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Stylized facts of business cycles in the G7 from a real business cycles perspective*

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This paper investigates the basic stylized facts of business cycles in the G7 countries using quarterly data from 1960 to 1989. The methodology used is based on Kydland and Prescott (1990). The evidence suggests that the real business cycles model can account for several major stylized facts for all seven countries. In particular, consumption is procyclical and fluctuates generally less than output; investment is procyclical and fluctuates more than output; net exports are countercyclical; prices are countercyclical; government consumption and money do not have a clear cut pattern. Real business cycles models cannot account for some basic stylized facts of labor dynamics, however, primarily because they cannot account for variations in employment and hours per worker. This and other evidence suggests that labor hoarding might, especially in Europe and Japan, be the main force behind employment dynamics.

Key words: Stylized facts; Business cycles; G-7; Real business cycles; Labour hoarding
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1. Introduction

In recent years, the stylized facts of business cycles have been again in the forefront of research in macroeconomics.[1] This renewed interest is mainly

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[1]The stylized facts of business cycles were in the forefront of research in macroeconomics in the first half of the twentieth century. Leading piece of this literature is the work of Burns and Mitchell (1946). A survey of more recent work on this spirit is Zarnowitz (1991).

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due to the work of Kydland and Prescott (1982, 1988, 1990, 1991a,b), who have engaged in an attempt to explain the basic features of business cycles in the US economy with stochastic dynamic general equilibrium models capable of generating artificial data.[2] These models are variations of what we shall call 'benchmark real business cycles' (BRBC) model, which descends from the work of Solow (1956), Cass (1965), Koopmans (1965), and Brock and Mirman (1972).[3] It is well known that the thesis of this model is that business cycles are the product of exogenous technology shocks and the (shock) propagation mechanism generated by the optimizing behavior of economic agents operating in competitive environments.[4] The derivation and interpretation of the Kydland and Prescott results have been controversial issues [see, e.g., the exchange between Prescott (1986) and Summers (1986) and the critical paper of Eichenbaum (1991)]. In the meantime, there has been a number of papers that modify and/or extend the BRBC model, so as to focus on a particular subset of business cycle behavior or to address simulation problems or statistical inference. Very little has been done, however, to confront the real business cycle (RBC) models with alternative data sets.[5] In this paper we wish to pursue that tack.

In particular, the purpose of this paper is to investigate the basic stylized facts of business cycles in the G7 countries using quarterly data from 1960 to 1989 and the BRBC model as guidance. The objectives of our analysis have the following sequential structure: First, is to ascertain whether the stylized facts of these economies can be accounted for by the BRBC. Whenever major discrepancies are found, to examine whether existing extensions of the BRBC could account for these discrepancies. And, whenever existing BRBC extensions fail to account for these discrepancies, to make some intuitive suggestions about possible modifications of the BRBC towards filling that gap. What we do not do at this stage, however, is to examine whether a model that integrates all possible extensions of the BRBC will consistently account for all major stylized facts.

[2]An important early paper with a similar aim is Long and Plosser (1983).

[3]The original exposition of this model is Prescott (1986). This model features a logarithmic additively separable temporal utility function in consumption and leisure; a Cobb–Douglas production function in capital and labor inputs; an AR(1) technology shock with innovations that are observed at the time the contemporaneous decisions about consumption, leisure, capital and labor inputs are made; and fixed geometric depreciation of capital stock. Although, the BRBC model does not perform quantitatively as well as some of its more elaborate counterparts, it is most suitable for a benchmark as most other versions of the RBC model may be thought of as its extensions.

[4]See Plosser (1989) and McCallum (1990) for illuminating surveys. A recent excellent exposition of the methodological issues involved by RBC modeling is provided by Donaldson and Danthine (1992).

[5]An exception is the work of Backus and Kehoe (1992), who seem to be the first to have examined the properties of business cycle fluctuations in many countries from a real business cycles perspective.

For comparison purposes, the methodology used is mainly that of Kydland and Prescott (1990) (henceforth, KP).

The paper has four sections. Section 2 presents the methodology. Section 3 presents and discusses the selected stylized facts. Section 4 offers some conclusions.

It should be mentioned at the outset, that current versions of the RBC model can qualitatively and often quantitatively account for several important stylized facts of all seven economies. Confirming Backus and Kehoe (1992) (henceforth BK), we find considerable regularities among countries in the behavior of output and its expenditure components, except government spending. In particular, these components are procyclical, consumption fluctuates generally less and investment considerably more than real GNP/GDP. Confirming KP's finding for the United States, we find prices to be countercyclical in all countries. The last result also confirms BK's finding about the countercyclicality of prices in the post WWII period in several countries. Further, money does not have a clear cut pattern and its behavior varies both across countries and definitions of money stock.

But, current versions of the RBC model do not seem to be able to account for some basic stylized facts of labor dynamics. This is primarily because these models cannot account for the variations in employment and hours per worker. Then, since employment lags output both at the overall, industry, and manufacturing levels and, moreover, has a considerably smaller variability than output, especially in Europe and Japan, it suggests that labor hoarding rather than technology shocks may be the main force behind labor dynamics.

2. Methodology

The cornerstone of the theory and measurement of RBC models is, actually, its assumption about economic growth: namely, that steady state growth emanates from exogenous labor-augmenting technical change and that this rate varies over time and (especially important for this study) across countries. Then, one can define the growth and business cycles components of a variable as its smoothed trend and the deviations of the smoothed trend from the actual values of the variable, respectively [Lucas (1977)].[6]

There are, of course, many methods to construct smooth trend.[7] For comparison purposes, in this paper we have chosen to do so by employing the method developed by Hodrick and Prescott (1980) (henceforth, HP). The

[6]A general discussion of the implications of the nature of secular, cyclical, and seasonal fluctuations for the econometric modelling of smoothed trend can be found in Singleton (1988).

[7]An excellent survey on the controversial topic of stochastic trends is Diebold and Nerlove (1990). See also DeJong and Whiteman (1991).

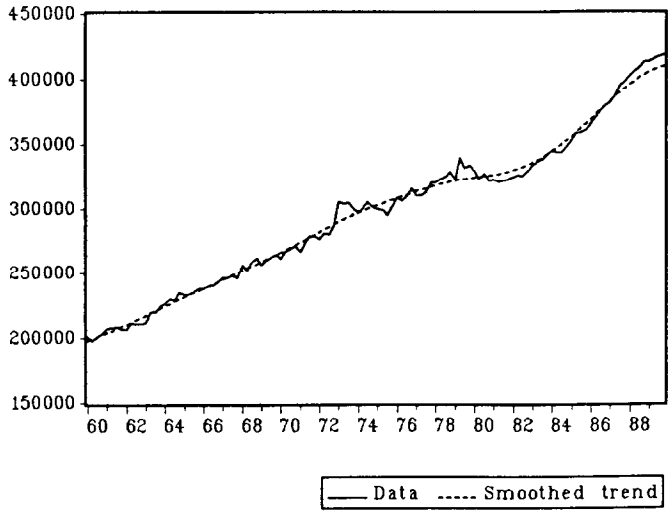

Fig. 1

HP filter has been discussed elsewhere.[8] Briefly, however, the HP filter has been designed so as to satisfy the following criteria [KP (p. 8)]:

> 'The trend component of real GNP should be approximately the curve that students of business cycles and growth should draw through a time plot of this time series.
>
> The trend of a given time series should be a linear transformation of that time series, and that transformation should be the same for all series. Lengthening the sample period should not significantly alter the value of the deviations at a given date, except possibly near the end of the original sample. The scheme should be well defined, judgement free, and cheaply reproducible.'

An illustration of this filter using the quarterly real GDP data of the United Kingdom, is depicted in fig. 1.

If one does not take the view that growth considerations affect the answer to the business cycles questions they are addressing, there are some potential problems with the way the HP filter is used to study business cycle fluctuations. Most importantly, there are two consistency issues in ascertaining whether the stylized facts of business cycle fluctuations that have been obtained from the HP filter can be accounted for by the RBC model. First, we are not going to examine whether the growth and the business cycles components of the variables involved interact in a way that is consistent with

[8]See, e.g., King and Rebelo (1988), Cogley (1990), and Canova (1991).

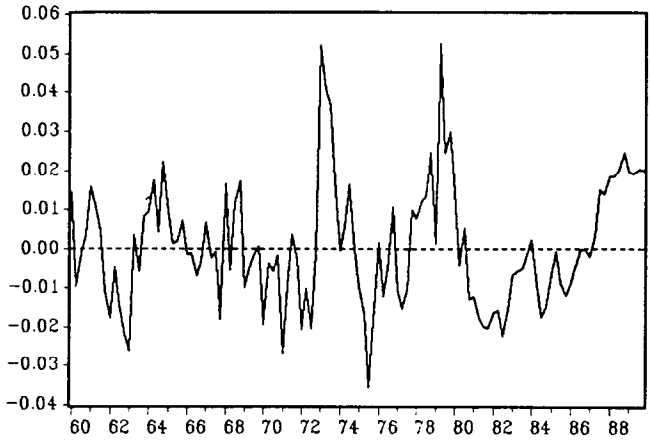

Fig. 2

this model.[9,10] Second, using the HP filter to derive the business cycle component of any given variable separately does not ensure that the pertinent variables have a common growth component, as required by the theory. A cursory check of a few of these variables, for which we performed cointegration tests in Appendix A shows that this may be a real problem. For several countries, but especially for Italy and France, the growth components of several variables fail to be cointegrated at the usual levels of significance.[11]

Finally, it has been reported [King and Rebelo (1993), Cogley (1990), Canova (1991), and Harvey and Jaeger (1991)] that the HP filter may seriously alter measures of persistence, relative variability, and comovements. This seems to be somewhat of a problem for comparing measures of relative variability, persistence, and comovements between actual and artificially created data. Nevertheless, we checked whether measures of comovement between output and price, output and money, and output and employment remain robust under unit root and log-polynomial deterministic trends. The results of our sensitivity analysis are reported in Appendix B. It is important

[9]King, Plosser, and Rebelo (1988) emphasized this point and chose to represent trend via deterministic exogenous labor augmenting technical change.

