

Swedish Postwar Business Cycles: Generated Abroad or at Home?

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Abstract

This paper investigates the relative importance of foreign and domestic shocks for the Swedish postwar business cycle in a neoclassical stochastic growth model of a small open economy. I extend previous work in the literature by allowing for stochastic fiscal policy, since recent research has shown that fiscal policy shocks may be important for business cycles. It is found that the introduction of fiscal policy improves the empirical fit of the model, although not significantly so when hours worked are detrended with the HP-filter. The results suggest that domestic shocks are more important than foreign shocks for output fluctuations. Among the domestic shocks, innovations in fiscal policy seem to have been more important than technology shocks during this period. Foreign shocks are very important for fluctuations in the real exchange rate and the current account.

Keywords: real business cycle model; fiscal policy; small open economy; simulated method of moments; variance decomposition.

JEL Classification Numbers: E17; E32; E62.

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I. Introduction

What is the relative importance of domestic and foreign shocks for Swedish postwar business cycles? A view that is common in Sweden - or at least has been - is that business cycles are mainly caused by foreign shocks, such as fluctuations in foreign demand for Swedish exports, see e.g. Lindbeck (1975). Using an equilibrium small open economy model, Lundvik (1992) finds support for this view. However, two drawbacks of Lundvik's study are, first, that his model does not fit the data, and second, that he only introduced one type of domestic shock into his model: innovations in total factor productivity.

Recent research has provided evidence that fluctuations in fiscal policy seem to matter for the business cycle; see for instance Braun (1994) and McGrattan (1994) for closed economy results, and Kalulunia and Nyankiye (2000) for open economy results. In a dynamic general equilibrium model for a closed economy, Jonsson and Klein (1996), henceforth JK96, find that the introduction of stochastic fiscal policy can account for some of the key features of Swedish postwar business cycles. They estimate the model with Simulated Method of Moments (SMM) and demonstrate that the empirical fit of the model is significantly improved when allowing for fiscal policy shocks. But as a consequence of their closed economy setting, they do not account for the presence of foreign shocks.

The ideas of this paper are to introduce stochastic fiscal policy into a modified version of Lundvik's (1992) model, first, to check the robustness of JK96 results in a small open economy framework, and second, to investigate whether either foreign shocks or domestic shocks are most important for Swedish postwar business cycles.

The main results in the paper are as follows. First, I find that the introduction of fiscal policy improves the empirical fit of the model, although not significantly so as in JK96. None of the models are rejected by the data using correct, i.e. small-sample adjusted, significance

levels, whereas both versions are strongly rejected using asymptotic levels.¹ To my knowledge, this is the first paper to compute correct critical values by means of a well-defined Monte-Carlo simulation exercise when testing for the empirical fit of the equilibrium model. By many empirical macroeconomists, equilibrium models are often considered to have the disadvantage that they do not fit the data. The results in this paper suggest that one possible explanation of the poor fit of equilibrium models may be due to small-sample problems. I think more research to explore this issue on different dimensions is warranted.

Second, by decomposing the simulated volatility in output per capita, the real exchange rate and the current account attributed to various foreign and domestic shocks, I find that the relative importance of foreign and domestic shocks are quite different in the short and long run. In the short run, i.e. in the 1 – 5 years horizon, foreign shocks account for roughly 30 percent of the fluctuations in output. The most important source of output fluctuations in the short run according to the model are shocks to total factor productivity, which account for about 45 percent. In the long run, foreign shocks and domestic technology shocks are found to be less important and account for about 15 and 20 percent of the fluctuations in output, respectively. Instead, fiscal policy shocks are found to be very important, as in JK96, and explain about 65 percent of the fluctuations in output in the long run. The contribution of foreign shocks in the short run is well in line with the findings of the studies which have used vector autoregressions; see e.g. Mellander et al. (1992) and Englund et al. (1994), but suggest a less important role for foreign shocks in the long run during this period. Presumably, the reason for this difference is that fiscal policy shocks have been so persistent during the postwar period, due to the build-up of the “welfare” state in Sweden, and both Mellander et al. (1992) and Englund et al. (1994)

