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Stylized Facts and International Business Cycles -

The German Case

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Abstract

This paper studies the business cycle in Germany using the HP-filter (Hodrick/Prescott (1997)) to isolate the cyclical component. A two-country International Business Cycle model in line with Baxter/Crucini (1995) is built to explain these facts. The combination of GHH-preferences with taste shocks resulting from government consumption is shown to be an important feature of the German business cycle. A VAR model for the exogenous variables is estimated that enables the model not only to account well for the observed positive international correlations of outputs, consumptions and savings but also for their lead-lag relationship. Hours worked and investments are positively correlated in this model - a property not realized in other single-good models of the International Business Cycle in the literature.

JEL classification: E32, F41

Keywords: International Real Business Cycles; Stylized Facts; GHH-preferences

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1 Introduction

The theoretical analysis of the international business cycle was pioneered by Dellas (1986) and Cantor/Mark (1987) in the tradition of the Real Business Cycle school. This work has initiated a vivid body of research which focused primarily on the explanation of the US and its relation to Europe or the remaining G7 countries. Simultaneously much effort has been devoted to the description of the business cycle, that is to the establishment of stylized facts. Only in recent years some authors have analyzed the development in European countries. The study of Christodoulakis/Demelis/Kollintzas (1995) can serve as an example here. Unfortunately very few studies try to develop country specific models and to obtain stylized facts at the same time in a unified framework for European countries.[1] The present paper wants to serve as a contribution to this research area.

In section 2 stylized facts for Germany are derived using the Hodrick/Prescott (1997)-filter widely employed in the literature. Section 3 presents a single-good, two-country model in line with Baxter/Crucini (1995) to account for the German business cycle. The model is modified with respect to the utility function and the exogenous forcing processes for technology and government consumption. Government consumption is allowed to act like a taste shock through the possibility to be a substitute for private consumption. The model is calibrated to German data and the standard deviations and cross correlations are compared to the empirical results. It is shown that the lead-lag structure can be replicated quite well. Investment and hours worked are positively correlated internationally. The consumption correlation is well below unity and the output correlation is positive but still below the consumption correlation so that the quantity anomaly cannot be resolved. Impulse response functions give a graphical interpretation and clarification for this result. They reveal that the strong spillover effect of US technology shocks to Germany is of significant importance for the explanation of the lead-lag structure. Section 4 contains some conclusions and suggestions for future research.

2 Stylized Facts of the German Business Cycle

Before evaluating the performance of a Real Business Cycle model the data has to be analyzed. I will restrict the analysis to the German economy which has already been studied by Brandner/Neusser (1992). Here special attention is given to the transformation of the data. In order to compare correctly the implications of the model with the data the variables have to be treated equally, as far as it is possible. Elimination of a linear trend in the model requires to detrend the data linearly as well. The formulation of the model in per capita terms implies to look

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1 In Hénin (1995) there are two papers that deal explicitly with the French business cycle. Harjes (1997) is looking at the German economy while Lundvik (1992a,b) analyzes Swedish data. See Correia/Neves/Rebelo (1992,1995) for an analysis of the Portuguese economy.

at the respective empirical per capita terms. Moreover it is important to consider lead-lag relationships and not only the contemporaneous correlations as is frequently done in the literature. Many international correlations do not peak at lag zero but show significant lead of some aggregates over the other country's variable. Only few papers can be used to compare the results of such an analysis: Reynolds (1992) and Zimmermann (1997) are notable exceptions. In the next two subsections I will present results for Germany and for the business cycles between Germany and the US. The US is considered because it is the country that can be best regarded as the rest of the world even though it is not a major trading partner of Germany.

2.1 Business Cycles in Germany

As the detailed analysis of Canova (1998) has shown business cycle facts depend heavily on the way the business cycle component is extracted. For the sake of brevity I will not present results here for the case of extracting only a common linear trend from the time series under study.[2] In some cases I will depart from the literature in calculating the relevant macroeconomic aggregates. The filter used will be the HP-filter as to preserve comparability with the literature where possible.

I study quarterly data taken in most cases from the Deutsche Bundesbank.[3] Output, consumption, investment and savings are all divided by the population size to get per capita variables. In order to have a proper measure for hours worked one has to take into account both the time worked per day and per employed person as well as the size of the population. The relevant concept for hours worked in the model is hours worked per capita so that one has to multiply hours worked daily by total employees and to divide by the population size. This procedure is also suggested by King/Plosser/Rebelo (1988a). Concerning the trade balance I follow the literature regarding the ratio of the difference between exports and imports to GNP, but - and in this respect deviating from other studies - for real variables because the model will be formulated for real terms. There is hardly any justification for the use of nominal trade variables.

Table 2.1 contains the results for the cyclical components.[4] In accord with many other studies consumption $(\hat{c})$ is less volatile than output $(\hat{y})$ while investment $(\hat{\imath})$ is more volatile. Hours per capita $\hat{N}$ fluctuate about half as much as output whereas the real wage $\hat{w}$ shows a similar volatility as consumption. Savings $\hat{s}$ which are defined as output minus consumption (private plus government consumption) are the most volatile aggregate. For the trade balance a relative

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2 Extracting a common linear time trend implies some very strange results, e.g. that consumption is more volatile than output and that investment is lagging countercyclically.

3 A detailed list of the series can be found in the appendix. The data covers the period 1968:1 - 1991:1. The sample selection is due to the German Unification: Data for (old) West Germany end in 1991.

4 The HP-filter was used with $\lambda = 1600$.

standard deviation cannot be computed because of the lack of comparability: $(tb_t/y_t)-(\overline{tb/y})$ measures the absolute deviation of the trade balance to output ratio from its mean whereas $\hat{y}$ is the relative deviation of output per capita from its mean $(\hat{y}=(y_t-y)/y)$. Output, investment and the trade balance show similar autocorrelation patterns as well as consumption and the real wage do. Hours worked show the strongest persistence, savings the weakest. Consumption, investment and savings are strongly procyclical. Hours worked are procyclical and lag output one quarter (0.70) while the trade balance leads countercyclically with three quarters (-0.37).[5] The real wage seems to be uncorrelated with output. Closer inspection reveals a lag of six quarters (0.52), a fact usually not recognized when restricting the analysis to only one or two leads or lags.

The paper of Brandner/Neusser (1992) is closest to the analysis undertaken here. They also consider per capita aggregates. Consumption fluctuates exactly as much as is indicated in table 2.1 and shows an almost identical autocorrelation and cross correlation with output. Their sample range is similar the one employed here: 1960:1 - 1989:4, DIW data. Smeets (1992) gets a leading consumer real wage which is contemporaneously positively correlated with output. In fact he doubts the existence of a positive correlation between real wages and output (sample range 1962 - 1988). Fiorito/Kollintzas (1994) use OECD data and experience a negative contemporaneous correlation between the manufacturing real wage and output. Closer inspection of their table 5 (p. 256), however, reveals that one could also see a tendency for the real wage to lead countercyclically (four lags, -0.26) as well as to lag procyclically (five quarters, 0.25).

It should be pointed out that hours worked per capita are not constant in Germany. Due to the steady decline in average employee hours worked per day hours per capita show a negative trend over the sample range. Fitting a linear trend reveals a decline of about 0.7 % per year. The assumption of constancy of N in many models along the lines of King/Plosser/Rebelo (1988a,b) is - taken seriously - false for the German case. Nevertheless the assumption will be maintained in the model presented in section 3.

In the US all variables except the trade balance and consumption show a higher absolute standard deviation. Relative to output savings and investment fluctuate more and consumption less than the German aggregates. All variables are more persistent in comparison to Germany. Consumption, investment and savings are significantly stronger correlated with output in the US. Hours worked are procyclical without any lag while the real wage is leading procyclically, not lagging. The differences with respect to the labor market may be due to institutional factors while more persistent technology shocks are likely to be the cause for higher auto- and cross correlations in the US.

5 Blackburn/Ravn (1991) also detect a leading trade balance with three quarters (-0.54) and a similar standard deviation (1.05 %). In Reynolds (1992) the trade balance leads countercyclically with two quarters (-0.33).

2.2 International Cycles between Germany and the US

In order to analyze the international business cycles between Germany and the US a similar analysis of the US business cycle has to be undertaken.[6] The sample range is the same as the one for Germany to have two equally sized samples. I use the Citibase series for total consumption as there is no differentiation in the model between different types of consumption and as there are no such data in Germany.[7] The same holds for investment. The calculation of the trade balance to output ratio as well as hours worked are conducted in the same manner as in the German case.

As pointed out before special interest is given to the lead-lag relationship of the variables. Further efforts concern the description of the labor market and the saving-investment correlation.

