Wälde, Klaus; Woitek, Ulrich

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KLAUS WÄLDE

ULRICH WOITEK

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Address of the author(s):

Klaus Wälde
Technical University Dresden,
Department of Economics
Mommsenstr. 13
01062 Dresden
Germany

e-mail : waelde@iwb-dresden.de

Ulrich Woitek
University of Munich,
Department of Economics
80539 Munich
Germany

e-mail : u.woitek@lrz.uni-muenchen.de

Editors:

Faculty of Business Management and Economics, Department of Economics

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Working paper coordinators:

Michael Berlemann
Oliver Greßmann
e-mail: wpeconomics@mailbox.tu-dresden.de

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Klaus Wälde
Technical University Dresden
Department of Economics
01062 Dresden
waelde@iwb-dresden.de

Ulrich Woitek
University of Munich
Department of Economics
80539 Munich
u.woitek@lrz.uni-muenchen.de

Abstract:

The literature on endogenous growth cycles predicts countercyclical R&D expenditure. Aggregate R&D expenditure in G7 countries from 1973 to 1997 seems to be procyclical. Implications for future theoretical research are discussed.

JEL-Classification: C2, E32, O41

Keywords: Cyclical Properties of R&D Expenditure; Growth Cycles

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1 Introduction

Growth rates of virtually all economic variables are time varying. The reasons for these fluctuations are manyfold. Some of the factors implying non-constant growth rates can reasonably be considered to be exogenous. Oil price shocks, shifts in preferences or sometimes also shifts in expectations can be put in this category. However, fluctuations can also be the result of events that are endogenous to an economy. As Bental and Peled (1996), Matsuyama (1999, 2001) and Wälde (1999, 2002) have stressed, intentional R&D by profit maximizing firms can not only be the source for positive long-run growth rates but also for short-run fluctuations.

Models presented by these authors combine capital accumulation with R&D. Generally speaking, these model economies feature a growth path on which periods of high growth are followed by periods of low growth and vice versa. Similarily, periods of high innovative activity are followed by periods of low innovative activity. Whereas in Matsuyama's work, a temporary patent protection for innovators leads to a synchronization of innovative activity, it is relative returns for investors in Bental and Peled and Wälde's approach that coordinates investment decisions.

A common prediction of these models is a countercyclical allocation of resources to R&D.[2] In periods of high returns to capital (or no patent protection) and high growth of GDP, few resources are allocated to R&D. With low returns to capital (or temporary patent protection) and low growth, resource allocation to R&D is high. Empirically speaking, resource allocation to R&D should be negatively correlated with growth rates of GDP. The present paper tests this prediction.

A widely used technique to do this is to detrend the data using the Hodrick-Prescott (HP) filter and calculate descriptive statistics based on the filtered series. However, it is well known that the HP filter can create spurious cyclical structure and spurious correlations (Harvey and Jaeger, 1993) if the series is I(0). Given the limited reliability of unit-root tests (e.g. Banerjee et al. 1993) to discriminate between I(0) and I(1) series, and the shortness of our time series, we adopt the approach proposed by Canova (1998). We compare the outcome for filtering techniques with different implications for the nature of the non-stationarity, and judge the robustness of our results by comparing the outcome.

Evidence on cyclical behaviour of R&D is provided by Saint-Paul (1993) and Geroski and Walters (1995). Saint-Paul uses a VAR approach and finds

[2] Francois and Lloyd-Ellis (forthcoming) obtain this result in a multi-sector economy without capital accumulation.

"very little evidence of any pro- or countercyclical behavior" of R&D activity (measured by R&D expenditure). Geroski and Walters, using UK innovations and patents data, find some procyclical behavior of these quantities (correlation coefficients of .62 and .23, respectively). Fatas (2000) provides a plot of growth rates of R&D expenditure and GDP for the USA from 1961 to 1996 and argues that they are procyclical. We complement these studies by being more comprehensive both with respect to countries and years covered, by using different data and methods and by stressing the link to theories of endogenous fluctuations and growth.

2 Results

2.1 The data and descriptive statistics

We study G7 countries and use annual data for the period from 1973 - 1997. This time period and frequency was largely dictated by the availability of data on R&D. Data on industrial R&D expenditure in current national prices are from OECD (1997, 2000a). GDP data in current national prices and price deflators used to express time series in 1995 prices are from OECD (2000b). R&D and GDP data were divided by total employment (OECD, 2000b) and the resulting per-capita (i.e. per number of workers) series were used for all computations.