¹ However, it should be noted that as in JK96, I have chosen to subject hours of work per capita in logs to the HP-filter because of the strong downward trend in this variable (see Section 3.2 for further details). Clearly, this decision may downplay the importance of fiscal policy shocks, because one possible explanation of the negative trend in hours worked during this period is the build-up of the “welfare state” (i.e. increased income- and payroll-taxes coupled with more generous unemployment and sick-leave benefits).

use data for a longer sample period. Interestingly, it is a robust result that foreign shocks are of decisive importance for fluctuations in the real exchange rate and the current account both in the short and long run.

The structure of the paper is as follows. In Section 2, I present the equilibrium model. The data set and some basic stylized facts for the Swedish postwar period are reported in Section 3. In Section 4, I discuss various issues regarding calibration and estimation of the deep parameters and processes for the exogenous variables in the model. The SMM estimation results and the variance decompositions are then reported in Section 5. Finally, Section 6 concludes.

II. The equilibrium model

In this section, I construct a neoclassical stochastic growth model for a small open economy. There are two goods in the model, one domestic good which can be used for private and public consumption, investment and export, and one foreign good which can be used for consumption and as an intermediate input in production. The price of the foreign good in terms of the domestic good, the real exchange rate, is endogenously determined in the economy. By this procedure, it is implicitly assumed that the economy has some monopoly power in the world market for its own good. The foreign demand of the domestically produced good is determined by the exogenous foreign income level and the real exchange rate. The individuals have access to an international market for one-period real bonds with an exogenously given real interest rate. There are two main sources of domestic disturbances in the economy: fluctuations in fiscal policy and the technology level. As in the “best” version of the models with fiscal policy in JK96, I account for three types of fiscal policy disturbances.² On the income side I have shocks to payroll and consumption taxes, which in 1995 covered roughly 55 percent of public sector

² “Best” in the sense that it resembled the Swedish postwar business cycle best.

income.³ On the expenditure side, I model public consumption expenditure exogenously, while public transfers to the agents are endogenous.⁴

Infinitely many identical infinitely lived agents maximize expected utility given by

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, c_t^*, h_t), \quad (1)$$

$$u(c_t, c_t^*, h_t) \equiv \frac{\left[\left(c_t^\eta (c_t^*)^{1-\eta} \right)^\alpha (1-h_t)^{1-\alpha} \right]^{1-\sigma} - 1}{1-\sigma}$$

where c_t is consumption of the domestically produced good in time period t , c_t^* is consumption of the foreign good and h_t is the share of available time spent in employment. In (1), $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution between consumption and leisure and β the subjective discount factor, while α and η reflect the trade-off between consumption and leisure, and the foreign and domestic consumption good respectively.⁵

The flow budget constraint facing the agent is

$$(1 + \tau_t^c)(c_t + Q_t c_t^*) + i_t + Q_t b_{t+1}^* = \frac{W_t}{1 + \tau_t^w} h_t + R_t^K k_t + Q_t (1 + R_t^{B^*}) b_t^* + TR_t \quad (2)$$

where τ_t^c and τ_t^w are the exogenous consumption and payroll tax rates. Thus, W_t is interpreted as a gross wage. Q_t denotes the real exchange rate; a higher value means a real depreciation. i_t is the agent's investment and R_t^K , given by (6), is the gross real return on the capital stock k_t .

b_{t+1}^* denotes the agent's holding of the foreign bond at the beginning of time period $t + 1$, and

³ I do not include income taxes in the model because good data do not exist on (marginal) labor income taxes and the capital stock in Sweden during the whole postwar period. JK96 included income taxes in the model but found that they deteriorated the fit of the equilibrium model, and led to implausible estimates for the deep parameters. Presumably, this was the case because of difficulties in estimating and modeling the income tax system. There are three good reasons to believe, however, that the inclusion of income taxes would not affect the main conclusions in the paper. The first is that JK96 report that income taxes were not the most important source of fluctuations in their analysis, and the second is that as long as we have some taxes in the model that are highly autocorrelated, fiscal policy will pick up most of the volatility in the variance decompositions studied in Section 5.2 on the lower frequencies anyway. Third, when the model is calibrated with an income tax equal to 40 percent in steady state, the variance decompositions for output in Section 5 change relatively little in the short run whereas fiscal policy shocks are even more important in the long run.