Table 2.2 depicts the results for the respective correlations. Inspecting the table one quickly recognizes the peculiarities of the German business cycle vis-à-vis the US. German output lags one quarter US output with a correlation of 0.67 whereas German investment leads one quarter (0.43). Consumption covaries contemporaneously with US consumption (0.55) and hours worked even lag two quarters behind the US (0.61). Savings show the same pattern as outputs with a slightly reduced correlation. The behavior of real wages and the trade balance is strange and cannot be detected from table 2.2 alone. Whereas real wages seem to be uncorrelated they show the highest correlation (0.35) at a lead of 26 quarters for the German wage. The German trade balance seems to lead 26 quarters with a correlation of 0.57.

The graphs of the cyclical components in figure 2.1 rather suggest no relationship for real wages and the trade balance. But the lagging character for German output and hours can be well detected.

Savings and investment are more highly correlated in the US (0.92) than in Germany (0.51). Here the highest correlation occurs at lag zero. There is no clear cut pattern for the real wage in Germany: There seems to be a tendency to lag 13 quarters countercyclically (-0.52) behind hours worked whereas in the US it shows a lead of three quarters (0.74).

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6 A detailed description will not be presented here. See the above paragraph for a short comparison of the results with the German data. Studies of the US business cycle itself which come closest to the procedure used here are those of Kydland/Prescott (1990) and Huffman (1994). It should be taken in mind that these authors do not use per capita data. But they employ the same data source (Citibase).

7 See the appendix for a complete list of the data used. Some authors propose to calculate the flow of services from the consumption of durable goods and to add this component to consumption of nondurables to arrive at a proper measure of total consumption in the data. I do not follow this procedure because the measure of consumption in the model should be interpreted as total consumption without differentiating consumption categories.

Reynolds (1992) also studies the business cycle between Germany and the US. She gets a correlation of 0.66 at one lag between the outputs and 0.57 at one lead for investment giving support to the above results. Zimmermann (1997) reports a lag of US output behind the German one (0.41) and a lead of US consumption of five quarters (0.22), contradicting my results.[8] For investment he does not report correlations at leads or lags and gets a contemporaneous correlation of 0.31.

Blackburn/Ravn (1991) also document a stronger correlation between savings and investment in the US than in Germany. Zimmermann (1997) has a similar result. Perhaps this is a consequence of the greater openness of the German economy. Results for the labor market are difficult to compare because the authors use aggregated hours series or employment. Brandner/Neusser (1992) get a correlation of 0.66 between the real wage and the number of employed persons. When using total hours worked the correlation drops to 0.60. Danthine/Donaldson (1993) use IMF data (1957:1 - 1989:4) which results in a correlation of 0.29 for Germany. Due to the fact that there are no studies calculating correlations between the real wage and hours worked **per capita** it is of special interest whether the model to be presented in the next section can account for the peculiarities of these correlations in the data.

3 A Two-Country Model

In this section a two-country, single-good model along the lines of Baxter/Crucini (1995) is developed and used to explain the German business cycle. Few attempts have been made to construct a RBC model for Germany (the paper of Harjes (1997) is an exception). I have experimented with many different model versions. Here only the version with the best fit of the facts will be exposed. The superiority will be motivated at several stages in subsection 3.3.

3.1 The Model

The world consists of two equally sized countries which are populated by a large number of identical households so that one can restrict the analysis to representative agents. Both countries produce the same good. Households maximize their respective live-time utilities which are given in (3.1) and (3.2):

$$(3.1)\quad U = E_0\left[\sum_{t=0}^{\infty}\beta^t\,\frac{\left[C_t^p + \zeta G_t - \psi X_t N_t^{\nu}\right]^{1-\sigma} - 1}{1-\sigma}\right],\quad \nu > 1,\ \psi,\sigma > 0$$

[8] Note that Zimmermann (1997) does not use per capita data.

$$(3.2)\quad U^{*}=E_{0}\left[\sum_{t=0}^{\infty}\beta^{*t}\frac{\left[C_{t}^{p^{*}}+\zeta^{*}G_{t}^{*}-\psi^{*}X_{t}^{*}\left(N_{t}^{*}\right)^{\nu^{*}}\right]^{1-\sigma^{*}}-1}{1-\sigma^{*}}\right],\ \nu^{*}>1,\ \psi^{*},\sigma^{*}>0$$

As before, a star denotes US variables. The utility functions take the form that was originally proposed by Greenwood/Hercowitz/Huffman (1988) in a closed economy setting and which have been labeled GHH-preferences by Correia/Neves/Rebelo (1995). These authors use a variant of this function in a small open economy model. Devereux/Gregory/Smith (1992) used it first in an international RBC model to explain the observed lower than output consumption correlations. Here it is combined with a special form of taste shocks through government consumption as in Bec (1995) and Roche (1996). This combination together with stochastic exogenous government consumption is new to the literature.[9]

C_t^p denotes private consumption and G_t government consumption. It is assumed that the household's total consumption is given by the sum of C_t^p and a share ζ of G_t:

$$(3.3)\quad C_t = C_t^p + \zeta G_t$$

The higher ζ the better private and government consumption can be substituted. ζ is likely to be zero for pure public goods and close to one for libraries, hospitals and school lunches because these goods could be easily provided privately. According to Barro (1981) ζ lies between zero and one whereas Graham (1993) also gets negative values.

σ governs the intertemporal elasticity of substitution or the degree of risk aversion. N_t represents hours worked and is multiplied by the labor augmenting technical progress X_t.[10] β is the discount factor and ψ, ν are parameters. The same applies to the star-parameters.

The total amount of time is normalized to one so that the sum of leisure L_t and N_t cannot exceed one:

$$(3.4)\quad 1 - L_t - N_t = 0$$

$$(3.5)\quad 1 - L_t^* - N_t^* = 0$$

Production technologies are Cobb-Douglas in both countries influenced by exogenous technology shocks A_t, A_t^*:

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9 Harjes (1997) studies a similar function, but does not allow for stochastic government consumption. Furthermore he develops a so called semi-small open economy instead of a two-country model.

10 This formulation guaranties the compatibility of the utility function with steady state growth.

(3.6) $Y_t = A_t K_t^{1-\alpha} (N_t X_t)^{\alpha}$, $0 < \alpha < 1$

(3.7) $Y_t^* = A_t^* (K_t^*)^{1-\alpha^*} (N_t^* X_t^*)^{\alpha^*}$, $0 < \alpha^* < 1$

with K_t capital stock, Y_t output and α as labor's share.

In contrast to labor new capital is international mobile. The capital stock is costly to adjust which is modeled with the help of an adjustment cost function ϕ originally proposed by Baxter/Crucini (1993).

(3.8) $K_{t+1} = \phi\left(\frac{I_t}{K_t}\right) K_t + (1-\delta) K_t$, $0 < \delta < 1$

(3.9) $K_{t+1}^* = \phi^*\left(\frac{I_t^*}{K_t^*}\right) K_t^* + (1-\delta^*) K_t^*$, $0 < \delta^* < 1$

ϕ need not be directly specified. It suffices to determine its behavior in the steady state. In particular it is assumed that the model with and without adjustment costs yields the same steady state. This determines ϕ and ϕ'. A third parameter needed is the elasticity of Tobin's q[11] with respect to the investment to capital ratio I/K.[12] The parameters will be discussed when calibrating the model. δ denotes the depreciation rate.

Budgets must be balanced so that taxes are equal to government consumption.

(3.10) $\tau Y_t = G_t$, $0 < \tau < 1$

(3.11) $\tau^* Y_t^* = G_t^*$, $0 < \tau^* < 1$

There are no transfers to households as in Baxter (1992). Moreover tax rates τ, τ^* are constant.

Two possible market structures can be analyzed. Baxter/Crucini (1995) call them complete and incomplete markets. Since the case of incomplete markets comes closest to match the stylized facts it will be presented here.

Incomplete markets means that households can only trade noncontingent bonds and not all types of assets. This amounts to model the evolution of bonds B_t and therefore the trade balance TB_t explicitly.

The resource constraints for output are

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11 It can be shown that $q = 1/\phi'$.

12 This elasticity is $\xi = [\partial(1/\phi')/\partial(I/K)] \cdot [(I/K)/(1/\phi')]$.

$$(3.12)\quad Y_t = C_t^p + I_t + G_t + TB_t$$

$$(3.13)\quad Y_t^* = C_t^{p^*} + I_t^* + G_t^* + TB_t^*$$

where

$$(3.14)\quad TB_t = B_t - (1+r_{t-1})B_{t-1} \text{ and } TB_t^* = B_t^* - (1+r_{t-1})B_{t-1}^*$$

are the corresponding equations for the trade balance. r_t is the world interest rate which will be determined endogenously.