[10]In a certain sense there are deeper problems with studying the decomposition of a variable to its growth and trend components without explicitly specifying a model with a stable steady state growth path to guide this decomposition. Generalized versions of the Cass–Koopmans model may not have such paths. In fact, Boldrin and Montrucchio (1986) have shown that such models may exhibit all kinds of complicated dynamics, incluing chaotic.

[11]The results of Appendix A cannot be directly compared, say, with those studies showing that consumption and income are cointegrated, since our data deal with HP-trended variables and with real GNP/GDP rather than disposable income.

to mention that, in general, we do not find that the essential results of our study would be altered.

On several occasions we encountered series that they were not seasonally adjusted (s.a.). To remove seasonality we followed a dummy variables procedure in which the growth component is consistently obtained by applying to the data the HP filter rather than the usual log-polynomial trend.

Again, for comparison purposes, the statistics we present are those of KP. For each series we report the following: (a) the percentage standard deviation of the series (as a measure of the relative amplitude of the fluctuations in the series); (b) the cross correlation of the series with real GNP/GDP or an industrial output variable (as an indicator of the type of comovement of the series with GNP/GDP or the appropriate industry output variable).

Thus, for a given variable X and the pertinent GNP/GDP or industry output variable, Y, the comovements we examine are classified as follows. If $\rho(j)$, $j \in \{0, \pm 1, \pm 2, \dots\}$, denotes the cross correlation between Y_t and $X_{t \pm j}$, we say that, the cycle of X is leading, is synchronous, or is lagging the cycle of Y as $|\rho(j)|$ is maximum for a negative, zero, or positive j, respectively. And, we say that X is procyclical (countercyclical) as $\rho(0)$ is positive (negative) and not very close to zero. In particular, for $0.5 \leq |\rho(0)| < 1$ we use the adverb 'strongly', for $0.2 \leq |\rho(0)| < 0.5$ we use the adverb 'weakly' and, when $0 \leq |\rho(0)| < 0.2$ we say that the series are contemporaneously uncorrelated. The cutoff point 0.2 was chosen because it corresponds in our samples (0.22 for France and 0.18 in all other countries) to the value required to reject at the 5% level of significance the null hypothesis that the population correlation coefficient is zero in a two-sided test for bivariate normal random variables. The cutoff point to reject the null that $|\rho(j)|$ is less than 0.5 is 0.35 for France and 0.38 for the other countries in the corresponding one-tailed test. Also, the corresponding elasticities of the real GNP/GDP with respect a given variable at a certain lag/lead can be recovered by multiplying the relevant correlation coefficients by the relative variability (σ_y/σ_x). Finally, for GNP/GDP shares we also present the mean of the series (table 1).

3. Stylized facts

As already noted we let the RBC model dictate which facts to examine and how to organize them. Thus, the stylized facts presented below are grouped in three categories: (a) the components of spending, income, and output; (b) prices and monetary variables; and (c) the factors of production. This order is different from KP, for we left what we think are the most controversial, from an RBC perspective, stylized facts to the end.

Our data are OECD's Main Economic Indicators (MEI) as released in a

RATS format by VAR Econometrics. The sample has not been divided in sub-periods because the smoothed trend itself should be able to capture the most important structural breaks.

3.1. *The components of spending*

Data on GNP/GDP and the components of spending are presented in table 1. The nature of GNP/GDP fluctuations will be examined in detail in subsection 3.3. For reference purposes however, it is important to briefly discuss them first.

In all seven countries GNP/GDP deviations from smooth trend have about the same volatility and are strongly positively autocorrelated, showing strong persistence in the business cycle fluctuations, with the exception of the United Kingdom. These findings are both consistent with the findings of KP and those of BK, who used annual century long data for a set of ten countries including Canada, Germany, Italy, the United Kingdom, and the United States.

Qualitatively, in the BRBC model persistence in GNP/GDP is explained even without persistence in the technology shock. Intuitively, the income effect of a 'good' temporary technology shock creates an incentive to consume more and work less in the current period as well as in future periods and the substitution effect of this happening creates an incentive to consume more in the current and future periods and to work more in the current period and less in the future periods. Either effect implies that savings and investment must rise so as to create the additional capital necessary to produce more output and enjoy more consumption in the future. The increase in capital implies that current and future output will be positively correlated. Quantitatively, the strong positive autocorrelation of output will require that technology shocks are strongly positively autocorrelated. Finally, there is no problem in accounting for the volatility of output. The BRBC with highly persistent technology shocks can accounts for about eighty percent of the post-Korean War GNP volatility [Prescott (1986)] in the United States. Other models can account from a minimum of fifty five percent to as much as all of output variability [Hansen (1985)]. Most existing RBC models with one source of disturbances being technology shocks account for about two thirds of output volatility [Kydland and Prescott (1991)], as did the original Solow (1956) growth accounting.

Models with more than one source of disturbances or more complicated technologies can account for all of output variability reducing, of course, the role of technology shocks. We are going to discuss these models later. It should be stated, however, that the original RBC models were not constructed for accounting all of output variability. Rather, the question that

Table 1

Cross correlations of real GNP/GDP with the components of spending, income, and output in levels. [a,b]

Variable	Vol.	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
(1) Real GNP/GDP												
USA	1.74	0.01	0.21	0.41	0.65	0.85	1.0	0.85	0.65	0.41	0.21	0.01
Canada	1.39	−0.12	0.04	0.27	0.51	0.78	1.0	0.78	0.51	0.27	0.04	−0.12
Japan	1.53	0.02	0.19	0.38	0.59	0.78	1.0	0.78	0.59	0.38	0.19	0.02
Germany	1.69	−0.02	0.23	0.35	0.46	0.67	1.0	0.67	0.46	0.35	0.23	−0.02
France	0.90	−0.06	0.10	0.30	0.54	0.77	1.0	0.77	0.54	0.30	0.10	−0.06
UK	1.54	−0.02	0.07	0.20	0.37	0.55	1.0	0.55	0.37	0.20	0.07	−0.02
Italy	1.70	−0.21	−0.04	0.22	0.52	0.80	1.0	0.80	0.52	0.22	−0.04	−0.21
(2) Consumption expenditure												
US	1.29	0.32	0.48	0.59	0.72	0.79	0.80	0.63	0.43	0.22	0.00	−0.17
Canada	1.27	−0.08	0.16	0.40	0.57	0.72	0.79	0.65	0.44	0.27	0.06	−0.03
Japan	1.33	−0.10	0.08	0.28	0.42	0.56	0.72	0.54	0.40	0.22	0.01	−0.11
Germany	1.53	0.11	0.26	0.37	0.46	0.58	0.69	0.55	0.49	0.38	0.32	0.21
France	0.86	−0.27	0.42	−0.63	0.73	0.72	0.62	0.30	0.10	−0.14	0.25	−0.32
UK	1.67	0.03	0.13	0.30	0.39	0.46	0.67	0.42	0.38	0.26	0.10	0.08
Italy	1.19	−0.15	0.07	0.34	0.59	0.74	0.78	0.69	0.50	0.25	0.03	−0.15
(3) Fixed investment												
US	5.57	0.14	0.30	0.47	0.67	0.83	0.90	0.78	0.59	0.35	0.12	−0.09
Canada	4.60	−0.43	−0.29	−0.07	0.18	0.40	0.53	0.52	0.41	0.32	0.21	0.14
Japan	4.57	−0.11	0.04	0.23	0.45	0.64	0.83	0.78	0.69	0.51	0.29	0.05

Germany	4.90	0.04	0.26	0.37	0.42	0.60	0.84	0.54	0.42	0.37	0.29	0.12
France	2.70	−0.11	0.06	0.26	0.46	0.66	0.78	0.69	0.57	0.41	0.25	0.13
UK	3.57	−0.11	−0.04	0.08	0.23	0.33	0.60	0.53	0.38	0.31	0.23	0.05
Italy	4.88	−0.16	−0.00	0.23	0.47	0.70	0.88	0.81	0.67	0.47	0.25	0.05
(5) Equipment investment												
US	6.28	−0.13	0.02	0.21	0.46	0.68	0.86	0.87	0.77	0.59	0.38	0.18
Canada	7.13	−0.49	−0.35	−0.18	0.03	0.27	0.43	0.51	0.53	0.50	0.34	0.25
Japan	5.96	−0.09	0.02	0.17	0.38	0.58	0.74	0.73	0.69	0.54	0.34	0.14
Germany	6.09	0.12	0.36	0.48	0.52	0.61	0.73	0.58	0.49	0.39	0.23	0.09
France	3.90	0.08	−0.23	0.39	0.58	0.70	0.74	0.53	0.31	0.12	−0.06	−0.17
UK	4.88	−0.12	−0.07	0.05	0.21	0.38	0.56	0.51	0.47	0.44	0.32	0.25
Italy	7.92	−0.15	0.01	0.25	0.48	0.69	0.85	0.74	0.57	0.38	0.14	−0.05
(6) Construction investment												
US	6.26	0.31	0.45	0.57	0.70	0.80	0.78	0.58	0.35	0.11	−0.10	−0.27
Canada	3.83	−0.23	−0.12	0.10	0.34	0.50	0.55	0.41	0.18	0.06	0.01	−0.04
Japan	5.58	−0.04	0.09	0.23	0.31	0.32	0.43	0.35	0.18	0.07	−0.05	−0.18
Germany	5.56	0.00	0.15	0.22	0.27	0.47	0.72	0.40	0.28	0.27	0.25	0.10
France	2.49	−0.25	−0.11	0.08	0.25	0.48	0.65	0.65	0.65	0.54	0.45	0.33
UK	3.90	0.15	0.19	0.28	0.26	0.21	0.38	0.27	0.08	−0.00	−0.08	−0.24
Italy	3.57	−0.11	0.00	0.18	0.36	0.57	0.74	0.74	0.65	0.50	0.36	0.20
(7) Inventory changes												
US	18.2	−0.01	0.08	0.22	0.35	0.49	0.64	0.48	0.26	0.03	−0.14	−0.30
Canada	35.4	0.07	0.15	0.25	0.43	0.60	0.68	0.53	0.33	0.06	−0.18	−0.32
Japan	45.4	−0.05	−0.03	0.07	0.23	0.38	0.38	0.38	0.25	0.20	0.20	0.10
Germany	49.2	0.07	0.19	0.31	0.32	0.33	0.35	0.29	0.14	0.02	−0.13	−0.27
France	30.1	−0.15	−0.09	−0.04	0.05	0.22	0.47	0.44	0.25	0.16	−0.05	−0.27
UK	26.6	0.03	0.12	0.16	0.26	0.42	0.55	0.38	0.19	0.00	−0.08	−0.17
Italy	66.8	−0.07	0.10	0.21	0.39	0.51	0.56	0.32	0.00	−0.24	−0.41	−0.48
(8) Government final consumption												
US	1.98	−0.07	−0.04	0.00	0.06	0.11	0.19	0.24	0.27	0.30	0.35	0.37
Canada	1.46	−0.18	−0.20	−0.24	−0.23	−0.20	−0.12	−0.09	−0.08	0.05	0.14	0.18
Japan	2.89	0.25	0.33	0.30	0.28	0.30	0.32	0.04	−0.05	−0.08	−0.05	−0.06
Germany	1.47	−0.19	−0.11	−0.13	−0.10	−0.06	0.05	0.06	0.16	0.23	0.36	0.41
France	0.70	0.46	0.61	0.56	0.46	0.32	0.18	−0.07	−0.23	−0.31	−0.30	−0.24
UK	1.43	−0.09	−0.03	−0.07	−0.06	0.02	0.04	−0.05	−0.01	−0.07	−0.05	0.04
Italy	0.60	0.30	0.18	0.05	−0.14	−0.30	−0.39	−0.43	−0.41	−0.33	−0.21	−0.04