⁴ Note that JK96 considered the ratio of public consumption expenditure to GDP, denoted g_t , to be exogenous. This assumption may be valid in the long run, but in a business cycles analysis it seems more reasonable to assume that g_t is endogenous and the level of public consumption expenditure exogenous.

⁵ In the model, I abstract from population growth and represent all variables in per capita terms. Finally, note that capital letters denote economy-wide averages which the agent takes as given and small letters individual specific values which the agent internalizes.

$R_t^{B^*}$, given by (14), the real interest rate received on b_t^* . From (2), it is clear that b_t^* is not a risk-free asset; the return on it will fluctuate because of changes in Q_t and $R_t^{B^*}$. Finally, TR_t is the lump-sum transfer from the public sector to the agent.

The production function is assumed to have constant returns to scale and to be of the Cobb-Douglas type

$$Y_t = e^{\ln Z_t} \left(IM_t^{\theta_{IM}} K_t^{1-\theta_{IM}} \right)^\theta (T_t^H H_t)^{1-\theta} \quad (3)$$

where Y_t is output, IM_t intermediate input (of the foreign good), Z_t the technology level and T_t^H the deterministic labor-augmenting technological level which follows

$$T_t^H = (1 + \gamma) T_{t-1}^H = (1 + \gamma)^t. \quad (4)$$

In (4), γ is the deterministic labor-augmenting rate of technological change. Accordingly, the perfect competition zero profit maximizing conditions for the representative company are

$$W_t = (1 - \theta) e^{\ln Z_t} \left(\frac{IM_t^{\theta_{IM}} K_t^{1-\theta_{IM}}}{T_t^H H_t} \right)^\theta T_t^H, \quad (5)$$

$$R_t^K = \theta (1 - \theta_{IM}) e^{\ln Z_t} \left(\frac{IM_t^{\theta_{IM}} K_t^{1-\theta_{IM}}}{T_t^H H_t} \right)^\theta \frac{T_t^H H_t}{K_t} \quad (6)$$

and

$$Q_t = \theta \theta_{IM} e^{\ln Z_t} \left(\frac{IM_t^{\theta_{IM}} K_t^{1-\theta_{IM}}}{T_t^H H_t} \right)^\theta \frac{T_t^H H_t}{IM_t}. \quad (7)$$

The technology level is assumed to be exogenous and the natural log of it to follow a stationary AR(1)-process

$$\ln Z_{t+1} = \rho_{\ln Z} \ln Z_t + \varepsilon_{t+1}^{\ln Z}, \quad \varepsilon^Z \sim i.i.d. N(0, \sigma_{\ln Z}^2), \quad -1 < \rho_{\ln Z} < 1. \quad (8)$$

Individual and aggregate investment in period t produce productive capital in period $t + 1$ according to

$$k_{t+1} = (1 - \delta) k_t + i_t \quad (9)$$

and

$$K_{t+1} = (1 - \delta)K_t + I_t. \quad (10)$$

where δ is the rate of capital depreciation.