The model is solved using the algorithm of King/Plosser/Rebelo (1990). For this purpose all variables except hours worked are divided by the deterministic technical progress X_t. As in Baxter/Crucini (1995) bond holdings of the home country (Germany) will be eliminated as a state variable because the world bond market must clear in equilibrium.

$$(3.15)\quad \pi B_t + (1-\pi)B_t^* = 0$$

π denotes the size of the home country. The optimum conditions for bond holdings can be used to eliminate the interest rate.

3.2 Steady State and Calibration

Restricting trade to bonds alone leads to certain types of asymmetries in the model. This is mainly due to the inclusion of the steady state ratio of the trade balance to output tb/y. So the question arises as to whether it is possible to model two asymmetric countries. Baxter's (1995) statement clearly points in this direction: "For an application to particular countries, one would of course wish to calibrate the two countries differently, so that each matched the long-run features of a specific economy." But unfortunately such a country specific calibration cannot be done in this model. The reasons are both theoretical and empirical.

Different types of deterministic technical progress $X_t \neq X_t^*$ in the model require to have information about X_t^*/X_t at the steady state. But as X_t^* and X_t grow at different rates, this ratio is not constant. It will either grow without bounds or converge to zero. So there is no theoretical steady state value for the ratio which is needed in one of the Taylor approximations of the optimality conditions. Empirically X_t grows faster than X_t^* so that the ratio converges to zero in the long run. Allowing for different labor shares α, α^* implies different steady state outputs y, y^*.[13] Taylor approximations need information on y^*/y - the ratio of the outputs at the steady state - that can only be obtained from the output data series. Theoretically this ratio is constant, as the linear trends $X_t = X_t^*$ have already been removed. But empirically y^*/y declines because

[13] Small variables denote "detrended" variables: $y = y/X$, $y^* = y^*/X$ etc.

X_t^*/X_t declines. In order not to produce counterfactual implications one has to assume equal labor shares $\alpha = \alpha^*$.

Nevertheless certain asymmetries can arise. Calculating (3.15) at the steady state determines the bond holdings to output ratio b/y.

$$(3.16)\quad \frac{b}{y} = -\frac{(1-\pi)}{\pi}\frac{b^*}{y^*}$$

This can be used to pin down the trade balance to output ratio tb/y (see (3.14))

$$(3.17)\quad \frac{tb}{y} = \frac{\gamma_X - 1 - r}{\gamma_X}\frac{b}{y} \qquad \frac{tb^*}{y^*} = \frac{\gamma_X - 1 - r}{\gamma_X}\frac{b^*}{y^*}$$

whereas the resource constraints (3.12), (3.13) imply

$$(3.18)\quad \frac{c^p}{y} = 1 - \frac{i}{y} - \frac{tb}{y} - \frac{g}{y} \qquad \frac{c^{p^*}}{y^*} = 1 - \frac{i^*}{y^*} - \frac{tb^*}{y^*} - \frac{g^*}{y^*}$$

Finally for the investment to output ratio the efficiency conditions reveal that

$$(3.19)\quad \frac{i}{y} = \frac{(\gamma_X - 1 + \delta)(1-\tau)(1-\alpha)}{r+\delta} \qquad \frac{i^*}{y^*} = \frac{(\gamma_X - 1 + \delta)(1-\tau^*)(1-\alpha)}{r+\delta}$$

The steady state ratio of government consumption to output is set to 0.1953 for Germany which equals the average of that ratio over the sample range. At the same time this determines the tax rate τ. For the US the respective values are $g^*/y^* = \tau^* = 0.1991$. It is assumed that the depreciation rates as well as the adjustment cost functions are equal: $\delta = \delta^*$, $\phi = \phi^*$.[14] Therefore the investment to capital ratios are the same: $i/k = i^*/k^* = \gamma_X - 1 + \delta = 0.0304$. The trade balance to output ratio tb/y shows an empirical value of 0.01004 in Germany.[15] In order to have equal per capita wealth in the two countries at the steady state this ratio (or the bond ratio respectively) is set to zero. This causes $tb/y = tb^*/y^* = 0$ as well as $b^*/y^* = b/y = 0$. But $c^p/y = 0.5499$ and $c^{p^*}/y^* = 0.5473$ as well as $i/y = 0.2548$ and $i^*/y^* = 0.2536$ are different due to country specific government consumption and tax rates.

[14] It is difficult to calculate the depreciation rate from the data because there are no capital stock series. There is no empirical information about the adjustment cost functions either.

[15] It is easier to determine this ratio than the one between bond holdings and output.

The preference parameters ν, ν^* are set equal to 1.7 as in Greenwood/Hercowitz/Huffman (1988). According to Aschauer (1985) and in line with Bec (1995) and Roche (1996) ζ, ζ^* are chosen to be 1/3. The parameters which govern the degree of risk aversion, σ, σ^*, are set to one, in contrast to Correia/Neves/Rebelo (1995) who use a value of 2. The use of equal preference parameters in the two countries is due to the lack of empirical counterparts. Moreover specific estimates of these parameters for Germany do not exist.

Because the preference parameters ψ, ψ^* cannot be determined empirically either steady state hours worked N, N^* are specified to be 0.20 in both countries and the corresponding optimality conditions are used to pin down ψ, ψ^*.[16]

$$(3.20)\quad \psi = \frac{\alpha}{\nu}\left(\frac{(1-\alpha)(1-\tau)}{r+\delta}\right)^{\frac{1-\alpha}{\alpha}} N^{1-\nu} = 5.40 \quad \psi^* = \frac{\alpha}{\nu}\left(\frac{(1-\alpha)(1-\tau^*)}{r+\delta}\right)^{\frac{1-\alpha}{\alpha}} N^{*1-\nu} = 5.38$$

The common growth factor of consumption, output, investment, savings and the real wage $\gamma_X = X_{t+1}/X_t$ equals 1.0054 for Germany which implies a growth rate of 2.2 % per year. Labor's share α shows an average of 0.56 over the sample range whereas for the depreciation rate δ the value of 0.025 employed in the literature is used.[17] The elasticity of Tobin's q with respect to the investment to capital ratio ξ is set to 1/15 according to the value chosen in Baxter/Crucini (1995).[18] ϕ and ϕ' equal $i/k = \gamma_X - (1-\delta)$ at the steady state and can thus be determined endogenously. The steady state world interest rate r is computed using Standard and Poor's 500 index and equals 6.9 % per year. This value is well in line with the literature (see Correia/Neves/Rebelo (1992)) and implies a value of 0.9884 for the discount factor $\beta = \beta^*$. Both countries are assumed to be equally sized $(\pi = 0.5)$.

There are several methods in the literature used to estimate the exogenous processes for technology and government consumption. Before doing that the relevant variables have to be determined.

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16 Empirically hours worked per capita are only 12 % of total time in Germany whereas in the US it is 23 % $(N^* = 0.23)$. Model results are not sensitive with respect to this difference since one can completely eliminate N, N^* and ψ, ψ^* from the Taylor approximations.

17 The value for α may seem to be very small. But an analysis of the data for other European countries in the period under study yields similar values. Moreover the compensation of employees is not corrected by special types of income that are normally accrued to proprietors' income but that are essentially a form of compensation of employees.

18 Model results are sensitive to this value.

Technology shocks can be identified with A_t, A_t^*, the factors augmenting total factor productivity. With Cobb-Douglas production functions they can be interpreted as Solow residuals and hence are that part of output growth that cannot be accounted for by the growth of labor and capital. Because data on capital stocks are not available or have to be constructed using investment series I will ignore the capital stock when computing the residuals. So Solow residuals are given by

$$(3.21)\quad \ln A_t = \ln y_t - \alpha \ln N_t$$

where y_t is - as mentioned above - the detrended output series. In a second step the series $\ln A_t$ is HP-filtered. This method differs from the one of Backus/Kehoe/Kydland (1992) who just look at the logarithms of the variables without filtering the resulting component. Moreover y_t and N_t are the same series used in the empirical analysis and not aggregate employment or total hours worked or aggregate output as in Backus/Kehoe/Kydland (1992). The concept of the Solow residuals is given a "within the model interpretation". The HP-filter removes a lot of low frequency variation from the series so that the persistence will be much lower in comparison to results of these authors.

Cyclical government consumptions are easier to compute because the series are directly measured and need not be derived as a residual. They are obtained after HP-filtering the logarithms of the series.