Time series for Germany cover West Germany only. As data for West Germany was not available up to 1997, data for West Germany for 1991 to 1997 were constructed by multiplying data for Germany as a whole by the 1991 - 1994 average ratio of West German to German data. As results obtained for Germany do not qualitatively differ from results for other G7 countries, these added observation errors do not seem to be substantial.

The annual (unweighted) average growth rate of real per-capita GDP of G7 countries amounts to 1.6%, ranging from .9% for Canada and 2.3% for Japan. The annual (unweighted) average growth rate of real per-capita R&D expenditure of G7 countries lies at 3.1% with extreme values at 1.3% for the UK and 4.7% for Japan and Canada. In each country, except the UK, the growth rate of R&D expenditure lies above the growth rate of GDP. The ratio of R&D expenditure to GDP in 1997 lies between .5% in Italy and 2.1% in Japan. Volatility (measured by the standard deviation of the cyclical component of a time series detrended by the HP filter with a smoothing parameter $\lambda = 100$) of R&D exceeds volatility of GDP by a factor between approx. 2.1 for the UK and 5.6 for Canada. Due to this much higher volatility (unweighted average 3.6), R&D expenditure can be considered to behave very similarily to "normal" investment.

2.2 Cross correlations

The trend and cyclical components of a time series were obtained by applying the various filters on logarithms of per-capita GDP and per-capita R&D data. We use the HP filter, a modified Baxter-King filter (BKM), the Christiano-Fitzgerald filter (CF) and a difference filter (DF), i.e. we computed growth rates by computing the differences of logs of time series. The smoothing parameter for the HP filter was $\lambda = 100$ and $\lambda = 6.25$ (suggested recently by Ravn and Uhlig, 2002), the modified Baxter-King (1999) filter has a cut-off frequency of 15 years, the filter length is 3. The undesireable sidelobes in the gain function are taken care of by the so called Lanczos's σ-factors (as used in A'Hearn and Woitek, 2001). For the Christiano-Fitzgerald (1999) filter, the cut-off frequency is again 15 years.

Correlation coefficients and corresponding $t-$ and $p-$values were obtained by regressing centered cyclical components of per-capita R&D data on centered cyclical components of per-capita GDP, correcting standard errors for heteroskedasticity and autocorrelation (Newey and West, 1987). Results on contemporanous correlations are presented in table 1.[3]

One, two and three asterisks indicate significance at the ten, five and one percent level, respectively. The overall impression is one of a positive correlation. 25 out of 35 estimates are positive, of which 15 are significant. Negative correlation coefficients were estimated for Canada (4 out of 5), for Italy (5 out of 5) and the U.S. (1 out of 5) of which only one is significant.

Correlations for lagged R&D expenditure were computed as well and are available upon request. No easily identifiable pattern emerged. We also looked at the correlation between investment (gross fixed capital formation from OECD, 2001) and R&D expenditure.[4] Here, only 4 out of 35 estimated correlation coefficients were negative, and none was significant. By contrast, 9 positive correlation coefficients were significant. The hypothesis of a negative correlation between R&D expenditure and GDP (or investment) made by theory is clearly rejected.

[3] A visual impression of the cyclicality of R&D expenditure can be gained from the plot on the last page of this paper, obtained by using the HP filter with $\lambda = 100$.

[4] It could be argued that the most direct prediction of existing models of endogenous fluctuations is the switching allocation of savings to either capital accumulation or R&D and hence their negative correlation. The negative correlation between R&D expenditure and GDP is an immediate consequence.

		HP100	HP6.25	DF	BKM	CF
CAN	ρ	-0.028	-0.164	-0.020	-0.195	0.006
	t-value	-0.124	-0.893	-0.099	-0.888	0.021
	p-value	0.902	0.381	0.922	0.386	0.983
FRA	ρ	0.132	0.000	0.353***	0.081	0.031
	t-value	0.639	0.000	3.225	0.444	0.119
	p-value	0.529	1.000	0.004	0.662	0.906
GER	ρ	0.341**	0.312*	0.275**	0.330*	0.337*
	t-value	2.330	1.797	2.132	1.807	1.953
	p-value	0.029	0.085	0.044	0.087	0.065
ITA	ρ	-0.227	-0.115	-0.113	-0.145	-0.355*
	t-value	-1.322	-0.666	-0.743	-0.840	-2.076
	p-value	0.199	0.512	0.465	0.412	0.051
JPN	ρ	0.478*	0.571***	0.522***	0.640***	0.461
	t-value	1.783	4.869	3.375	3.535	1.547
	p-value	0.087	0.000	0.003	0.002	0.138
GBR	ρ	0.488***	0.499***	0.423***	0.368**	0.456**
	t-value	2.956	3.932	5.119	2.317	2.115
	p-value	0.007	0.001	0.000	0.032	0.047
USA	ρ	0.170	0.116	0.141	-0.053	0.245
	t-value	0.873	0.675	0.568	-0.258	1.015
	p-value	0.392	0.506	0.576	0.799	0.322