The government's budget constraint is

$$\tau_t^c (C_t + Q_t C_t^*) + \frac{\tau_t^w W_t}{1 + \tau_t^w} H_t = G_t + TR_t \quad (11)$$

where G_t is exogenous public consumption expenditure. Since τ_t^c and τ_t^w are exogenous too, TR_t is endogenous and interpreted as the budget deficit. By this procedure, the public debt is always zero in every time period.⁶

Foreign demand for the domestically produced good, denoted X_t , is assumed to be determined by foreign income and the real exchange rate according to

$$X_t = Y_t^* Q_t^{\epsilon_X} \quad (12)$$

where Y_t^* denotes the exogenous foreign income level, assumed to grow at the same rate as domestic output in steady state.⁷ The specification (12) can be derived in an optimizing framework; see Armington (1969). Since Q_t , the real exchange rate, is endogenous in the model, export are endogenous as well. The stochastic part of Y_t^* in natural logs, \tilde{Y}_t^* , is assumed to evolve according to

$$\tilde{Y}_{t+1}^* = \rho_{\tilde{Y}^*} \tilde{Y}_t^* + \varepsilon_{t+1}^{\tilde{Y}^*}, \quad \varepsilon_{t+1}^{\tilde{Y}^*} \sim i.i.d. N(0, \sigma_{\tilde{Y}^*}^2), \quad -1 < \rho_{\tilde{Y}^*} < 1. \quad (13)$$

As in Lundvik (1992), it is assumed that only one foreign one-period real bond denominated in the foreign good exists, which pays a given world interest rate R_t^* . In order to get a stationary solution for the foreign bondholdings and the real exchange rate, I adopt the assumption in

⁶ Note that, given the assumption that fiscal policy is exogenous, whether the government has a debt or not will not matter for the dynamics around a given steady state in this economy, since the infinitely lived households are not borrowing constrained and the government would pay the same interest rate, $R_t^{B^*}$.

⁷ Formally, this implies that $Y_t^* = T_t^H \exp(\tilde{Y}_t^*)$.

Lundvik (1992), and specify exogenously an economy-specific risk premium on the given world interest rate as

$$R_t^{B^*} = \frac{\omega_0 \bar{Y}_t + \omega_1 B_t^*}{\omega_0 \bar{Y}_t + B_t^*} R_t^* \quad (14)$$

where $\omega_1 < 1$, B_t^* denotes aggregate foreign bondholdings and \bar{Y}_t the steady state-value of output in t . Since there is deterministic labor-augmenting technological growth at the rate γ in the model, \bar{Y}_t equals $\bar{Y} (1 + \gamma)^t$ where \bar{Y} is the steady-state level of output per efficiency units of labor. The economic rationale for this specification is that the larger the aggregate debt as a percentage of long-run expected GDP, the larger the risk premium that the economy must pay. $R_t^{B^*}$ is then interpreted as a risk-adjusted interest rate.⁸ The world real interest rate is assumed to be exogenously given by the stationary process

$$R_{t+1}^* = (1 - \rho_{R^*}) \bar{R}^* + \rho_{R^*} R_t^* + \varepsilon_{t+1}^{R^*}, \varepsilon^{R^*} \sim i.i.d.N(0, \sigma_{R^*}^2), \quad -1 < \rho_{R^*} < 1$$

which is a standard small open economy assumption.

On the aggregate level, the change in real foreign bond holdings in domestic terms is given by

$$Q_t (B_{t+1}^* - B_t^*) = X_t - Q_t (C_t^* + IM_t) + Q_t R_t^{B^*} B_t^* \quad (15)$$

where $Q_t (C_t^* + IM_t)$ is aggregate import of the foreign good. It is then natural to think of $X_t - Q_t (C_t^* + IM_t)$ as the trade balance and $Q_t (B_{t+1}^* - B_t^*)$ as the current account.

The aggregate resource constraint

$$Y_t = C_t + I_t + G_t + X_t = (C_t + Q_t C_t^*) + (I_t + Q_t IM_t) + G_t + X_t - (Q_t C_t^* + Q_t IM_t) \quad (16)$$

also holds in every period. It should be emphasized that we from now on think of $C_t + Q_t C_t^*$ as aggregate consumption, $(I_t + Q_t IM_t)$ as aggregate investment and $(Q_t C_t^* + Q_t IM_t)$ as aggregate import in domestic units.