Table 1 (continued)

Variable	Vol.	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
(9) Exports												
US	5.22	−0.48	−0.41	−0.29	−0.13	0.10	0.33	0.46	0.49	0.46	0.44	0.35
Canada	4.07	0.05	0.14	0.27	0.37	0.52	0.61	0.45	0.30	0.13	−0.08	−0.23
Japan	4.65	−0.08	−0.12	−0.16	−0.15	−0.13	−0.05	0.01	0.13	0.21	0.27	0.25
Germany	3.10	−0.25	−0.19	−0.18	−0.11	0.08	0.38	0.24	0.15	0.14	0.04	−0.05
France	2.72	−0.15	−0.03	0.08	0.26	0.44	0.60	0.53	0.39	0.35	0.23	0.15
UK	3.20	−0.09	−0.18	−0.12	0.03	0.18	0.47	0.20	0.25	0.15	0.15	0.10
Italy	3.61	0.14	0.07	0.09	0.11	0.21	0.26	0.12	−0.04	−0.26	−0.38	0.34
(10) Imports												
US	5.20	0.13	0.21	0.33	0.46	0.63	0.75	0.73	0.52	0.28	0.06	−0.16
Canada	5.15	−0.24	−0.06	0.17	0.43	0.68	0.79	0.70	0.55	0.31	0.04	−0.11
Japan	5.60	−0.25	−0.13	0.02	0.24	0.39	0.47	0.48	0.46	0.39	0.28	0.14
Germany	3.53	0.05	0.19	0.36	0.46	0.60	0.70	0.61	0.55	0.47	0.25	0.12
France	4.11	−0.06	0.13	0.31	0.50	0.71	0.82	0.67	0.41	0.18	−0.06	−0.22
UK	3.93	−0.09	0.02	0.15	0.30	0.50	0.53	0.51	0.45	0.26	0.15	0.03
Italy	5.75	−0.04	0.13	0.33	0.50	0.65	0.70	0.58	0.33	0.05	−0.15	−0.20

[a]Vol., for volatility, is measured by the standard deviation of the filtered data multiplied by one hundred. All variables are in logs. Data on variables as shares of real GNP/GDP are available in Fiorito and Kollintzas (1992).

[b]Default ranges for samples are: US, Canada, Japan, and Italy (60Q1–89Q3), Germany (60Q1–89Q2), France (70Q1–89Q3), and UK (60Q1–89Q1).

these models were addressing was what fraction of total output variability could be accounted for by their one-shock economy models.[12]

With the exception of government spending, the major components of spending, income, and output also behave very similarly in all seven countries. Thus, consumption and investment are about sixty and twenty percent of GNP/GDP. Consumption expenditure which includes durables is less volatile than GNP/GDP, except in the United Kingdom, despite the fact that consumption expenditure includes durables. GNP/GDP is much less volatile than investment expenditures. Fixed investment is relatively three to four times more variable than consumption. Consumption and investment are strongly procyclical and coincidental. Consumption leads income in France only, while equipment investment seems to be lagging in Canada and in the US. These results are also consistent with the findings of BK.

Qualitatively, these facts can easily be accounted for by the BRBC model. For, in the example discussed above, output will fluctuate more than consumption, implying that investment will fluctuate more than output. More importantly, there are several RBC models that can quantitatively account for these findings.[13]

The most variable component of investment and, indeed of GNP, is inventory investment. This component is synchronous and procyclical. The BRBC model does not incorporate inventories. But, these findings can be accounted for by a slightly modified version of the BRBC; in particular Kydland and Prescott (1982) and Christiano (1988) have explained both of these features of inventory investment. They allowed for employment and investment decisions to be made before and consumption and inventory decisions to be made after the technology shock is (fully) known. In this manner, when there is an unexpected technology shock inventory investment buffers consumption. And, when there is an expected technology shock, inventories and fixed investment may again be used to smooth consumption. Thus, inventory investment becomes procyclical and, as the residual of a smoothing process, very volatile.

Not surprisingly, given differences in preferences, institutions, and war crises, government consumption which includes military expenditures, behaves differently in each country. In the United States it is 22 percent of GNP, more variable than GNP, contemporaneously uncorrelated and lags the GNP cycle by five quarters. In Canada, government final consumption is 23 percent of GNP, more variable than GNP, procyclical and lags the GNP cycle by three quarters. In Japan, government final consumption is 23

[12]The magnitude of the variance of the technology shock, however, is a controversial issue. See Summers (1986), McCallum (1989), Burnside, Eichenbaum and Rebelo (1990), and Cassing and Kollintzas (1991). This issue will be taken up later.

[13]See, e.g., Prescott (1986), Kydland and Prescott (1982) and Hansen (1985).

percent of GDP, more variable than GDP, procyclical, and coincidental or slightly leading. In Germany, government final spending is 20 percent of GDP, less variable than GDP, procyclical, and lags the GDP cycle by five quarters. In France, government final spending is 19 percent of GDP, less variable than GDP, procyclical, and leads the GDP cycle by four quarters. In the United Kingdom, government final spending is 22 percent of GDP, less variable than GDP, and uncorrelated with GDP at all lags/leads. Finally, in Italy government final spending is about 16 percent of GDP, less variable than GNP, countercyclical and lags the GNP cycle by about one quarter.

The BRBC model abstracts from government spending. But, a simple extension of this model with government goods partially substitutable for private goods [e.g., Barro (1990, ch. 12), Aiyagari et al. (1990)] is consistent with the procyclicality of government spending. Intuitively, an increase, say, in government spending tends to reduce real wealth and, therefore, decrease consumption and leisure. Under the stated assumptions, the direct effect of government spending dominates the decrease in consumption and aggregate demand increases. Since the aggregate supply of labor also increases, the real wage rate will decrease and the real interest rate and aggregate output will increase. Aggregate consumption and aggregate investment will further decline, because of the crowding out. This decline will be greater for consumption and less for investment the more persistent is the increase in government spending, due to the consumption smoothing motive. Thus, aggregate output rises but, typically, by not as much as the increase in government spending (i.e., the pertinent multiplier is positive but less than one). This is consistent with our results, when the highest correlations are converted to multiplier units.[14]

The behavior of exports and imports is very similar in all seven countries. Exports and imports are more variable than consumption and GDP/GNP but less variable than investment. Exports are weakly or strongly (Canada and France) procyclical, but, typically, their cycle coincides with the GNP/GDP cycle. The exceptions are the United States and Japan, where exports lag output by two and four quarters respectively. Imports are strongly procyclical and their cycle coincides with the GNP/GDP cycle. The GNP/GDP share of exports does not have a stable pattern but the GNP/GDP share of imports is strongly procyclical or weakly procyclical (Germany) and its cycle coincides with the cycle of GNP/GDP.[15] This last finding implies

[14]Aiyagari, Christiano and Eichenbaum (1990) and Christiano and Eichenbaum (1990) show that the multiplier can be greater than one.

[15]These findings seem to suggest that international interdependence may be an important source of fluctuations. But Canova and Dellas (1992) who looked into this issue found little evidence for that. Moreover, their results are very sensitive to the detrending method utilized.

that net exports are countercyclical as we actually obtain. These findings are, again, consistent with those of BK and the earlier findings of Dellas (1986).

RBC models, as one economy models, can only explain exports. In addition, the BRBC model is a closed economy model. But, open economy versions of this model that feature country specific technology shocks and a perfect international credit market, can account for the above findings [Dellas (1986), Backus et al. (1991), Mendoza (1991), Baxter and Crucini (1992)]. In these models, international credit markets in the presence of idiosyncratic technology shocks tend to make consumption less and investment more variable than in the closed economy, respectively.[16] Moreover, in these models net exports are countercyclical. Intuitively, if an economy experiences a 'good' technology shock it will invest more by borrowing in the international credit markets. Thus, net exports will go down while output rises. Further, the more persistent is the technology shock the stronger the underlying countercyclicality.

3.2. *Prices and monetary variables*

The stylized facts pertaining to prices and monetary variables are reported in table 2. The comovements of GNP/GDP and the following variables: money stock as measured by M1, M2, and M3; interest bearing quasi-moneys as measured by M2−M1 and M3−M1; velocities of M1, M2, and M3; and prices (GNP/GDP deflator and CPI). As already mentioned, money does not have a clear cut pattern and its behavior varies both across countries and money stock definitions. Thus, apart from the facts that: (i) With the exception of M1 in the United Kingdom and, possibly, M1 and M2 in Italy, money stocks do not have a strong positive correlation with GNP/GDP at any lead or lag; (ii) With the exception of M3 for the United States, money stocks fluctuate more than real GNP/GDP; and (iii) Velocity measures fluctuate, in general, more than the corresponding money stocks; there are no other uniformities in the behavior of monetary variables.