Table 1: Correlation coefficients between GDP and R&D expenditure for G7 countries

3 Conclusion

What do these findings imply for further research? Bental and Peled (1996) briefly and Francois and Lloyd-Ellis (forthcoming) extensively discuss empirical evidence on countercyclical R&D expenditure.[5] These authors provide evidence in favour of their - and therefore also - Matsuyama's and Wälde's approach. Generally speaking, some R&D activities (in a broad sense including reorganization of production or managment processes and training) indeed seem to increase during downturns. On the other hand, it seems fair to argue that there is stronger evidence for procyclical rather than countercyclical behavior of R&D expenditure from the analysis undertaken here.

While data might remain inconclusive for some time, future research should focus on making models more flexible. Other specifications might

[5] Cf. also Saint Paul (1993, 1997) on the related "opportunity cost" literature.

imply R&D expenditure whose cyclical behavior depends on parameter values. This might then help to find new empirical strategies that would allow to understand why there is both pro- and countercyclical evidence of R&D in a broad sense.

References

[1] A'Hearn, B. and Woitek, U., 2001, More International Evidence on the Historical Properties of Business Cycles. Journal of Monetary Economics 47: 321 - 346.

[2] Banerjee, A., Dolado, J., Galbraith, J. and Hendry, D., 1993, Cointegration, Error-Correction and the Econometric Analysis of Non-Stationary Data. Oxford University Press, Oxford.

[3] Baxter, M. and King, R. G., 1999, Measuring Business Cycles. Approximate Band-Pass Filters for Economic Time Series. Review of Economics and Statistics 81: 575-593.

[4] Bental, B., Peled, D., 1996, The accumulation of wealth and the cyclical generation of new technologies: A Search Theoretic Approach. International Economic Review 37, 687 - 718.

[5] Canova, F., 1998, Detrending and Business Cycle Stylized Facts. Journal of Monetary Economics 41: 475-512.

[6] Christiano, L. and Fitzgerald, T., 1999, The Band Pass Filter. NBER Working Paper No 7257.

[7] Fatás, A., 2000, Do Business Cycles Cast Long Shadows? Short-Run Persistence and Economic Growth. Journal of Economic Growth 5: 147 - 162.

[8] Francois, P. and Lloyd-Ellis, H., forthcoming, Animal Spirits Through Creative Destruction. American Economic Review.

[9] Geroski, P. A. and Walters, C. F., 1995, Innovative Activity over the Business Cycle. Economic Journal 105: 916 - 928.

[10] Harvey, A. C. and A. Jaeger, 1993, Detrending, Stylized Facts and the Business Cycle. Journal of Applied Econometrics 8: 231-247.

[11] Matsuyama, K., 2001, Growing through Cycles in an Infinitely Lived Agent Economy. Journal of Economic Theory 100: 220 - 234.

[12] Matsuyama, K., 1999. Growing through cycles. Econometrica 67, 335 - 347.

[13] Newey, W. K. and West, K. O., 1987, A Simple, Positive Semi-definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix. Econometrica 55: 703 - 708.

[14] OECD, 2001, International sectoral database. OECD [Organization for Economic Co-Operation and Development], Paris.

[15] OECD , 2000a, Research and Development Expenditures in Industry 1977-1998. OECD, Paris.

[16] OECD, 2000b, Statistical Compendium Edition 1.2000 (on CD). OECD, Paris.

[17] OECD , 1997, ANBERD: Business Enterprise R-D Expenditures in Industry 1973-1995 (on diskettes). OECD, Paris.

[18] Ravn, M. O.; Uhlig, Harald, 2002, On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations. Review of Economics and Statistics 84: 371 - 376.

[19] Saint-Paul, G., 1993, Productivity Growth and the Structure of the Business Cycle. European Economic Review 37: 861 - 883.