⁸ Note that (14) implies that, if $B_t^* = 0$, then $R_t^{B^*} = R_t^*$, but if $B_t^* \rightarrow \infty$, then $R_t^{B^*} = \omega_1 R_t^* < R_t^*$. Finally, if $B_t^* \rightarrow -\omega_0 \bar{Y}_t$, then $R_t^{B^*} \rightarrow \infty$. As in Lundvik (1992), I set the parameters governing the risk premium, ω_0 and ω_1 , to 5 and 0.99 respectively.

As in JK96, fiscal policy is treated as an exogenous VAR(p) model

$$\boldsymbol{\tau}_t = \boldsymbol{v} + \sum_{i=1}^p \boldsymbol{\varphi}_i \boldsymbol{\tau}_{t-i} + \boldsymbol{\varepsilon}_t^\tau, \boldsymbol{\varepsilon}_t^\tau \sim i.i.d. N(\mathbf{0}, \boldsymbol{\Sigma}) \quad (17)$$

where $\boldsymbol{\tau}_t \equiv [\tilde{G}_t \ \tau_t^c \ \tau_t^w]'$ and \tilde{G}_t denotes the stochastic part of public expenditure in natural logs.

In Appendix A, I characterize and show how to compute the competitive equilibrium in this model.

III. Data

In this section, I present the annual data set and some stylized facts for Swedish postwar business cycles 1950-1995. By including data until 1995, I cover the deep recession in the Swedish economy in the beginning of the 1990s.⁹

Basic definitions

A major part of the data set are the GDP identities in nominal and real per capita terms. In addition, I have total employment in hours, the total nominal gross wage sum, nominal social insurance contributions and the nominal current account in the data set.¹⁰ The measure of output, Y , is nominal GDP at factor costs per capita divided by the deflator for GDP at market prices.¹¹ The series for private consumption per capita, C , includes durable goods but excludes the net of indirect taxes and subsidies (deflated with the deflator for GDP at market prices). Two reasons for this procedure are, first, that durable goods are subject to consumption taxes and, second, that I want the GDP identity to hold in real terms up to a measurement error in

⁹ I use only postwar data, since Hassler et al. (1994) report some instability in Swedish business cycles in connection with World War I and World War II. In fact, this is also an additional reason to redo the calculations in Lundvik (1992), since he uses data for the period 1871-1988.

¹⁰ See Appendix B for sources of the data set and exact definitions of all the variables.

¹¹ One shortcoming in the national accounts in Sweden is that there are no deflators for GDP at factor costs, or for indirect taxes and subsidies. Therefore, I have had to accept the deflator for GDP at market prices as a proxy for the deflators of GDP at factor costs, and for indirect taxes and subsidies. This has some quantitative importance which is discussed in Appendix B in greater detail.

the national accounts. For the latter reason, I have also included inventory investment in the series for private investment per capita, I . Real public expenditure, G , includes both real public consumption and investment. The consumption tax, τ^c , is calculated as the net of nominal indirect taxes and subsidies divided by nominal consumption expenditure, while the payroll tax, τ^w , is calculated as nominal social insurance fees divided by the net of the total nominal gross wage sum and social insurance fees. The share of available time spent in employment, H , is measured as the average total number of hours worked per capita. It should be noted that dividing the series by the population in working age (i.e. population between 18 – 65) instead of the total population as is done here has no impact on the results since the growth rates of those series are the same during the sample (0.18 and 0.17 percent for total and 18 – 65 respectively) and the correlation for the detrended series is very close to unity (0.99). Consequently, it is not a demographic change that accounts for the decline in hours worked in Sweden which is shown in Figure 1. Finally, the real exchange rate (inverse of the terms of trade), Q , and the current account, CA , are calculated as the import deflator divided by the export deflator and the nominal CA divided by the nominal GDP at factor costs respectively.