In particular, in the United States we confirm the KP findings that M1 is weakly procyclical and weakly leading or coincidental with real GNP. The difference between M1 and M3 is more correlated with real GNP but otherwise its cycle has a similar phase relative to real GNP as M1. Velocities are weakly procyclical. In Canada, Italy, and the United Kingdom M1 is weakly procyclical and leading the GNP/GDP cycle. But, M2, except in Italy, and M2−M1 are contemporaneously uncorrelated with GNP/GDP and have a negative leading comovement vis-à-vis the latter. In the United

[16]Backus, Kehoe and Kydland (1990) report significant differences between their model economy and the U.S. economy. Most seriously, in the model foreign output and domestic output are less correlated than foreign and domestic consumption. In the data the opposite is true.

Table 2

Prices and monetary variables.

Variable	Vol.	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
(1) M1 Volatility												
US	1.66	0.00	0.07	0.15	0.24	0.29	0.29	0.20	0.14	0.09	0.08	0.08
Canada	2.25	0.21	0.31	0.43	0.50	0.43	0.24	0.09	−0.09	−0.17	−0.11	−0.05
Japan	2.61	−0.34	−0.21	−0.08	0.03	0.09	0.10	0.12	0.11	0.11	0.10	0.12
Germany	4.64	0.17	0.15	0.14	0.11	0.03	−0.00	−0.05	−0.17	−0.17	0.01	0.02
France	2.64	0.27	0.31	0.33	0.32	0.27	0.12	0.01	−0.08	−0.13	−0.11	−0.07
UK[a]	3.25	0.47	0.57	0.63	0.62	0.51	0.33	0.13	−0.07	−0.26	−0.35	−0.35
Italy[b]	3.77	−0.03	0.10	0.24	0.38	0.46	0.42	0.35	0.22	0.08	−0.01	−0.11
(2) M2												
US	NA											
Canada	2.93	−0.50	−0.51	−0.48	−0.41	−0.27	−0.08	0.11	0.28	0.40	0.46	0.47
Japan	1.65	−0.41	−0.25	−0.10	0.05	0.14	0.18	0.16	0.13	0.08	0.03	0.02
Germany[c]	2.63	−0.26	−0.17	−0.10	0.03	0.12	0.25	0.35	0.35	0.35	0.34	0.29
France	5.00	0.24	0.29	0.32	0.33	0.34	0.27	0.20	0.15	0.13	0.15	0.13
UK	3.97	−0.34	−0.25	−0.19	−0.11	−0.07	−0.03	−0.03	−0.00	−0.02	−0.03	−0.02
Italy	2.09	0.14	0.27	0.29	0.48	0.49	0.39	0.23	0.04	−0.11	−0.21	−0.30
(3) M3												
US	1.51	0.13	0.22	0.31	0.41	0.47	0.48	0.41	0.30	0.17	0.04	−0.08
Canada	NA											
Japan	NA											
Germany	NA											
France	1.31	0.36	0.41	0.46	0.43	0.36	0.17	0.04	−0.08	−0.18	−0.19	−0.17
UK	NA											
Italy	NA											

(4) M2−M1											
US	NA										
Canada	3.77	−0.50	−0.52	−0.51	−0.46	−0.32	−0.11	0.10	0.29	0.43	0.47	0.47
Japan	1.40	−0.36	−0.22	−0.07	0.08	0.17	0.21	0.18	0.11	0.01	0.07	−0.11
Germany	7.90	−0.33	−0.30	−0.28	−0.18	−0.06	0.09	0.21	0.29	0.35	0.35	0.29
France	7.34	0.22	0.27	0.30	0.32	0.35	0.31	0.26	0.23	0.23	0.23	0.19
UK	8.01	−0.45	−0.39	−0.35	−0.27	−0.21	−0.12	−0.06	0.02	0.06	0.07	0.08
Italy	6.86	0.09	0.14	0.13	0.04	0.00	−0.02	−0.03	−0.12	−0.15	−0.12	−0.06
(5) M3−M1												
US	1.97	0.16	0.23	0.31	0.38	0.42	0.42	0.35	0.26	0.13	0.00	−0.12
Canada	NA											
Japan	NA											
Germany	NA											
France	1.17	0.27	0.30	0.35	0.31	0.27	0.15	0.05	−0.03	−0.13	−0.18	−0.19
UK	NA											
Italy	NA											
(6) Velocity M1												
US	2.02	−0.21	−0.16	−0.09	0.02	0.16	0.33	0.33	0.26	0.17	0.09	0.01
Canada	2.44	−0.26	−0.15	−0.05	0.03	0.18	0.30	0.31	0.26	0.17	0.06	0.05
Japan	3.30	−0.06	−0.01	−0.05	−0.04	0.02	0.14	0.08	0.06	0.03	0.00	−0.08
Germany	5.00	−0.23	−0.12	−0.08	−0.00	0.15	0.31	0.28	0.35	0.34	0.14	0.06
France	11.40	−0.40	−0.44	−0.43	−0.40	−0.29	−0.10	−0.01	0.05	0.06	0.02	−0.02
UK	3.16	−0.53	−0.60	−0.54	−0.42	−0.19	0.20	0.20	0.29	0.38	0.36	0.36
Italy	6.83	−0.22	−0.33	−0.29	−0.23	−0.19	−0.10	−0.02	0.07	0.09	0.03	0.04
(7) Velocity M2												
US	NA											
Canada	2.34	0.15	0.18	0.25	0.34	0.38	0.35	0.13	−0.12	−0.33	−0.45	−0.50
Japan	2.56	0.00	−0.06	−0.08	−0.05	0.03	0.17	0.11	0.11	0.10	0.08	0.00
Germany	2.71	0.12	0.19	0.19	0.15	0.11	0.02	0.01	−0.06	−0.14	−0.36	−0.40
France	9.60	−0.36	−0.40	−0.40	−0.39	−0.34	−0.22	−0.17	−0.13	−0.12	−0.15	−0.14
UK	4.33	0.29	0.22	0.25	0.26	0.30	0.42	0.27	0.17	0.10	0.03	0.02
Italy	10.20	−0.26	−0.35	−0.30	−0.17	−0.08	0.02	0.06	0.16	0.17	0.09	−0.05
(8) Velocity M3												
US	1.68	−0.11	−0.11	−0.10	−0.05	0.00	0.07	0.07	0.07	0.07	0.07	0.08
Canada	NA											
Japan	NA											

Table 2 (continued)

Variable	Vol.	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
Germany	NA											
France	2.81	−0.57	−0.60	−0.56	−0.46	−0.30	−0.04	0.03	0.10	0.12	0.09	0.06
UK	NA											
Italy	NA											
(9) Implicit GDP/GNP deflator												
US	0.95	−0.47	−0.60	−0.68	−0.72	−0.70	−0.63	−0.51	−0.37	−0.22	−0.06	0.08
Canada[d]	1.71	−0.47	−0.51	−0.50	−0.46	−0.41	−0.34	−0.20	−0.07	0.04	0.14	0.21
Japan	1.84	−0.36	−0.46	−0.51	−0.52	−0.48	−0.43	−0.34	−0.21	−0.10	−0.01	0.02
Germany	0.97	−0.32	−0.35	−0.34	−0.28	−0.24	−0.15	0.07	0.23	0.33	0.35	0.44
France	1.31	−0.37	−0.48	−0.53	−0.60	−0.61	−0.60	−0.47	−0.34	−0.25	−0.18	−0.08
UK	2.33	−0.09	−0.22	−0.34	−0.45	−0.54	−0.57	−0.48	−0.39	−0.23	−0.09	0.08
Italy	1.84	−0.54	−0.64	−0.68	−0.61	−0.50	−0.33	−0.14	0.04	0.16	0.18	0.17
(10) CPI												
US	1.51	−0.57	−0.67	−0.73	−0.73	−0.67	−0.55	−0.39	−0.22	−0.03	0.15	0.31
Canada	1.77	−0.32	−0.41	−0.45	−0.43	−0.35	−0.32	−0.22	−0.15	−0.01	0.05	0.15
Japan	NC											
Germany	1.01	−0.49	−0.53	−0.52	−0.45	−0.42	−0.39	−0.27	−0.21	−0.14	−0.04	0.05
France	1.61	−0.44	−0.57	−0.63	−0.64	−0.61	−0.55	0.41	−0.25	−0.11	0.03	0.15
UK	2.81	−0.06	−0.22	−0.25	−0.37	−0.38	−0.43	−0.36	−0.31	−0.15	−0.08	0.01
Italy	2.04	−0.44	−0.52	−0.59	−0.57	−0.49	−0.32	−0.13	0.03	0.14	0.21	0.19

[a]71Q2–89Q2.
[b]62Q1–89Q3.
[c]M1 plus quasi-money.
[d]61Q1–89Q3.

Kingdom and Italy M2−M1 is especially volatile. In Japan M1 and M2 have a negative leading comovement with real GNP. In Germany M1 is uncorrelated, while M2 is lagging real GDP, as it would be implied by a money demand rather than money supply relation between these two variables. Finally, in France M1, M2, and M2−M1 are weakly procyclical and leading the GDP cycle. M3 and M3-M1 are also leading, and they are contemporaneously uncorrelated with GDP.

The figures for Japan and Germany can be accounted by the BRBC model where money is ignored (i.e., money may enter through the Quantity Theory formulation). The figures for the United Kingdom, Italy, and to a lesser extend for France and the United States can be accounted for by extensions of the BRBC model where money is allowed to play a role, in the sense of affecting real variables. For example, in the cash in advance models of Cooley and Hansen (1989) and the Lucasian monetary misperceptions and the transaction costs or money-in-the-utility-function models of Kydland (1989). In these models, where money is not neutral, the predicted effects of money on output and employment are positive but relatively small. Further, the evidence for a positive leading comovement between M3-M1 and real GNP/GDP in the case of France and the United States can be accounted by extensions of the BRBC model that allows for institutional credit arrangements to affect real variables [Imrohoroglu and Prescott (1991)]. The channel by which money affects real variables in these models is the real interest rate. That is, money and real interest rates are negatively related. There is some evidence for this mechanism in the negative and leading comovement of real interest rate and real GNP/GDP for all countries (table 3).