Given the respective series for Germany and the US a VAR (1) model is fitted to the data. This was also done by Roche (1996) in a sensitivity analysis using data for the US and an aggregate of the remaining G7 countries. But he did not use this estimation in his model simulations. Here - and this is new to the literature - the estimated VAR (1) model is considered as the correctest estimate for the driving processes. It will neither be symmetrized as in Backus/Kehoe/Kydland (1992) or in Ravn (1997) nor will the variances of the noise terms be normalized to one as in Baxter/Crucini (1995). It will be shown that the model with the "true" exogenous processes as estimated from the data yields the best explanation of the stylized facts.

The estimation of the VAR model yields the following result:

$$(3.22)\quad \begin{bmatrix} \hat{A}_t \\ \hat{A}_t^* \\ \hat{g}_t \\ \hat{g}_t^* \end{bmatrix} = \begin{bmatrix} \underset{(0.0853)}{0.2774} & \underset{(0.1072)}{0.6066} & \underset{(0.0715)}{-0.1717} & \underset{(0.0918)}{0.0882} \\ \underset{(0.0704)}{0.0674} & \underset{(0.0885)}{0.6793} & \underset{(0.0590)}{0.0010} & \underset{(0.0758)}{-0.0887} \\ \underset{(0.1244)}{0.0785} & \underset{(0.1563)}{0.0405} & \underset{(0.1043)}{0.1585} & \underset{(0.1339)}{0.4599} \\ \underset{(0.0711)}{-0.0180} & \underset{(0.0893)}{-0.0209} & \underset{(0.0595)}{-0.0249} & \underset{(0.0765)}{0.7561} \end{bmatrix} \begin{bmatrix} \hat{A}_{t-1} \\ \hat{A}_{t-1}^* \\ \hat{g}_{t-1} \\ \hat{g}_{t-1}^* \end{bmatrix} + \begin{bmatrix} \varepsilon_{\hat{A},t} \\ \varepsilon_{\hat{A}^*,t} \\ \varepsilon_{\hat{g},t} \\ \varepsilon_{\hat{g}^*,t} \end{bmatrix}$$

$$\text{with } \psi_{\hat{A},\hat{A}^*,\hat{g},\hat{g}^*} = \begin{bmatrix} 0.00007256 & 0 & 0 & 0 \\ 0 & 0.00004943 & 0 & 0 \\ 0 & 0 & 0.00015421 & 0 \\ 0 & 0 & 0 & 0.00005029 \end{bmatrix}$$

The numbers in brackets denote standard errors. The ε's are the noise terms and $\psi_{\hat{A},\hat{A}^*,\hat{g},\hat{g}^*}$ is the variance-covariance matrix. All coefficients which are not significantly different from zero at a 10 % level are considered to be zero.[19] So the variables in the US follow pure AR (1) processes. The German technology process shows the same structure as that in Roche (1996). But there are no significant negative spillovers from German to US government consumption. German technology worsens due to a rise in German government expansion (-0.1717) and the German technology experiences a significant positive spillover from the US (0.6066). This result confirms findings of Elliot/Fatás (1996). They show that European and Japanese shocks are mainly country specific without any significant effects on the US. But US shocks are the driving force behind the strong technological spillovers to Europe and Japan. The high persistence of consumption and investment and their strong correlation with output in the US can be explained by the stronger persistence of the technology shock. The coefficient is more than twice as high as the value in Germany (0.6793 vs. 0.2774). The variance of the US technology shock is smaller than the one in Backus/Kehoe/Kydland (1992) while that for Germany is higher than the one for the European aggregate so that the effect on the variability of the model aggregates is ambiguous. All off-diagonal elements in the variance-covariance matrix are set to zero in order to avoid problems later when computing impulse response functions. It must be mentioned that these coefficients are not equal to zero in the estimated VAR.[20] In contrast to Roche (1996) there are positive correlations between all noise terms, even between the fiscal ones. The technology noise terms have a correlation of 0.125, about have as high as the one in Baxter/Crucini (1995).

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[19] An exception is the value 0.1585. Setting this coefficient to zero would imply that German cyclical government consumption is not influenced by the previous period's value which seems implausible.

[20] From an econometric point of view the variance-covariance matrix must be diagonal in order to be able to compute reasonable impulse response functions later on in the model. Here the matrix has been made diagonal by simply setting the elements equal to zero without calculating a Choleski factorization. The use of diagonal variance-covariance matrices is not standard in the IRBC literature: Both Baxter/Crucini (1995) as well as Backus/Kehoe/Kydland (1992) allow for correlated innovations of the shocks and nevertheless compute impulse responses in the model. It is not clear whether this is a valid procedure that produces reasonable results.

3.3 Business Cycle Implications

As mentioned above the model is solved using the King/Plosser/Rebelo (1990) algorithm. The moments of the variables are computed with the help of Parseval's theorem in the frequency domain which allows for an "exact" computation in contrast to the solution one obtains after simulating the model several times and using the averages over the simulations. Because of the asymmetries different business cycle implications arise for the US and Germany. As the focus is on Germany only these results are reported in table 3.1.

The standard deviation of output matches exactly the empirical counterpart. In Zimmermann (1994) the volatility of output is higher in the model than in the data. The other standard deviations fall short the empirical ones, except hours worked. The relative volatility of hours worked comes closest to reality (0.59 vs. 0.57) while consumption is not volatile enough. Especially investment and savings display a too low absolute and relative variability. The real wage as well as the trade balance show only half of the empirical relative standard deviation.

Due to the GHH-preferences the processes for output, hours worked and the real wage depend only on the German capital stock and German technology shock so that they are perfectly correlated and differ only with respect to their variability. Consumption and savings are too strongly correlated with output while investment lies within the neighborhood of the empirical value. All variables including the trade balance are procyclical and show no lead or lag. This result misses especially the countercyclical lead of the latter and the behavior of the real wage which is lagging six quarters empirically. The lagging character of hours worked cannot be replicated either. The autocorrelations are all too low due to the low degree of persistence of the exogenous processes.

The behavior of the trade balance is very sensitive with regard to the elasticity of Tobin's q ξ. A value of 1/120 can generate a negative contemporaneous correlation with output.

Using standard preferences as in Baxter/Crucini (1995) without taste shocks the relative volatility of consumption drops to 0.16. Savings become perfectly correlated with output (1.00) while at the same time hours worked and the real wage are also nearly perfectly correlated with output (0.99, 0.97). The autocorrelation pattern is very similar to the one under GHH-preferences.

In a variant of the model with transitory technology and government spending shocks and common shock variances and spillovers across countries consumption fluctuates more than output while the trade balance is only weakly correlated with output (0.37). Both model variants are not able to produce a better explanation of the data. Especially they do not match the labor market regularities and cannot explain the leading countercyclical trade balance. Government shocks alone are not only unable to explain the variability of the aggregates in this kind of model but also cannot replicate the auto- and cross correlation patterns of the data either. They can only be added to technology shocks to improve upon the model outcome.

As already shown by Devereux/Gregory/Smith (1992) in a model with 100 % depreciation of capital, GHH-preferences cause more severe differences concerning international correlations. The results are presented in table 3.2.

The model can quite well replicate the empirical lag of German output behind US output with a remarkable correlation of 0.53. The correlation of consumption is well below unity (0.60). Hours worked are positively correlated: German hours worked lag one quarter (0.53) while empirically they lag two quarters. The model produces strongly positively correlated investments (0.99) and savings (0.49) where the latter even match exactly the empirical lag of one quarter. The acyclical behavior of the trade balance and real wages cannot be replicated. Due to the two-country structure of the model the trade balances are perfectly negatively correlated. The saving-investment correlation is counterfactually stronger in Germany (0.83) than in the US (0.65). The perfect correlation between hours worked and the real wage is due to the GHH utility function and preserves the model from improving upon the explanation of the labor market.

Considering the model results under standard preferences without taste shocks reveals that consumptions are perfectly correlated. The correlation of outputs is substantially smaller (0.31) and hours worked are negatively correlated (-0.33). So the main improvement due to GHH-preferences is to substantially reduce the consumption correlation and to produce comoving hours worked as in the data.

In the model variant with symmetric shock variances and spillovers across countries investments are essentially uncorrelated (0.03), savings are negatively correlated (-0.35) and the consumption correlation is higher (0.77) while outputs are correlated weaker (0.30). All these correlations peak at zero lag. This leads to the following conclusions: First, the lead-lag structure of the correlations in table 3.2 is caused by the asymmetric VAR model for technology and government spending shocks. This strongly supports the methodology to estimate the "true" dynamic structure of these shocks from the data and not to use symmetric benchmark simulations. Second, a positive investment correlation can only be achieved when there are strong spillovers from the US technology to the German technology. This is exactly the case here (see the discussion of equation (3.22)).

