for US and euro area GDP log levels. They are strikingly similar.

It is interesting to note that in order to generate the empirical characteristics of euro area and US cycles, with rare recessions and prolonged phases of expansions, we do not need to simulate out of a complicated non-linear model: our simple linear model does the job. This has already been documented by Harding and Pagan (2002a) and stressed in their discussion with Hamilton, 2001 (see also Harding and Pagan, 2003a, b).

Notice that the model implies that the second shock, which is neutral on output, is European-specific so that to explain euro area cyclical output we need more than technological shocks; however, for the US, technology explains the bulk of cyclical fluctuations.

Table 6 Simulation results

		Peak to trough amplitude		
	True	Lower bound	Simulated	Upper bound
Euro	**0.4979**	0.0937	0.3324	0.5744
US	**0.6294**	0.2163	0.5306	.08851
		Trough to peak amplitude		
	True	Lower bound	Simulated	Upper bound
Euro	**0.6254**	0.4038	0.6065	0.7781
US	**0.9589**	0.6441	.08621	1.0612
		Peak to trough duration		
	True	Lower bound	Simulated	Upper bound
Euro	**2.5000**	2.0000	3.0921	5.6667
US	**3.4000**	2.0000	3.1397	6.0000
		Trough to peak duration		
	True	Lower bound	Simulated	Upper bound
Euro	**35.0000**	10.0000	36.9428	95.0000
US	**23.5000**	11.2500	29.5700	65.5000
		No. of recessions		
	True	Lower bound	Simulated	Upper bound
Euro	**4.0000**	1.0000	3.2033	6.0000
US	**5.0000**	2.0000	4.0433	7.0000

Table 7 Concordance index

	Real	Lower bound	Simulated	Upper bound
	0.8222	0.7463	0.8427	0.9254

The costs of business cycles: consumption

The statistical model we have defined is very simple, it captures the basic features of the cycles in the US and the euro economies. A proper multivariate analysis goes beyond the scope of this paper. Rather than fully going in that direction, we perform, on consumption, the same analysis we did for output to obtain a first rough estimate of the welfare costs of the business cycle.

Table 8 shows standard deviations of consumption in the short and long run.

Table 8 Standard deviation of the growth rate of consumption and of the HP trend

	US	Euro area
$std\ (\Delta c)$	0.70	0.59
$std\ (\Delta HP)$	0.16	0.123
$\frac{std\ (\Delta HP)}{std\ (\Delta c)}$	0.23	0.39

Comparing these results with those for GDP, we can see that, in Europe, the standard deviation of consumption is larger than the standard deviation of output. This implies that there is less consumption smoothing in Europe than in the US, probably as a consequence of less efficient capital markets. A first observation is then that,although in the US, output volatility is more pronounced than in the euro area, the relative effect on welfare is mitigated by a relatively high degree of consumption smoothing.

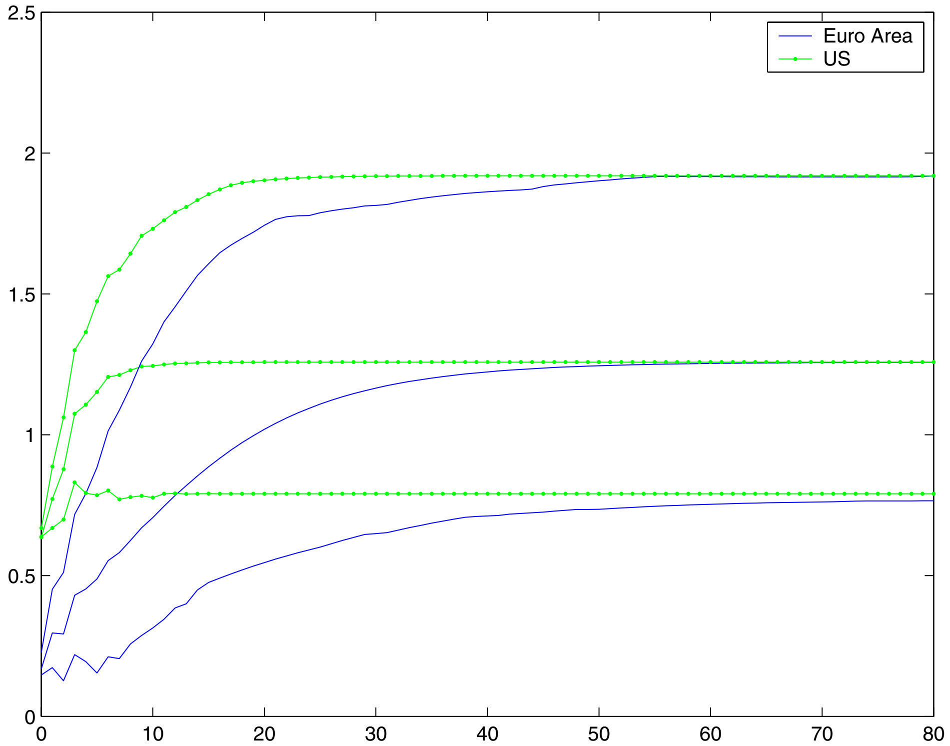
There is another aspect of fluctuations that indicates that the welfare losses associated with output volatility are less pronounced in the US. This can be seen from the impulse response functions of consumption in response to the technology shocks.