The figures for Canada cannot be easily interpreted. First, there is a difficulty with the very different patterns of M1 and M2, and second, the strongly negative and leading comovement of M2−M1.

Also confirming the KP finding for the United States and the BK findings for post WWII Canada, Germany, Italy, Japan, the United Kingdom, and the United States, we find that in all seven countries both the GNP/GDP deflator and the CPI are countercyclical and leading GNP/GDP in most cases.[17,18]

The BRBC can easily account for a negative correlation between output and prices, as technology shocks shift the aggregate supply of output up and down a relatively stable downward-sloping aggregate demand.[19] In fact, the

[17]This stylized fact for the U.S. has been confirmed recently in an extensive study by Cooley and Ohanian (1991).

[18]This fact along with that on the comovement of money and GNP/GDP are contrary to common beliefs [see, e.g., Bernanke (1986, p. 76), Mankiw (1989, pp. 81, 88)] and has been used to criticize the BRBC model.

[19]Visualizations of demands and supplies in the RBC framework are not particularly helpful and may be misleading, but in this case the demand supply visualization seems appropriate.

Table 3

The factors of production.

Cross correlations of real GNP with												
Variable	Volatility	s.d.	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
(1) Real GNP/GDP													
USA	1.74		0.01	0.21	0.41	0.65	0.85	1.0	0.85	0.65	0.41	0.21	0.01
Canada	1.39		−0.12	0.04	0.27	0.51	0.78	1.0	0.78	0.51	0.27	0.04	−0.12
Japan	1.53		0.02	0.19	0.38	0.59	0.78	1.0	0.78	0.59	0.38	0.19	0.02
Germany	1.69		−0.02	0.23	0.35	0.46	0.67	1.0	0.67	0.46	0.35	0.23	−0.02
France	0.90		−0.06	0.10	0.30	0.54	0.77	1.0	0.77	0.54	0.30	0.10	−0.06
UK	1.54		−0.02	0.07	0.20	0.37	0.55	1.0	0.55	0.37	0.20	0.07	−0.02
Italy	1.70		−0.21	−0.04	0.22	0.52	0.80	1.0	0.80	0.52	0.22	−0.04	−0.21
(2) Employment													
USA	1.05		−0.11	0.06	0.24	0.44	0.65	0.83	0.88	0.80	0.66	0.47	0.27
Canada	1.25		−0.35	−0.21	0.00	0.22	0.45	0.67	0.71	0.59	0.44	0.37	0.25
Japan	0.68		−0.03	0.00	0.06	0.24	0.26	0.27	0.19	0.24	0.18	0.06	−0.08
Germany[a]	1.02		−0.26	−0.11	−0.08	0.08	0.15	0.29	0.30	0.25	0.17	0.05	0.07
France	0.56		−0.27	−0.20	−0.09	0.13	0.35	0.60	0.68	0.61	0.51	0.40	0.21
UK	1.00		−0.28	−0.19	−0.09	0.13	0.26	0.43	0.51	0.58	0.55	0.54	0.46
Italy	0.92		−0.22	−0.22	−0.05	0.03	0.23	0.35	0.39	0.40	0.38	0.24	0.14
(3)=(1)/(2) Productivity													
USA	1.04		0.13	−0.29	0.45	0.64	0.76	0.83	0.53	0.28	0.02	−0.13	−0.25
Canada	1.10		0.26	0.29	0.35	0.39	0.48	0.52	0.20	−0.02	−0.15	−0.36	−0.43
Japan	1.49		0.09	0.19	0.36	0.49	0.68	0.90	0.72	0.49	0.31	0.16	0.04
Germany	1.13		−0.09	−0.03	0.15	−0.04	0.15	0.61	0.09	−0.08	0.08	0.01	−0.21
France	0.72		0.13	0.28	0.45	0.57	0.69	0.78	0.43	0.20	−0.02	−0.18	−0.25
UK	1.41		0.17	0.21	0.26	0.29	0.40	0.76	0.22	−0.03	−0.20	−0.31	−0.36
Italy	1.64		−0.09	0.08	0.25	0.53	0.70	0.85	0.61	0.32	0.01	−0.18	−0.30
(6) Real interest rate[b]													
US	2.39	0.05	−0.33	−0.28	−0.21	−0.12	0.01	0.11	0.17	0.19	0.21	0.21	0.19
Canada	2.45	0.05	−0.33	−0.30	−0.23	−0.11	0.04	0.17	0.19	0.17	0.16	0.12	0.07
Japan	2.30	0.08	−0.29	−0.28	−0.21	−0.14	−0.04	0.08	0.19	0.24	0.29	0.28	0.25
Germany	2.32	0.05	−0.44	−0.37	−0.20	−0.01	0.16	0.28	0.47	0.57	0.57	0.49	0.42
France	2.10	0.08	−0.22	−0.24	−0.21	−0.19	−0.14	−0.07	0.00	0.07	0.12	0.14	0.15
UK	2.76	0.06	−0.24	−0.20	−0.14	−0.07	−0.01	−0.03	0.05	0.08	0.12	0.07	0.02
Italy	6.23	0.11	−0.24	−0.22	−0.18	−0.10	−0.04	0.04	0.09	0.12	0.11	0.08	0.06

[a]81Q1–89Q2.

[b]The real interest rate, r, is evaluated as $r(t) = (1 + (i(t)/100))*(p(t)/p(t+1))$ where i is the nominal rate (yield on long-term government bonds) and p is the GNP/GDP deflator. In this case data have been just logged, not filtered.

countercyclicality of prices and generally the weak correlation between money and output can be consistent with the RBC models with non-neutral money as well as the Quantity Theory. However, the Quantity Theory scenario would require a very low variability of velocity. Actually, even in the United States and Canada, where we have obtained the lowest values, the variability of velocity exceeds that of real GNP fluctuations.

As already mentioned in the introduction we examined the sensitivity of these findings to the detrending procedure. The results are in Appendix B. Both the fact that money does not strongly lead output and the fact that prices are countercyclical remain robust.[20]

3.3. *The factors of production*

Labor input, measured both in terms of workers and in terms of total hours, is procyclical in all countries and considerably less variable than output at the aggregate (table 3), industry (table 4), and manufacturing (table 5) levels. Moreover, hours per worker, whenever available, are also procyclical, leading or coincidental, and less variable than employment. These facts are consistent with the KP findings for the US economy. Further as in KP, we find that in most cases employment lags output. In the aggregate economy of the United States, Canada, Germany and France, employment lags by about a quarter, in Italy and the United Kingdom employment lags by about two quarters, while in Japan is roughly coincidental. In this last case, however, the correlations are weak. At the industry level, employment lags by about one quarter in the United States, by about two quarters in Germany and France, and by three quarters in Italy. And, finally, at the manufacturing level employment lags by one quarter in the United States and Canada and by two quarters in Japan, Germany and United Kingdom.

In general, however, we do not find productivity leading output, but in most cases it is coincidental. The only cases where productivity is leading in terms of hours is in the United States industry and manufacturing, confirming indirectly KP, and German manufacturing. Further, the only cases where productivity in terms of employment is leading are in the United States industry and manufacturing.

The relationship between the real wage rate and output differs from country to country. Thus, the real wage rate in manufacturing is procyclical in the United States and the United Kingdom, confirming the Dunlop/Tarshis evidence, and in Japan; countercyclical in Canada and France; and contemporaneously uncorrelated with output in Germany and Italy.

[20]This goes contrary to the Eichenbaum and Singleton (1986) findings, where the detrending method is crucial for the money-output causality.

Table 4

The factors of production in industry.

Variable	Volatility % s.d.	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
Cross correlations of real GNP/GDP with												
(1) Industrial production index												
US	3.70	−0.03	0.14	0.35	0.57	0.79	0.93	0.85	0.67	0.44	0.20	0.00
Canada	3.79	0.03	0.15	0.36	0.60	0.77	0.84	0.69	0.45	0.17	−0.07	−0.27
Japan	4.07	−0.09	0.04	0.23	0.44	0.62	0.75	0.76	0.66	0.48	0.28	0.03
Germany	3.06	−0.01	0.24	0.40	0.53	0.72	0.84	0.71	0.57	0.37	0.09	−0.09
France	2.70	−0.08	0.06	0.27	0.52	0.72	0.85	0.70	0.49	0.22	−0.01	−0.15
UK	2.85	−0.08	0.05	0.27	0.41	0.58	0.75	0.61	0.46	0.28	0.13	0.02
Italy	3.58	−0.13	0.03	0.23	0.48	0.72	0.88	0.65	0.38	0.10	−0.20	−0.36
Cross correlations of industrial production index with												
(2) Employment in industry												
US[a]	2.73	−0.31	−0.11	0.12	0.38	0.63	0.82	0.85	0.77	0.62	0.43	0.23
Canada	NA											
Japan	NA											
Germany	1.79	−0.32	−0.14	0.04	0.25	0.48	0.68	0.80	0.81	0.74	0.60	0.46
France	0.72	−0.43	−0.41	−0.32	−0.12	0.14	0.44	0.65	0.74	0.72	0.55	0.33
UK	NA											
Italy[b]	1.59	−0.46	−0.50	−0.42	−0.25	−0.05	0.14	0.33	0.43	0.50	0.48	0.43
(3)=(1)/(2) Productivity in industry												
US	2.05	0.21	0.41	0.58	0.70	0.78	0.75	0.50	0.20	−0.05	−0.27	−0.46
Canada	NA											
Japan	NA											
Germany	2.35	0.15	0.32	0.52	0.64	0.76	0.83	0.51	0.22	−0.02	−0.25	−0.45
France	2.47	−0.14	0.06	0.35	0.64	0.85	0.96	0.70	0.39	0.04	−0.023	−0.36
UK	NA											
Italy	3.79	−0.07	0.14	0.53	0.52	0.67	0.90	0.51	0.24	−0.05	−0.27	−0.45

[a]65Q1–89Q3.
[b]62Q1-88Q4

Table 5

The factors of production in manufacturing.