Considering another variant of the model with permanent shocks, but without spillovers (as Baxter/Crucini (1995) did in their model under standard preferences, but with GHH-preferences and taste shocks here) strengthens the difficulty of generating a positive investment correlation. In this model the correlation is highly negative (-0.90). Moreover outputs and hours worked are hardly positively correlated (0.11). This further underpins the proposed VAR model.

The main contribution of fiscal shocks acting as taste shocks in conjunction with GHH-preferences is a better description of the behavior of consumption. Its variability increases and the correlation with output decreases relative to a model without this feature. This decrease corrects for the counterfactual perfect correlation that would result if only GHH-preferences were considered. The most important improvement is a further reduction of the international consumption correlation which brings the model more in line with the data.[21]

Unfortunately the model cannot replicate the correct lead-lag structure of consumption and investment. In the model the German aggregates lag one quarter behind the US while empirically consumptions covary contemporaneously and investment leads one quarter. Hours worked lag two quarters in the data and only one quarter in the model. The higher saving-investment correlation in Germany is a result of equal steady state outputs $y = y^*$. Allowing them to be different results in a smaller correlation in Germany than in the US, just as in the data. The model fails to match the correct ranking of the international correlations - as all other single-good models in the literature. The "quantity anomaly" (Backus/Kehoe/Kydland (1995)) remains unresolved.

The dominance of this model over all other types analyzed is established through its ability to match the lead-lag structure of output and savings as well as to produce strongly positive international output, savings, investment and hours worked correlations. This has not been achieved by any other single-good model in the literature.

3.4 Impulse Response Functions

Impulse response functions allow for a deeper analysis of the dynamic reactions to a one percent exogenous technology or government shock. Figure 3.1 shows the impulse responses of the variables due to a one percent German technology shock.

There are no spillovers from German to American technology so $\hat{A}^*$ remains zero all the time. Due to the small AR coefficient the effects are not very long lasting. They die out quite quickly. Output, hours worked and real wages show an identical reaction and differ only with respect to the intensity of the initial response. Because there is no direct influence of German technology shocks on these US variables the initial reaction is zero. The positive response after a few quarters is due to the strong correlation between investment in both countries influencing the evolution of the capital stocks. Foreign consumption reacts positively but not as strong as home consumption thus being positively but less than perfectly correlated. US savings and the trade balance are the only aggregates that decline in response to the shock. Nevertheless savings are positively correlated. It should be noted that savings, trade balances and consumptions diverge in their consecutive reaction whereas the other variables reach their old steady state values. This is a consequence of the well known characteristic that models with restricted (=incomplete) markets

21 Interestingly, the correlation of total consumption $\left(\hat{c}, \hat{c}^*\right)$ is lower than the private consumption $\left(\hat{c}^p, \hat{c}^{p^*}\right)$ correlation for lags of German consumption. Otherwise it is higher. This contrasts results in Bec (1995) who finds higher correlations.

show up an instability of bond holdings that carries over to the above mentioned aggregates although the exogenous processes are stationary.[22]

Fiscal shocks have a negative impact on German technology but no effect on US government consumption. This special dynamic structure carries over to the aggregates and shows up in a specific reaction of the German variables. Figure 3.2 displays the impulse response functions which evolve after a one percent fiscal shock in Germany.

The graph for $\hat{g}, \hat{g}^*$ is omitted because it resembles very much that of $\hat{A}, \hat{A}^*$ in figure 3.1. Instead the response of $\hat{A}, \hat{A}^*$ is shown: as mentioned above, technology follows an AR (1) process in the US so there is no reaction of $\hat{A}^*$. Initially $\hat{A}$ responds negatively but this reaction is even strengthened through the spillover from the fiscal shock resulting in the strongest reaction in period 2 after the shock. This basic structure is inherited by all other home aggregates. It must be mentioned that the strength of the initial fiscal shock is not very high; only investment and savings display a remarkable response of about -0.3 and -0.5 respectively.[23] But the effect is strongly amplified via the negative impact on technology. For the foreign output, hours worked and real wage there is no initial reaction that slowly gets negative due to the negative direct influence of the fiscal shocks on foreign investment. This crowding out leads to a slight increase in savings abroad which eventually gets negative (after only a few quarters). As with technology shocks the paths of consumption, savings and the trade balance diverge and reach new steady state values.

4 Conclusions

The paper analyzed the German business cycle and proposed a two-country, single-good model to explain the stylized facts. Special attention was given to the selection of the data and to the way data transformations had to be performed: The model should be taken as a benchmark for this exercise. It was shown that GHH-preferences in combination with taste shocks and an asymmetric VAR (1) model for the driving processes can explain the international correlations of the aggregates quite well, especially the observed lead-lag structure and the positive investment and hours worked correlations. The model failed in explaining the features of the labor market and the saving-investment correlation. The zero correlation between the trade balances cannot be reproduced due to the two-country formulation of the model.

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[22] It is not clear whether the approximation around a nonstationary steady state - as is done in the King/Plosser/Rebelo (1990) algorithm - is valid and yields correct results. Some authors try to circumvent this problem by imposing stationary cardinal utility functions as in Mendoza (1991) or by allowing bond holdings to be an argument of the utility function as in Bruno/Portier (1995).

[23] The direct response of investment in a model with GHH-preferences is a special characteristic of the underlying exogenous processes.

In the literature mainly two ways have been proposed to improve upon the deficiencies. On the one hand, the countries are allowed to produce more than a single good and on the other hand, multi-country models were proposed. Often the papers focus on a very special deficiency which is tried to overcome. One conclusion from all these efforts is that it is particularly difficult to explain simultaneously a high volatility of the terms of trade and the correct ranking for the international correlations. There seems to be a trade off between an adequate description of this volatility and the mapping of the international correlations. In contrast the model at hand demonstrates in a tractable way how to achieve a reasonably good fit of the data - without complicated extensions with respect to the number of goods or the countries considered.

Unfortunately the results of many models cannot be directly compared to this model. There is a trend to use the models only for the explanation of very specific aspects of the data like output dynamics (see Canova/Marrinan (1998)) or the behavior of savings and investment (see van Wincoop/Marrinan (1996)) without reporting results with respect to the business cycle properties of the models. Moreover a detailed analysis of lead-lag structures is still missing. Since the models do not face the stylized facts they are prevented from being discarded on this ground.

All models in the literature - including the one presented here - perform extremely bad for the labor market variables. Future research should combine the strategy pursued by the researchers on closed economy Real Business Cycle models (Hansen (1985), Cho/Rogerson (1988), Kydland (1995)) with the multi-country open economy strand as in van Wincoop (1996) and with non-walrasian features concerning the labor market in the spirit of Danthine/Donaldson (1993) (see, for example, Danthine/Donaldson (1995)).

Appendix

Data for Germany and the US are taken from the DSI Statistical International Yearbook 1992.[24]

Germany

If not indicated otherwise, data are quarterly and taken from the Deutsche Bundesbank, Saisonbereinigte Wirtschaftszahlen. The computation of the aggregates is described in the main text.

output: DA0192, real gross domestic product, at constant prices 1985.

consumption: DA0180, real private consumption, at constant prices 1985.

investment: DA0184, real equipment, and DA0185, real construction, at constant prices 1985.

government consumption: DA0014, real government expenditures, at constant prices 1985.

trade balance: DA0188, real exports (goods and services) and DA0190, real imports (goods and services), at constant prices 1985.

hours worked: H1105B, DIW, hours worked daily per employee, seasonally adjusted and 01997007, Statistisches Bundesamt, persons employed and 01997001, Statistisches Bundesamt, population

real wage: DU5141, Deutsche Bundesbank, compensation of employees, total economy, standard wages on hourly basis, Index, 1985=100 and UU0062, Deutsche Bundesbank, consumer price index, all items, Index, 1985=100 (monthly)

United States of America

If not indicated otherwise, data are quarterly and taken from Citibase, Citicorporation. For the computation of the aggregates see the main text.

output: GDPQ, real gross domestic product, at constant prices 1987.

consumption: GCQ, real personal consumption expenditures, at constant prices 1987.

investment: GPIQ, gross private domestic investment, at constant prices 1987.

government consumption: GGEQ, real government purchases of goods and services, at constant prices 1987.

trade balance: GNETQ, net exports of goods and services, at constant prices 1987.