[20] Saint-Paul, G., 1997, Business Cycles and Long-Run Growth. Oxford Review of Economic Policy 13: 145 - 153.

[21] Wälde, K., 2002, The Economic Determinants of Technology Shocks in a Real Business Cycle Model. Journal of Economic Dynamics and Control 27: 1 - 28.

[22] Wälde, K., 1999, Optimal Saving under Poisson Uncertainty. Journal of Economic Theory 87: 194 - 217.

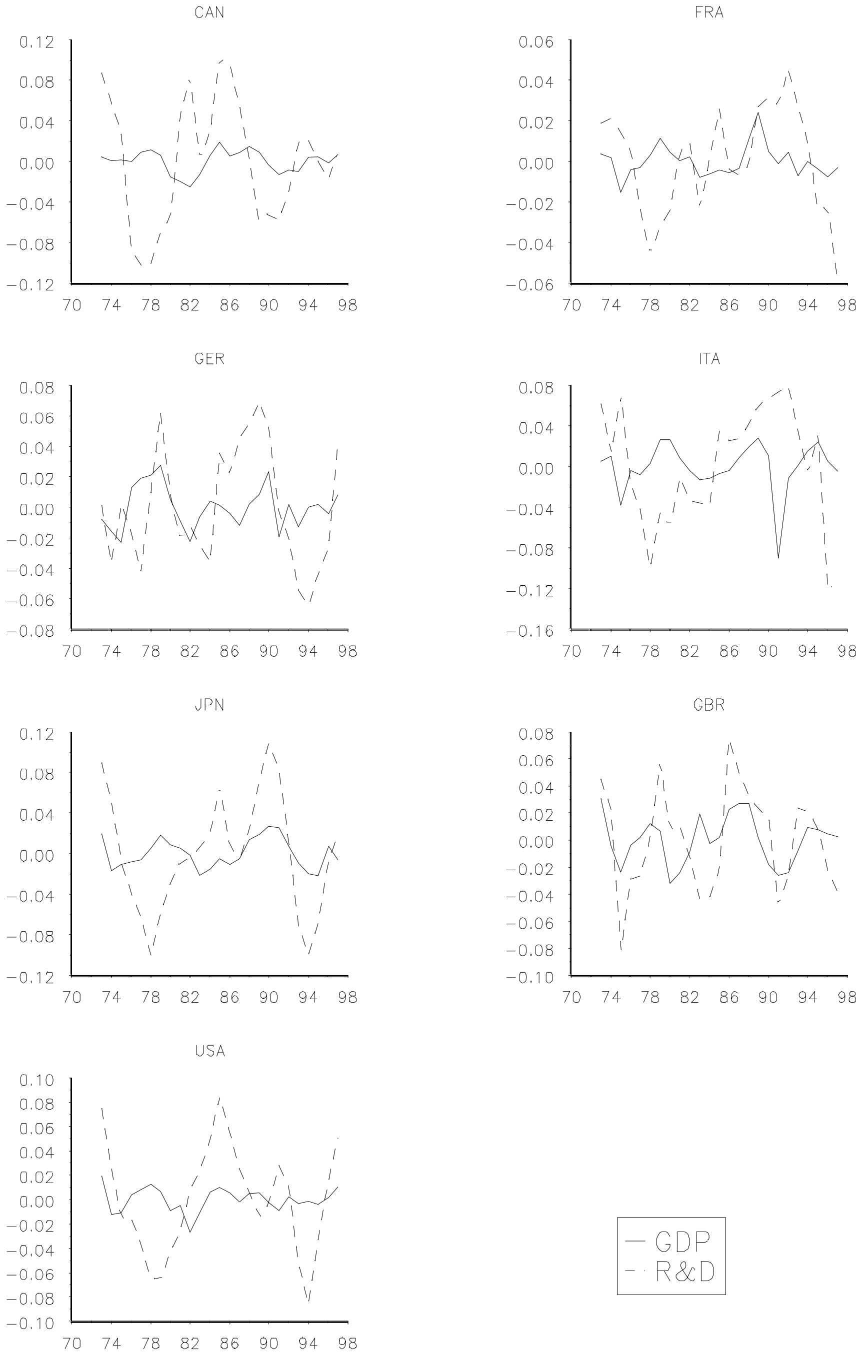

Figure 1: Cyclical components of per-capita GDP and per-capita R&D expenditure (using the HP filter with $\lambda = 100$)