Variable	Volatility % s.d.	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
Cross correlations of real GNP/GDP with												
(1) Production index in manufacturing												
US	4.09	0.00	0.18	0.38	0.60	0.81	0.93	0.85	0.66	0.43	0.19	−0.01
Canada	3.95	−0.03	0.12	0.36	0.62	0.81	0.88	0.73	0.48	0.21	−0.03	−0.21
Japan	4.11	−0.09	0.04	0.23	0.44	0.62	0.75	0.76	0.65	0.48	0.27	0.03
Germany	3.15	−0.01	0.20	0.37	0.51	0.71	0.85	0.72	0.58	0.39	0.13	−0.06
France	3.02	−0.09	0.06	0.28	0.53	0.73	0.87	0.71	0.50	0.23	0.01	−0.17
UK	NA											
Italy	3.92	−0.13	0.02	0.21	0.46	0.70	0.87	0.63	0.37	0.09	−0.20	−0.36
Cross correlations of manufacturing production index with												
(2) Employment in manufacturing												
US	2.72	−0.32	−0.15	0.09	0.37	0.67	0.90	0.93	0.81	0.63	0.41	0.20
Canada	3.35	−0.36	−0.28	−0.11	0.07	0.29	0.44	0.50	0.44	0.38	0.28	0.25
Japan	1.82	−0.32	−0.27	−0.17	0.02	0.15	0.30	0.39	0.43	0.42	0.35	0.27
Germany	2.21	−0.32	−0.16	0.03	0.26	0.50	0.72	0.85	0.87	0.81	0.68	0.51
France	NA											
UK	1.86	−0.38	−0.27	−0.08	0.09	0.29	0.54	0.73	0.75	0.68	0.57	0.45
Italy	NA											
(3) Hours per worker in manufacturing[a]												
US	0.94	0.18	0.38	0.57	0.72	0.83	0.80	0.50	0.16	−0.12	−0.29	−0.38
Canada	1.72	0.09	0.15	0.21	0.26	0.31	0.28	0.17	0.03	−0.03	−0.12	−0.16
Japan	1.10	0.26	0.46	0.64	0.73	0.73	0.64	0.39	0.08	−0.23	−0.48	−0.60
Germany	1.14	0.03	0.20	0.37	0.57	0.74	0.79	0.72	0.49	0.23	0.00	−0.21
France	NA											
UK	1.22	0.11	0.12	0.26	0.36	0.47	0.69	0.46	0.28	0.04	−0.22	−0.33
Italy	NA											
(4) = (2)x(3) Total hours in manufacturing												
US	3.32	−0.21	−0.02	0.23	0.51	0.78	0.97	0.90	0.71	0.48	0.26	0.06
Canada	3.14	−0.38	−0.25	−0.02	0.22	0.43	0.59	0.59	0.48	0.31	0.18	0.16
Japan	1.96	−0.15	0.00	0.19	0.39	0.54	0.63	0.58	0.44	0.26	0.06	−0.09

Table 5 (continued)

Variable	Volatility % s.d.	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
Germany	2.98	−0.22	−0.05	0.16	0.41	0.66	0.84	0.90	0.84	0.69	−0.51	0.30
France	NA											
UK	2.41	−0.24	−0.15	0.06	0.24	0.46	0.75	0.78	0.71	0.54	0.32	0.17
Italy	NA											
(5)=(1)/(2) Productivity in manufacturing in terms of employment												
US	2.00	0.31	0.49	0.65	0.78	0.86	0.81	0.50	0.17	−0.09	−0.28	−0.40
Canada	3.63	0.17	0.31	0.46	0.60	0.70	0.72	0.51	0.27	0.05	−0.19	−0.39
Japan	3.97	−0.09	0.15	0.43	0.68	0.85	0.90	0.74	0.47	0.15	−0.14	−0.36
Germany	2.20	0.25	0.41	0.57	0.64	0.69	0.71	0.35	0.03	−0.22	−0.44	−0.59
France	NA											
UK (4)/(8)	2.46	0.17	0.26	0.40	0.55	0.67	0.78	0.34	0.06	−0.16	−0.37	−0.45
Italy	NA											
Cross correlations of manufacturing production index with												
(6)=(1)/(4) Productivity in manufacturing in terms of hours												
US	1.22	0.37	0.51	0.63	0.72	0.76	0.72	0.44	0.16	−0.06	−0.24	−0.36
Canada	3.32	0.15	0.26	0.39	0.52	0.62	0.64	0.47	0.27	0.08	−0.14	−0.35
Japan	3.25	−0.20	0.03	0.31	0.58	0.79	0.88	0.77	0.54	0.27	0.00	−0.24
Germany	1.76	0.29	0.39	0.47	−0.44	−0.39	0.38	−0.03	−0.29	−0.42	−0.56	−0.60
France	NA											
UK	1.89	0.15	0.25	0.33	0.46	0.54	0.55	0.13	−0.13	−0.26	−0.36	−0.39
Italy	NA											
(7) Real Hourly wages in manufacturing[a]												
US	0.90	0.19	0.29	0.36	0.42	0.49	0.49	0.37	0.24	0.13	−0.00	−0.09
Canada	1.61	0.36	0.27	0.11	−0.06	−0.17	−0.25	−0.30	−0.26	−0.24	−0.22	−0.24
Japan	2.46	−0.11	−0.01	0.08	0.15	0.21	0.24	0.25	0.24	0.22	0.19	0.18
Germany	1.12	−0.15	−0.26	−0.22	−0.20	−0.15	−0.10	−0.12	−0.00	0.14	0.23	0.25
France	0.75	−0.27	−0.40	−0.49	−0.53	−0.50	−0.41	−0.26	−0.15	0.00	0.19	0.29
UK	1.61	−0.13	−0.02	0.07	0.21	0.35	0.46	0.28	0.16	0.00	−0.04	−0.05
Italy	1.93	−0.18	−0.17	−0.11	−0.13	−0.12	−0.11	−0.22	−0.15	−0.00	0.10	0.04

[a]Earnings divided by the GNP/GDP deflator. Data for France and Italy are hourly rates. The sample for UK is 63Q1–89Q1.

Table 6

Real wages and government spending.

	X_{t-5}	X_{t-4}	X_{t-3}	X_{t-2}	X_{t-1}	X_t	X_{t+1}	X_{t+2}	X_{t+3}	X_{t+4}	X_{t+5}
Cross correlation of real hourly wages in manufacturing with											
(1) Government final consumption											
US	0.03	0.01	0.01	−0.03	0.00	−0.02	−0.04	−0.04	−0.09	−0.03	0.01
Canada	−0.32	−0.22	−0.14	0.00	0.12	0.27	0.20	0.17	0.18	0.22	0.17
Japan	−0.14	−0.12	−0.12	0.03	−0.10	0.03	−0.07	0.02	0.18	0.09	0.19
Germany	0.12	0.10	0.09	0.15	0.16	0.15	0.04	0.01	0.03	0.02	0.07
France	−0.05	−0.03	−0.06	−0.10	−0.17	−0.20	−0.18	−0.11	−0.05	0.04	0.03
UK	0.10	0.07	0.05	0.05	0.02	0.08	0.04	0.01	−0.08	−0.08	−0.11
Italy	−0.19	−0.08	−0.01	0.09	0.03	−0.07	−0.21	−0.26	−0.22	−0.09	0.13

As already mentioned, the real interest rate is leading countercyclically in all cases and is more volatile than real GNP/GDP. The highest correlations occur when the real rate lead real GNP/GDP cycles by about one year. In some cases (Germany, Japan) the correlations between the real rate of interest and GNP/GDP become positive.

The procyclicality of total hours, productivity, and the real wage rate is very much consistent with the BRBC, where 'good' ('bad') technology shocks increase (decrease) the physical marginal product of labor, employment, the real wage rate, and output. The procyclicality of total hours, and the countercyclicality of productivity and the real wage rate can be accounted for in two ways. First, if one allows for government and/or preference shocks that affect labor supply decisions as in the model of Aiyagari et al. (1990) and Christiano and Eichenbaum (1989), discussed above. Second, in the 'price shocks' type model of Kydland (1991). It follows that by combining technology and preference or government shocks and/or price shocks in an RBC model one can explain a whole array of alternative cyclical properties of productivity and real wages. Partial support for this, as table 5 indicates, is that there is no correlation between government consumption and real wages for those countries where the real wage is procyclical (Japan, United States, and United Kingdom); while with the exception of Germany, there is a negative correlation between government consumption and real wages for those countries where real wages are countercyclical.

The relationship between the real rate of interest and output can also be accounted for, as explained in subsection 4.2. However, it should be emphasized that this relationship may be plagued by several measurement errors. Most importantly we do not use a short-term nominal rate and we measure the expected rate of inflation by its realized counterpart (see footnote b in table 3).

The major discrepancies between the RBC model and the evidence presented above are in labor dynamics. First, employment variations seem to be relatively too small and hours per worker variations seem to be relatively

too large to be accounted for by existing versions of the RBC model.[21] Second, employment lags output everywhere while hours per worker are coincidental or leading, contrary to RBC formulations where employment adjustments are explicitly or implicitly synchronous to output.

Now, what we mean by 'relatively', above is vis-à-vis the current versions of the RBC model. That is, although the variability of total hours predicted by the indivisible-labor [Rogerson (1988), Hansen (1985)] and work-week-of-capital [Kydland and Prescott (1988)] versions of the RBC model is about right, the variability of the components of total hours is not. In Kydland and Prescott (1988) as well as in the BRBC and the time-to-build [Kydland and Prescott (1982)] version of the RBC, employment is fixed; while in Hansen's (1985) model hours per worker are fixed. Thus, all the variability in these models is due to variability in one component of labor. Moreover, models that allow for hours-per-worker variability seem to grossly underpredict this variation [i.e., in the straight-time/over-time model of Hansen and Sargent (1988) and in the model of Kydland and Prescott (1991b)].[22] Moreover, with the exception of the last model, the above models fail to recognize the lagging employment adjustment. This is also the case in Burnside et al. (1990), where time varying effort is introduced in the indivisible-labor version of the RBC model to capture labor hoarding phenomena. For in this model, firms have to make employment decisions before and effort decisions after technology shocks materialize. This implies that employment is set before output is set, although employment will not fluctuate as much as output.[23]

A modification of the BRBC that could, in principle, account for these findings still implies some type of labor hoarding; that is, a situation where firms find relatively more costly to adjust employment rather than hours per worker, so that they have an incentive to smooth employment over the business cycle and utilize labor more intensively in expansions and less intensively in contractions.[24] There are several other reasons for this relative difference. In general, recursive production technologies whereby the production process is such that current output depends on past stocks and their current utilization rates [Cassing and Kollintzas (1991)]. If employment is such an input, then it will also tend to lag output. Also this difference may be accounted for by adjustment costs due to institutional factors guiding search by heterogeneous workers and union behavior. This scenario is

[21]See Kydland and Prescott (1991, Tables 3.1 and 3.2).