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[24] DSI Data Service & Information, P.O. Box 1127, D-47495 Rheinberg, Germany. This CD contains data from the most important international organizations: OECD, IMF, EUROSTAT, CITICORPORATION, UNIDO, DIW, Statistisches Bundesamt, Deutsche Bundesbank.

hours worked: LHCH, average hours worked weekly, all workers, all industries and LHEM, total employed of the civilian population and PM16 plus PF16, civilian noninstitutional population, men and women, older than 16 years (monthly)

real wage: LEH77, real gross average hourly earnings of production or nonsupervisory workers on private nonagricultural payrolls, at constant prices 1977 (monthly)

References

Aschauer, David A., 1985, Fiscal Policy and Aggregate Demand, American Economic Review 75, 117-127.

Backus, David K., Patrick J. Kehoe and Finn E. Kydland, 1992, International Real Business Cycles, Journal of Political Economy 100, 745-775.

Backus, David K., Patrick J. Kehoe and Finn E. Kydland, 1995, International Business Cycles: Theory and Evidence, in: Cooley, Thomas F. (ed.), Frontiers of Business Cycle Research. Princeton University Press. Princeton, New Jersey. 331-356.

Barro, Robert J., 1981, Output Effects of Government Purchases, Journal of Political Economy 89, 1086-1121.

Baxter, Marianne, 1992, Financial Market Linkages and the International Transmission of Fiscal Policy, Working Paper No. 336, Rochester Center for Economic Research. November.

Baxter, Marianne, 1995, International Trade and Business Cycles, in: Grossman, Gene M. and Kenneth S. Rogoff (eds.), Handbook of International Economics III. North-Holland. Amsterdam. 1801-1864.

Baxter, Marianne and Mario J. Crucini, 1993, Explaining Saving-Investment Correlations, American Economic Review 83, 416-436

Baxter, Marianne and Mario J. Crucini, 1995, Business Cycles and the Asset Structure of Foreign Trade, International Economic Review 36, 821-854.

Bec, Frédérique, 1995, The International Transmission of Real Business Cycles, in: Hénin, Pierre-Y. (ed.), Advances in Business Cycle Research - with Applications to the French and US Economies. Springer. Berlin. 143-172.

Blackburn, Keith and Morten O. Ravn, 1991, Contemporary Macroeconomic Fluctuations: An International Perspective, Working Paper 1991-12, Centre for International Economics, Institute of Economics, University of Aarhus.

Blanchard, Olivier J. and Stanley Fischer, 1989, Lectures on Macroeconomics. MIT Press. Cambridge, Massachusetts.

Brandner, Peter and Klaus Neusser, 1992, Business Cycles in Open Economies: Stylized Facts for Austria and Germany, Weltwirtschaftliches Archiv 128, 67-87.

Bruno, Catherine and Franck Portier, 1995, A Small Open Economy RBC Model: The French Economy Case, in: Hénin, Pierre-Y. (ed.), Advances in Business Cycle Research - with Applications to the French and US Economies. Springer. Berlin. 173-194.

Canova, Fabio, 1998, Detrending and Business Cycle Facts, Journal of Monetary Economics 41, 475-512.

Canova, Fabio and Jane Marrinan, 1998, Sources and Propagation of International Output Cycles: Common Shocks or Transmission?, Journal of International Economics 46, 133-166.

Cantor, Richard and Nelson N. Mark, 1987, International Debt and World Business Fluctuations, Journal of International Money and Finance 6, 153-165.

Cho, Jank-Ok and Richard Rogerson, 1988, Family Labor Supply and Aggregate Fluctuations, Journal of Monetary Economics 21, 233-245.

Christodoulakis, Nicos, Sophia P. Demelis and Tryphon Kollintzas, 1995, Comparisons of Business Cycles in Greece and the EC: Idiosyncrasies and Regularities, Economica 62, 1-27.

Correia, Isabel H., Joao L. Neves and Sergio T. Rebelo, 1992, Business Cycles in Portugal: Theory and Evidence, in: Amaral, João Ferreira do, Diogo Lucena and António S. Mello (eds)., The Portuguese Economy towards 1992. Kluwer. Boston. 1-64.

Correia, Isabel H., Joao L. Neves and Sergio T. Rebelo, 1995, Business Cycles in a Small Open Economy, European Economic Review 39, 1089-1113.

Danthine, Jean P. and John B. Donaldson, 1993, Methodological and Empirical Issues in Real Business Cycle Theory, European Economic Review 37, 1-35.

Danthine, Jean P. and John B. Donaldson, 1995, Non-Walrasian Economies, in: Cooley, Thomas F. (ed.), Frontiers of Business Cycle Research. Princeton University Press, Princeton, New Jersey. 217-242.

Dellas, Harris, 1986, A Real Model of the World Business Cycle, Journal of International Money and Finance 5, 381-394.

Devereux, Michael B., Allan W. Gregory and Gregor W. Smith, 1992, Realistic Cross-Country Consumption Correlations in a Two-Country, Equilibrium Business Cycle Model, Journal of International Money and Finance 11, 3-16.

Elliott, Graham and Antonio Fatás, 1996, International Business Cycles and the Dynamics of the Current Account, European Economic Review 40, 361-387.

Fiorito, Riccardo and Tryphon Kollintzas, 1994, Stylized Facts of Business Cycles in the G7 from a Real Business Cycle Perspective, European Economic Review 38, 235-269.

Graham, Fred C., 1993, Fiscal Policy and Aggregate Demand, American Economic Review 83, 659-666.

Greenwood, Jeremy, Zvi Hercowitz and Gregory W. Huffman, 1988, Investment, Capacity Utilization and the Real Business Cycle, American Economic Review 78, 402-417.

Hansen, Gary D., 1985, Indivisible Labor and the Business Cycle, Journal of Monetary Economics 16, 309-327.

Harjes, Thomas, 1997, Real Business Cycles in an Open Economy: An Application to Germany, Weltwirtschaftliches Archiv 133, 635-656.

Hénin, Pierre-Y. (ed.), 1995, Advances in Business Cycle Research - with Applications to the French and US Economies. Springer. Berlin.

Hodrick, Robert J. and Edward C. Prescott, 1997, Post-War U.S. Business Cycles: An Empirical Investigation, Journal of Money, Credit, and Banking 29, 1-16.

Huffman, Gregory W., 1994, A Primer on the Nature of Business Cycles, Federal Reserve Bank of Dallas, Economic Review, First Quarter, 27-41.

King, Robert G., Charles I. Plosser and Sergio T. Rebelo, 1988a, Production, Growth and Business Cycles I. The Basic Neoclassical Model, Journal of Monetary Economics 21, 195-232.

King, Robert G., Charles I. Plosser and Sergio T. Rebelo, 1988b, Production, Growth and Business Cycles II. New Directions, Journal of Monetary Economics 21, 309-341.

King, Robert G., Charles I. Plosser and Sergio T. Rebelo, 1990, Production, Growth and Business Cycles. Technical Appendix. University of Rochester. May. Revised Version. forthcoming: Computational Economics.

Kollmann, Robert, 1996, Incomplete Asset Markets and the Cross-Country Consumption Correlation Puzzle, Journal of Economic Dynamics and Control 20, 945-961.

Kydland, Finn E., 1995, Business Cycles and Aggregate Labor Market Fluctuations, in: Cooley, Thomas F. (ed.), Frontiers of Business Cycle Research. Princeton University Press, Princeton, New Jersey. 126-156.

Kydland, Finn E. and Edward C. Prescott, 1990, Business Cycles: Real Facts and a Monetary Myth, Federal Reserve Bank of Minneapolis, Quarterly Review, Spring, 3-18.

Lundvik, Petter, 1992a, Business Cycles in a Small Open Economy: Sweden 1871-1987, in: Lundvik, Petter, Business Cycles and Growth. Ph.D. Dissertation. Institute for International Economic Studies. Stockholm University. Chapter II. 19-58.

Lundvik, Petter, 1992b, Foreign Demand and Domestic Business Cycles: Sweden 1871-1988. in: Lundvik, Petter, Business Cycles and Growth. Ph.D. Dissertation. Institute for International Economic Studies. Stockholm University. Chapter III. 59-96.

Mendoza, Enrique G., 1991, Real Business Cycles in a Small Open Economy, American Economic Review 81, 797-818.

Ravn, Morten O., 1997, International Business Cycles in Theory and Practice, Journal of International Money and Finance 16, 255-283.

Reynolds, Patricia A., 1992, The International Transmission of Business Cycles. Ph.D. Dissertation. Northwestern University. UMI.

Roche, Maurice J., 1996, Government Spending and the International Business Cycle, Canadian Journal of Economics 29, 865-884.

Smeets, Heinz-D., 1992, "Stylized Facts" zum Konjunkturverlauf in der Bundesrepublik Deutschland, Jahrbücher für Nationalökonomie und Statistik 210, 512-532.