Figure 4 reports the impulse response functions to the non-neutral shock to consumption. The impulses are computed from a model which has the same parameterization of that estimated for GDP: autoregressive order equal to four and cointegrating vector [1 – 3/4]. Cointegration and Granger causality analyses on consumption give the same results as for GDP, and this justifies our parameterization. Note that the result on cointegration is consistent with stationarity of savings in both economies.

The impulses do not take into account differences in trend. We are restricting the model so as to obtain an equal long-run value of consumption (which implies a multiplication of the euro area impulses by 4/3).

The differences in persistence noticed for GDP also emerge for consumption. Even assuming that there are no long-run differences in variance and no differences in trend, Europe loses welfare because, after a technology shock, it reaches its steady state later than the US. In other words, the US enjoys all the advantages of growth immediately, while Europe has to wait much longer. Notice, however, that this also implies that losses, during recessions, are not as drastic as in the US and they are distributed over a long period of time. These features have an important consequence on the relative differences in welfare costs of business cycle fluctuations across the two economies. Since, in both economies, recessions are rare and short while expansions are 'the normal state', the larger loss of consumption in the early phase of recessionary episodes for the US, is more than compensated for by the rapid recovery. Overall, the losses of consumption generated by the business cyle are larger in the euro area than in the US.

Figure 4 Impulse response functions of consumption to international shocks



Conclusion

This paper argues that a model of the joint behaviour of US output and euro area output that can account for stylized facts on the business cycle in the two economies has one common trend, with a larger drift in the US than in the euro area. We also find that the euro-US output gap, defined as the differences between the euro output and the common euro-US trend, does not Granger-cause (and it is not Granger-caused by) the US output growth.

The model implies that there is one technology shock originating in the US (world shock). We show that this shock has a larger contemporaneous impact but less of a persistence effect on US output than on the euro area output, where it is absorbed at a slower rate. Fast absorption in the US induces large short-run variance of US output, while slow absorption in Europe induces high long-run volatility of euro area output.

A similar pattern is found in consumption data. The technology shock affects the long-run volatility of the two economies by the same amount, but, after the long-run shock, it takes longer for Europe to reach the steady state. Since the shocks have positive drift and recessions are a rare event, this implies that the euro area incurs a larger welfare loss due to business cycle fluctuations.

References

Artis, M.J., Z.G. Kontolemis, and D.R. Osborn (1997), 'Business cycles for G7 and European countries', *Journal of Business* 70, 249-279.

Artis, M. J. and W. Zhang (1997), 'International business cycles and the ERM: is there a European business cycle?' *International Journal of Finance and Economics* 2, 1-16.

Bry, G., and C. Boschan (1971), *Cyclical analysis of time series: selected procedures and computer programs*, National Bureau of Economic Research, New York.

Canova, F., M. Ciccarelli and E. Ortega (2003), 'Similarities in International Business Cycles', mimeo, March.

Del Negro, M. and C. Otrok, (2003), 'Time-varying European business cycles', manuscript, University of Virginia.

Fagan, G., J. Henry and R. Mestre (2001), 'An area-wide model (AWM) for the Euro area', ECB Working Paper series 42, European Central Bank.

Forni, M. and L. Reichlin (2001), 'Federal policies and local economies: Europe and the US', *European Economic Review*, 45, 109-134.

Hamilton J., (2001), 'Comment on A Comparison of Two Business Cycle Dating Methods', mimeo, University of California.

Harding D. and A. R. Pagan. (2002), 'Dissecting the Cycle: A Methodological Investigation', *Journal of Monetary Economics*, 49, 365-381.

Harding, D. and A. R. Pagan (2002b), 'Synchronization of cycles', mimeo, The University of Melbourne.

Harding D. and A. R. Pagan (2003), 'A Comparison of Two Business Cycle Dating Methods', *Journal of Economic Dynamics and Control*, 27, 1681-1690.

Harding D. and A. R. Pagan (2003b), 'Rejoinder to James Hamilton', *Journal of Economic Dynamics and Control*, 27, 1695-1698.

Montfort, A., J.P. Renne, R. Ruffer, and G. Vitale (2002), 'Is economic activity in the G-7 synchronized? Common shocks vs. spillover effects', manuscript.

Stock J.H., and M.W. Watson, (2003), 'Understanding changes in international business cycle dynamics', mimeo, June.

Appendix: data sources

US GDP and consumption: OECD, Main Economic Indicators

Euro Area GDP and consumption: Fagan et al., 2001 for sample 1970-1997 and Eurostat starting in 1998, first quarter.

Notes

1 For the BB algorithm, we have applied the parameterization suggested by Harding and Pagan (2002a).

2 On this point see also Forni and Reichlin (2001)