[22]The Kydland and Prescott (1991) model can account for a 0.24% variation in hours per worker while the corresponding variation in the U.S. that they report for 1954Q1–1988Q2 is 0.56%.

[23]The primary motivation behind the Burnside, Eichenbaum and Rebelo (1990) paper is to show that the importance of the technology shock ('Solow residual') to explain business cycle fluctuations is reduced once one allows for labor hoarding type behavior.

[24]The model of Kydland and Prescott (1991) can be thought of an RBC model, where firms rather than households are facing employment adjustment costs.

consistent with survey data [Fay and Medoff (1985)] and time series data [Bernanke and Parkinson (1991)] in US manufacturing and elsewhere. Further, they are consistent with the fact that employment in the European countries and Japan fluctuates relatively less than in the North American countries and total hours fluctuate considerably more than employment. This is because it is generally believed that labor institutions in Europe and Japan create more potent adjustment costs and flow of information impediments. Thus, labor hoarding type behavior may be more important in the European countries and Japan.

4. Concluding remarks

In this paper we examined whether the RBC model can account for the pertinent stylized facts of business cycles in the G7, following the methodology of Kydland and Prescott's (1990) study for the United States. Our data are stationary cyclical deviations obtained from filtering as in Hodrick and Prescott (1980) a selected number of OECD-MEI quarterly time series. Our data set does not fully match that of Kydland and Prescott both in terms of time coverage and available data series so that our results for the US can differ from theirs.

Real GNP/GDP is persistent in all countries. All components of expenditure are procyclical. Consumption expenditure is less volatile than GNP/GDP which in turn is much less volatile than investment expenditure. Inventory investment is by far the more volatile component of investment expenditures. Imports and exports fluctuate less than consumption and more than investment expenditures. Government consumption behaves differently in each country.

Prices are leading countercyclically everywhere. Money stock does not strongly lead output, but the evidence is different from country to country. A similar finding holds true for various proxies of credit aggregates.

The stylized facts pertaining to the components of spending and monetary variables confirm the results of Kydland and Prescott for the United States and of Backus and Kehoe (1992) for Canada, Germany, Italy, Japan, United Kingdom, and the United States. Further, we provide evidence that these results do not depend on the data filtering method.

A possible interpretation of this evidence, showing a fairly similar pattern in GNP/GDP private expenditure components, and prices while 'policy' variables such as government consumption and money stock have very dissimilar patterns could be that the instigators of business cycle fluctuations are technological in nature and that the business cycle propagation mechanisms are common [Lucas (1977)]. But, we do not want to overemphasize this, for as summarized below, we do observe some important differences in labor markets.

Employment, measured both in terms of workers and in terms of total hours, is procyclical, lagging, and considerably less variable than output at the aggregate, industry, and manufacturing level. Moreover, hours per worker, are also procyclical, coincidental or leading and less variable than employment. Real wages are procyclical in the United States, Japan and the United Kingdom and countercyclical in the other countries. Finally, there is evidence that real interest rates are leading countercyclically output, confirming conventional wisdom.

With the exception of the variabilities of hours per worker and employment and the lagging employment, which we take to indicate labor hoarding, we provide some simple intuitive explanations showing how current RBC models can account for these findings. Further, we conjecture that, in principle it is possible to construct RBC models that can account for the variabilities of hours per worker and employment and the lagging employment findings. These models should incorporate adjustment costs and variable employment utilization. Adjustment costs may reflect technological or institutional factors guiding search by heterogeneous workers and union behavior.

Finally, it should be mentioned, that we attempted to match specific stylized facts with particular RBC models. Thus, we do not know whether there is a synthesis of these models that could account simultaneously for all the stylized facts examined in this paper.

Appendix A: Proportionality of growth and cointegration

The neoclassical growth model requires in steady-state that per capita output (Y/N), expenditure (X/N) and capital (K/N) grow at the same rate:

$$[(\mathrm{d}/\mathrm{d}t)(Y/N)]/(Y/N) = [(\mathrm{d}/\mathrm{d}t)(X/N)]/(X/N). \tag{A.1}$$

By integrating (A.1) with respect to time we obtain

$$\log(Y(t)) - \log(X(t)) = \theta, \tag{A.2}$$

where θ is a constant, showing the proportionality of growth between Y and X.

Without loss of generality, expression (A.2) can be estimated as the contemporaneous cointegrating equation:

$$y(t) = a + b\,x(t) + u(t), \tag{A.3}$$

where $y = \log(Y)$ and $x = \log(X)$ are both nonstationary but where it may be found a constant b such that $u(t)$ is a stationary cointegrating vector. The latter exists if y and x share a common stochastic trend.

Among the possible tests, Engle and Granger (1987) recommend the ADF (Augmented Dickey–Fuller) procedure which amounts to estimate the t-ratio for α in the auxiliary OLS regression:

$$u(t) - u(t-1) = \alpha u(t-1) + \sum_{i=1}^{p} \beta_i\,(u(t-i) - u(t-i-1)) + \epsilon(t), \tag{A.4}$$

where higher order terms are included to make the estimated residuals white noise. To reject the null hypothesis of no cointegration, α has to be negative and significantly different from zero. However, the relevant statistic does not have a t-distribution but has been tabulated in a Monte Carlo study by Engle and Granger. The reported critical values for the two- variable case with 100 observations and $p = 4$ are: -3.77 (1%), -3.17 (5%), -2.84 (10%).

In the following table we report the 't-ratios' for α and for the corresponding equation obtained by normalizing (3) on x rather than on y. We report also fourth-order LM-tests – which are approximately distributed as χ^2 – to assess the null that residuals in (4) are not serially correlated.

In the cointegrating equation we regress the smoothed trend of the log of real GNP (y) on the smoothed trend of the log of major expenditure components (consumption, fixed investment, final government expenditure, exports and imports of goods and services). The growth variables are obtained by applying HP filter to the observed expenditure and GNP/GDP data.

Table A.1

Cointegration tests (ADF) for growth components

	GNP	Chisq(4)	X_i	Chisq(4)
Cointegration between real GNP/GDP and X_i normalized on:				
USA				
Consumption	−1.55	1.01	−1.64	1.03
Investment	−2.10	2.19	−2.15	2.25
Govt. expend.	−3.52	3.88	−3.95	4.36
Imports	−2.89	2.34	−2.68	2.43
Exports	−3.48	13.10	−5.93	13.54
Canada				
Consumption	−2.99	5.49	−2.88	5.43
Investment	−0.81	0.71	−0.59	1.15
Govt. expend.	−0.74	2.12	−1.03	2.00
Imports	0.05	2.86	0.10	2.80
Exports	−2.63	0.63	−2.82	0.39
Japan				
Consumption	−3.00	4.67	−2.97	4.70
Investment	−2.46	11.90	−2.35	10.71
Govt. expend.	0.01	5.91	−0.13	5.77
Imports	−2.01	8.16	−1.92	6.74
Exports	−2.28	7.61	−2.28	7.81
Germany				
Consumption	−2.85	7.10	−2.92	6.96
Investment	−2.64	4.29	−2.38	4.85
Govt. expend.	−1.61	9.64	−1.63	9.74
Imports	−2.32	4.42	−2.36	4.30
Exports	−2.06	5.94	−2.09	5.94
France (70Q1– 89Q3)				
Consumption	−1.93	5.83	−1.94	5.82
Investment	−1.22	2.30	0.05	1.85
Govt. expend.	−0.18	4.65	−0.36	4.49
Imports	−0.65	4.75	−0.30	4.49
Exports	−1.42	12.71	−1.49	12.56
UK				
Consumption	−1.03	8.81	−0.90	8.65
Investment	−3.73	5.07	−2.40	8.35
Govt. expend.	−3.04	2.57	−2.89	2.88
Imports	−0.46	5.70	−0.32	5.63
Exports	−0.74	8.25	−1.08	7.70
Italy (70Q1–89Q3)				
Consumption	−0.37	3.16	−0.33	3.18
Investment	−1.34	18.11	−0.81	17.69
Govt. exp.	−2.06	11.03	−2.32	12.50
Imports	−0.23	5.72	−0.13	5.71
Exports	−1.74	4.17	−1.97	4.29

Appendix B: Sensitivity of the results to alternative detrending procedures

Table B.1

Autocorrelation in real GNP/GDP at given lag (HP, TS, DS filters)[a]

	−1	−2	−3	−4	−5
USA					
HP	0.85	0.65	0.41	0.21	0.01
TS	0.94	0.85	0.73	0.61	0.49
DS	0.27	0.25	0.02	0.05	−0.13
Canada					
HP	0.78	0.51	0.27	0.04	−0.12
TS	0.91	0.79	0.07	0.55	0.44
DS	0.24	0.05	0.09	−0.02	−0.05
Japan					
HP	0.78	0.59	0.38	0.19	0.00
TS	0.95	0.90	0.84	0.77	0.69
DS	0.31	0.35	0.29	0.28	0.19
Germany					
HP	0.67	0.46	0.35	0.23	−0.02
TS	0.81	0.66	0.57	0.46	0.28
DS	−0.09	−0.09	0.07	0.24	−0.19
France					
HP	0.77	0.54	0.30	0.10	−0.06
TS	0.84	0.07	0.50	0.38	0.25
DS	0.23	0.19	0.05	0.03	0.11
UK					
HP	0.54	0.37	0.20	0.07	−0.02
TS	0.84	0.74	0.65	0.56	0.48
DS	−0.24	0.02	−0.04	−0.01	−0.04
Italy					
HP	0.80	0.52	0.22	−0.04	−0.21
TS	0.88	0.72	0.55	0.39	0.26
DS	0.26	0.20	−0.01	−0.09	−0.08

[a]HP = Hodrick–Prescott filter; DS = first differences of logged variables; TS = cycles are residuals from a qudratic trend (logged variables); RV = relative variability (s.d. of GNP/GDP/s.d. of the other variable).