Van Wincoop, Eric, 1996, Open Economy Real Business Cycle Models: A Multi-Country Approach, Working Paper, Federal Reserve Bank of New York. December.

Van Wincoop, Eric and Jane Marrinan, 1996, Public and Private Saving and Investment, Economics Working Paper 172, Department of Economics, Universitat Pompeu Fabra. June.

Zimmermann, Christian, 1994, Technology Innovations and the Volatility of Output: An International Perspective, Working Paper No. 34, Research Center on Employment and Economic Fluctuations, Université du Québec à Montréal. December.

Zimmermann, Christian, 1997, International Trade over the Business Cycle: Stylized Facts and Remaining Puzzles, Working Paper No. 37R, Research Center on Employment and Economic Fluctuations, Université du Québec à Montreal. August.

Table 2.1

Business cycle statistics for Germany, 1968:1 - 1991:1

			autocorrelation		cross correlation of variable $\hat{x}_t$ with $\hat{y}$ in				
variable $\hat{x}_t$	std. dev.	relative std. dev.	1	2	t-2	t-1	t	t+1	t+2
$\hat{y}$	1.55	1.00	0.61	0.49	0.49	0.61	1.0	0.61	0.49
$\hat{c}$	1.42	0.92	0.72	0.61	0.37	0.41	0.62	0.58	0.51
$\hat{i}$	4.23	2.73	0.63	0.48	0.40	0.48	0.78	0.51	0.43
$\hat{N}$	0.88	0.57	0.82	0.66	0.69	0.70	0.68	0.41	0.19
$\hat{w}$	1.30	0.84	0.72	0.43	0.24	0.08	-0.05	-0.11	-0.09
$\hat{s}$	5.33	3.44	0.49	0.34	0.36	0.48	0.80	0.39	0.28
$\frac{tb_t}{y_t}-\overline{\left(\frac{tb}{y}\right)}$	1.07		0.63	0.50	-0.15	-0.16	-0.11	-0.33	-0.36

Table 2.2[25]

Business cycle statistics for Germany and the US, 1968:1 -1991:1

		cross correlation of variable $\hat{x}_t$ with $\hat{z}$ in								
variable $\hat{x}_t$	variable $\hat{z}$	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
$\hat{y}$	$\hat{y}^*$	0.31	0.47	0.59	0.67	0.63	0.54	0.36	0.22	0.02
$\hat{c}$	$\hat{c}^*$	0.38	0.41	0.45	0.50	0.55	0.50	0.38	0.30	0.18
$\hat{i}$	$\hat{i}^*$	0.11	0.16	0.25	0.34	0.38	0.43	0.38	0.33	0.19
$\hat{N}$	$\hat{N}^*$	0.46	0.54	0.61	0.61	0.50	0.36	0.19	0.02	-0.11
$\hat{w}$	$\hat{w}^*$	0.07	-0.00	-0.04	-0.06	-0.05	-0.02	0.00	0.03	0.08
$\hat{s}$	$\hat{s}^*$	0.11	0.33	0.45	0.54	0.43	0.34	0.20	0.09	-0.09
$\frac{tb_t}{y_t}-\overline{\left(\frac{tb}{y}\right)}$	$\frac{tb_t^*}{y_t^*}-\overline{\left(\frac{tb^*}{y^*}\right)}$	0.18	0.18	0.14	0.09	0.10	0.13	0.07	0.03	-0.01
$\hat{s}$	$\hat{i}$	0.25	0.20	0.22	0.30	0.51	0.20	0.12	0.09	0.11
$\hat{s}^*$	$\hat{i}^*$	0.22	0.40	0.57	0.76	0.92	0.69	0.42	0.17	-0.08
$\hat{w}$	$\hat{N}$	0.43	0.43	0.34	0.25	0.14	0.02	-0.01	-0.00	0.01
$\hat{w}^*$	$\hat{N}^*$	-0.33	-0.14	0.07	0.29	0.50	0.64	0.71	0.74	0.73

[25] A star denotes US variables.

Table 3.1

Business cycle statistics of the model for Germany

			autocorrelation		cross correlation of variable $\hat{x}_t$ with $\hat{y}$ in				
variable $\hat{x}_t$	std. dev.	relative std.dev.	1	2	t-2	t-1	t	t+1	t+2
$\hat{y}_t$	1.55	1.00	0.36	0.10	0.10	0.36	1.00	0.36	0.10
$\hat{c}_t^p$	1.10	0.71	0.45	0.16	0.13	0.38	0.98	0.42	0.13
$\hat{i}_t$	2.79	1.80	0.58	0.26	0.02	0.27	0.84	0.57	0.31
$\hat{N}_t$	0.91	0.59	0.36	0.10	0.10	0.36	1.00	0.36	0.10
$\hat{w}_t$	0.64	0.41	0.36	0.10	0.10	0.36	1.00	0.36	0.10
$\hat{s}_t$	3.85	2.48	0.35	0.07	0.07	0.33	0.98	0.37	0.10
$\frac{tb_t}{y}-\frac{tb}{y}$	0.56		0.18	-0.06	0.09	0.24	0.66	-0.08	-0.23

Table 3.2

Business cycle statistics of the model for Germany and the US

		cross correlation of variable $\hat{x}_t$ with $\hat{z}$ in								
variable $\hat{x}_t$	variable $\hat{z}$	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
$\hat{y}$	$\hat{y}^*$	0.08	0.22	0.40	0.53	0.26	0.11	0.00	-0.06	-0.10
$\hat{c}^p$	$\hat{c}^{p*}$	0.08	0.23	0.42	0.60	0.47	0.22	0.06	-0.04	-0.10
$\hat{c}$	$\hat{c}^*$	0.07	0.22	0.42	0.60	0.47	0.22	0.06	-0.04	-0.10
$\hat{i}$	$\hat{i}^*$	-0.10	0.02	0.23	0.55	0.99	0.59	0.28	0.07	-0.06
$\hat{N}$	$\hat{N}^*$	0.08	0.22	0.40	0.53	0.26	0.11	0.00	-0.06	-0.10
$\hat{w}$	$\hat{w}^*$	0.08	0.22	0.40	0.53	0.26	0.11	0.00	-0.06	-0.10
$\hat{s}$	$\hat{s}^*$	0.10	0.23	0.39	0.49	0.13	0.04	-0.03	-0.07	-0.10
$\frac{tb_t}{y}-\frac{tb}{y}$	$\frac{tb_t^*}{y^*}-\frac{tb^*}{y^*}$	0.11	0.11	0.06	-0.18	-1.00	-0.18	0.06	0.11	0.11
$\hat{s}$	$\hat{i}$	-0.02	0.10	0.28	0.54	0.83	0.28	0.03	-0.09	-0.14
$\hat{s}^*$	$\hat{i}^*$	-0.13	-0.05	0.08	0.30	0.65	0.65	0.42	0.20	0.04
$\hat{w}$	$\hat{N}$	-0.09	-0.03	0.10	0.36	1.00	0.36	0.10	-0.03	-0.09
$\hat{w}^*$	$\hat{N}^*$	-0.08	0.03	0.22	0.52	1.00	0.52	0.22	0.03	-0.08

Figure 2.1

Cyclical components after HP-filtering

Germany and the US, 1968:1 - 1991:1

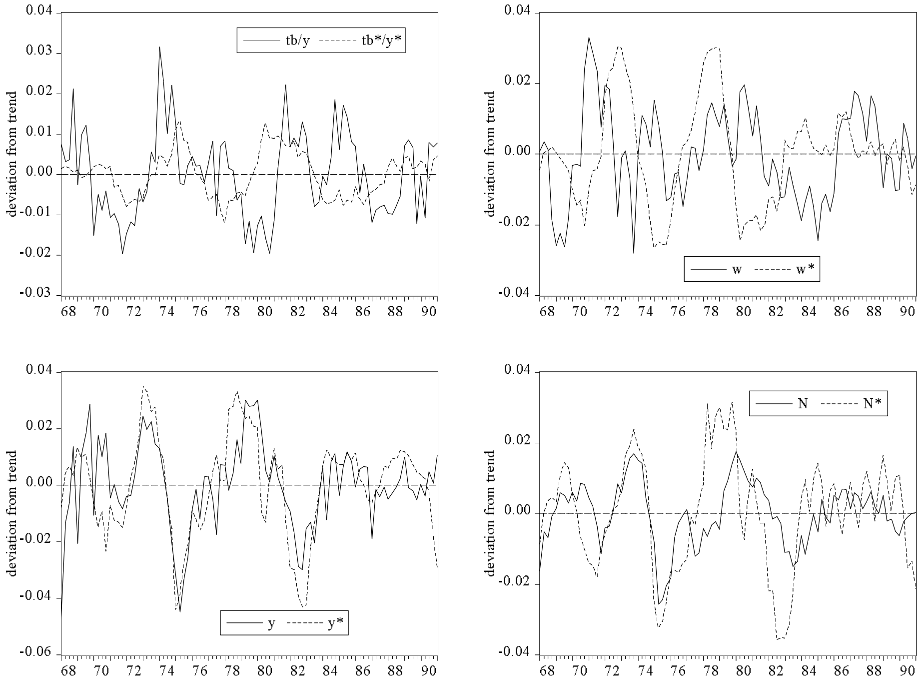


Figure 3.1

Impulse response functions

one percent technology shock in Germany

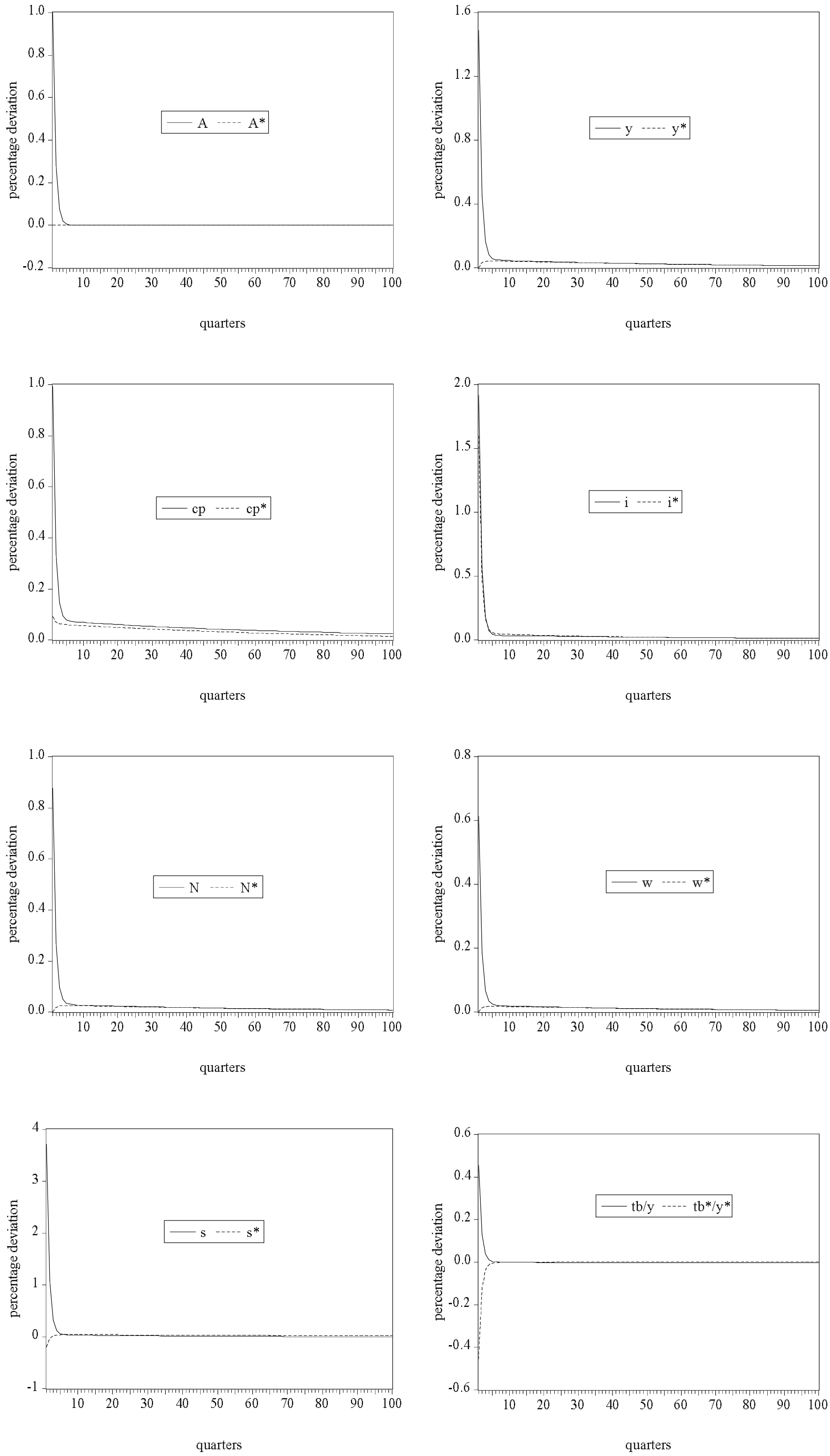
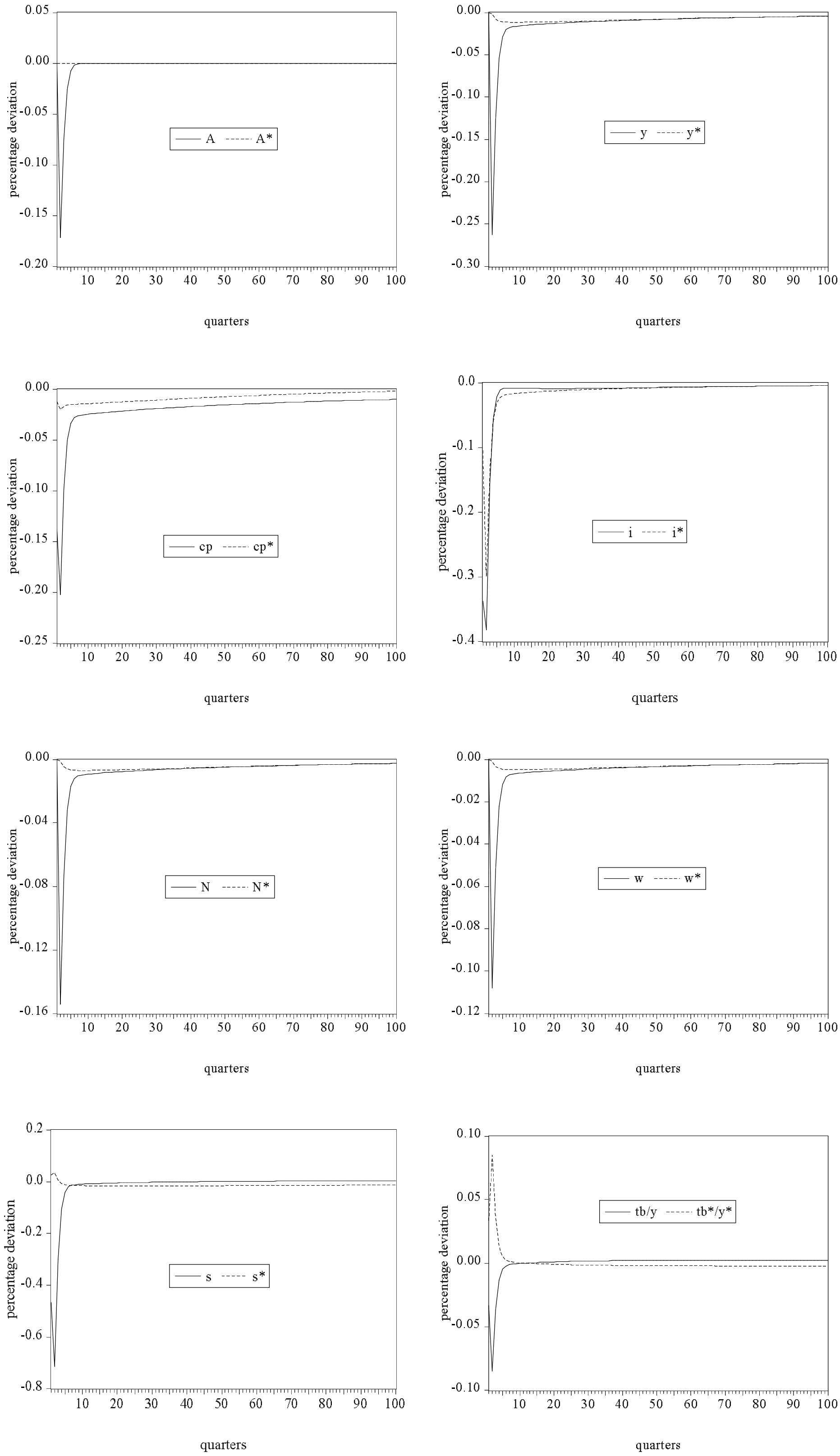


Figure 3.2

Impulse response functions

one percent fiscal shock in Germany



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