Table B.2

Cross-correlations in real GNP/GDP and money stock at given lag (HP, TS and DS filters).

	RV	−5	−4	−3	−2	−1	0	1	2	3	4	5
US												
HP	1.05	0.00	0.07	0.15	0.29	0.29	0.29	0.20	0.14	0.09	0.08	0.08
TS	1.39	0.02	0.04	0.10	0.19	0.24	0.25	0.16	0.11	0.06	0.05	0.04
DS	0.97	−0.07	−0.07	−0.09	0.14	0.16	0.16	−0.10	−0.04	−0.12	−0.06	−0.06
Canada												
HP	0.61	0.21	0.31	0.43	0.50	0.43	0.24	0.09	−0.09	−0.17	−0.11	−0.05
TS	0.32	0.14	0.22	0.29	0.35	0.37	0.35	0.36	0.33	0.33	0.35	0.37
DS	0.57	0.09	0.05	0.05	0.32	0.26	0.12	0.05	−0.08	−0.20	−0.03	0.09
Japan												
HP	0.58	−0.34	−0.21	−0.08	0.03	0.09	0.11	0.12	0.11	0.11	0.10	0.12
TS	0.57	−0.43	−0.34	−0.25	−0.15	−0.07	0.01	0.07	0.14	0.20	0.25	0.31
DS	0.59	0.13	0.24	0.26	0.33	0.35	0.30	0.31	0.32	0.32	0.27	0.30
Germany												
HP	0.37	0.17	0.15	0.14	0.11	0.03	0.00	−0.05	−0.17	−0.17	0.01	0.02
TS	0.48	−0.01	0.10	0.17	0.19	0.19	0.19	0.17	0.13	0.11	0.13	0.13
DS	0.38	−0.12	0.05	0.05	0.09	−0.14	0.06	0.06	−0.20	−0.027	0.28	0.04
France												
HP	0.34	0.27	0.31	0.33	0.32	0.27	0.12	0.01	−0.08	−0.13	−0.11	−0.07
TS	0.30	−0.23	−0.26	−0.28	−0.31	−0.36	−0.43	−0.39	−0.36	−0.32	−0.27	−0.21
DS	0.35	0.00	0.04	0.02	0.08	−0.20	−0.06	−0.03	−0.05	−0.05	0.06	0.0
UK[a]												
HP	0.51	0.47	0.57	0.63	0.62	0.51	0.33	0.13	−0.07	−0.26	−0.35	−0.35
TS	0.68	0.42	0.50	0.52	0.49	0.44	0.38	0.30	0.24	0.21	0.18	0.18
DS	0.79	0.13	0.27	0.19	0.13	0.04	0.15	−0.14	−0.11	−0.04	−0.08	−0.07
Italy												
HP	0.45	0.03	0.10	0.24	0.38	0.46	0.42	0.35	0.22	0.08	−0.01	−0.11
TS	0.25	−0.36	−0.30	−0.24	−0.19	−0.18	−0.14	−0.12	−0.11	−0.10	−0.08	−0.07
DS	0.50	−0.17	−0.02	0.05	0.20	0.25	0.13	0.11	0.01	−0.07	−0.05	−0.13

[a]47Q1–88Q4.

Table B.3

Cross-correlations in real GNP/GDP and implicit price deflator at given lag (HP, TS and DS filters).

	RV	−5	−4	−3	−2	−1	0	1	2	3	4	5
US												
HP	1.83	−0.47	−0.60	−0.68	−0.72	−0.70	−0.63	−0.51	−0.37	−0.22	−0.06	0.08
TS	0.47	−0.61	−0.67	−0.71	−0.74	−0.75	−0.75	−0.71	−0.66	−0.61	−0.55	−0.49
DS	1.40	−0.27	−0.30	−0.33	−0.34	−0.28	−0.30	−0.19	−0.20	−0.11	−0.08	−0.12
Canada												
HP	0.81	−0.47	−0.51	−0.50	−0.46	−0.41	−0.34	−0.20	−0.07	0.04	0.14	0.21
TS	0.33	−0.43	−0.42	−0.41	−0.39	−0.36	−0.34	−0.26	−0.19	−0.12	−0.05	0.02
DS	1.13	−0.30	−0.27	−0.27	−0.18	−0.18	−0.32	−0.10	−0.05	−0.06	−0.02	−0.02
Japan												
HP	0.83	−0.37	−0.46	−0.51	−0.52	−0.48	−0.43	−0.34	−0.21	−0.10	−0.01	0.02
TS	0.57	−0.80	−0.80	−0.79	−0.78	−0.77	−0.73	−0.67	−0.60	−0.53	−0.46	−0.39
DS	1.07	−0.03	−0.08	−0.11	−0.06	−0.06	−0.04	−0.06	0.07	0.08	0.20	0.17
Germany												
HP	1.05	−0.32	−0.35	−0.34	−0.28	−0.24	−0.15	0.07	0.23	0.33	0.35	0.44
TS	0.60	−0.37	−0.34	−0.30	−0.26	−0.22	−0.18	−0.07	0.02	0.09	0.15	0.21
DS	1.80	−0.09	−0.06	−0.10	0.03	−0.09	−0.19	0.10	0.14	0.13	−0.06	0.12
France												
HP	0.66	−0.37	−0.48	−0.53	−0.60	−0.61	−0.60	−0.47	−0.34	−0.25	−0.18	−0.08
TS	0.37	−0.53	−0.60	−0.65	−0.70	−0.74	−0.78	−0.66	−0.54	−0.42	−0.33	−0.23
DS	0.74	−0.44	−0.21	−0.11	−0.26	−0.19	−0.17	−0.14	0.01	−0.02	−0.04	−0.06
UK												
HP	0.66	−0.09	−0.22	−0.34	−0.45	−0.54	−0.57	−0.48	−0.39	−0.23	−0.09	0.08
TS	0.21	−0.66	−0.67	−0.68	−0.69	−0.70	−0.68	−0.62	−0.55	−0.47	−0.38	−0.30
DS	0.92	−0.08	−0.12	−0.09	−0.14	−0.16	−0.27	−0.01	−0.17	−0.03	−0.12	−0.01
Italy												
HP	0.92	−0.54	−0.64	−0.68	−0.61	−0.50	−0.33	−0.14	0.04	0.16	0.18	0.17
TS	0.21	−0.58	−0.62	−0.66	−0.67	−0.68	−0.68	−0.62	−0.56	−0.50	−0.45	−0.40
DS	0.73	−0.31	−0.35	−0.41	−0.30	−0.32	−0.25	−0.20	−0.08	−0.03	−0.12	−0.12

Table B.4

Cross-correlations in real GNP/GDP and employment at given lag (HP, TS And DS filters).

	RV	−5	−4	−3	−2	−1	0	1	2	3	4	5
US												
HP	1.66	−0.11	0.06	0.24	0.44	0.65	0.83	0.88	0.80	0.66	0.47	0.27
TS	2.02	−0.06	0.08	0.22	0.40	0.57	0.73	0.77	0.71	0.61	0.46	0.31
DS	1.66	−0.14	−0.01	−0.08	0.04	0.14	0.69	0.39	0.27	0.26	0.11	0.01
Canada												
HP	1.11	−0.35	−0.21	0.00	0.22	0.45	0.67	0.71	0.59	0.44	0.37	0.25
TS	1.33	−0.11	0.03	0.18	0.35	0.52	0.66	0.72	0.71	0.66	0.64	0.59
DS	1.12	−0.05	−0.09	−0.07	0.05	0.09	0.42	0.39	0.16	−0.06	0.19	−0.11
Japan												
HP	2.26	−0.03	0.00	0.06	0.24	0.26	0.27	0.19	0.24	0.18	0.06	−0.08
TS	4.18	0.56	0.56	0.56	0.60	0.60	0.59	0.52	0.48	0.41	0.32	0.23
DS	1.42	−0.06	0.03	−0.04	0.22	0.03	0.13	−0.10	0.13	0.08	0.04	−0.06
Germany												
HP	1.04	−0.26	−0.11	−0.08	0.08	0.15	0.29	0.29	0.25	0.17	0.05	0.07
TS	1.61	−0.02	0.13	0.03	0.09	0.09	0.10	0.15	0.22	0.07	−0.11	−0.08
DS	1.46	0.10	0.24	−0.05	0.16	0.06	0.17	0.14	0.23	0.12	−0.09	0.13
France												
HP	1.61	−0.27	−0.20	−0.09	0.13	0.35	0.60	0.68	0.61	0.51	0.40	0.21
TS	1.51	0.19	0.28	0.39	0.52	0.68	0.85	0.82	0.72	0.58	0.51	0.38
DS	1.10	−0.11	0.02	−0.04	0.11	0.05	0.30	0.35	0.19	0.14	0.16	0.18
UK												
HP	1.45	−0.25	−0.18	−0.07	0.15	0.27	0.44	0.52	0.57	0.55	0.52	0.45
TS	1.34	0.21	0.29	0.39	0.52	0.64	0.74	0.76	0.75	0.72	0.68	0.61
DS	2.26	−0.03	0.00	−0.15	0.20	−0.02	0.19	0.11	0.19	0.05	0.15	0.06
Italy												
HP	1.84	−0.22	−0.22	−0.05	0.03	0.23	0.35	0.39	0.40	0.38	0.24	0.14
TS	1.48	−0.47	−0.44	−0.37	−0.33	−0.25	−0.22	−0.17	−0.13	−0.10	−0.11	−0.12
DS	1.13	0.00	−0.19	0.06	−0.17	0.07	0.08	0.02	0.03	0.11	−0.07	0.02

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