Filtering and some stylized facts

Since the purpose of the paper is to study business cycle fluctuations, not trends, we want to extract the business cycle component of the series. Since Englund et al. (1992) and Hassler et al. (1994) have found that business cycle regularities in Swedish data do not seem to be sensitive to the filtering method, I have followed the convention in the real business cycle literature and applied the Hodrick-Prescott (1997) (HP-) filter on the data in natural logs with the smoothness coefficient λ set to 100. On annual data, this choice of λ captures what we normally mean by business cycles; that is, it produces cycles with a periodicity of 3-8 years. On *a priori* grounds,

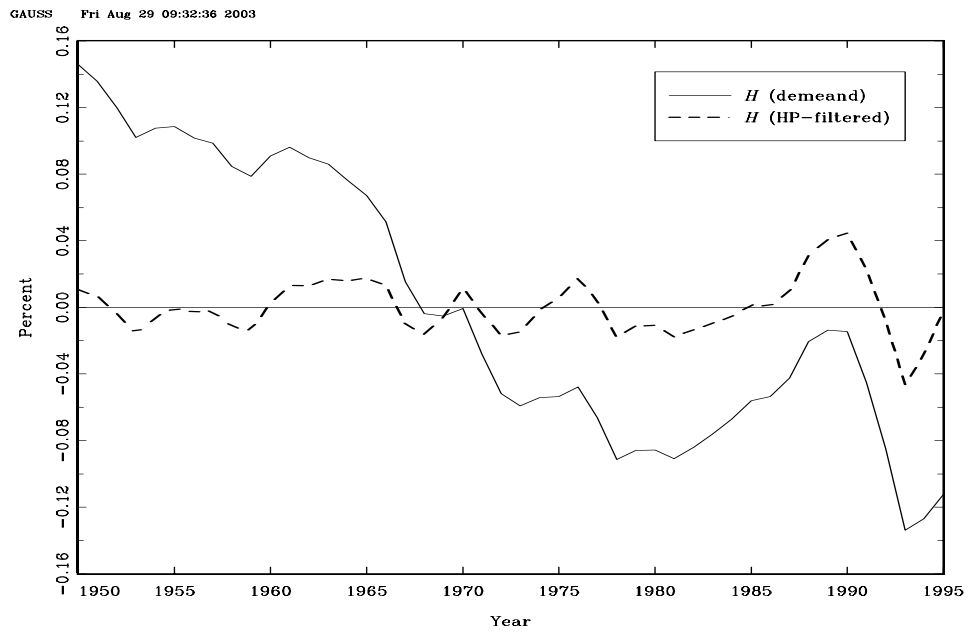


Figure 1: Hours worked per capita in logarithms (demeaned) and HP-filtered hours worked per capita 1950 – 1995.

and in accordance with the model, I have not HP-filtered τ^c , τ^w , CA or Q .¹² The basic features of Swedish postwar business cycles are reported in Table 1.

Table 1: Basic stylized business cycle facts for Sweden 1950-1995.

	Std. dev. in %	Std. dev. to \tilde{Y}	Correlation of variable with									
			itself in t at					\tilde{Y}_t at				
			$t-2$	$t-1$	t	$t+1$	$t+2$	$t-2$	$t-1$	t	$t+1$	$t+2$
\tilde{Y}	1.56	1.00	-0.20	0.38	1.00	0.38	-0.20	-0.20	0.38	1.00	0.38	-0.20
\tilde{C}	2.25	1.44	0.14	0.46	1.00	0.46	0.14	-0.21	0.12	0.49	0.17	0.13
\tilde{I}	9.39	6.01	-0.06	0.48	1.00	0.48	-0.06	-0.24	0.12	0.76	0.64	0.06
\tilde{G}	1.88	1.20	0.06	0.56	1.00	0.56	0.06	-0.22	-0.08	0.04	0.05	0.15
\tilde{X}	4.41	2.82	-0.16	0.48	1.00	0.48	-0.16	0.28	0.49	0.41	-0.16	-0.55
\tilde{M}	4.61	2.95	-0.17	0.33	1.00	0.33	-0.17	-0.16	0.20	0.67	0.41	-0.16
\tilde{H}	1.68	1.08	0.17	0.68	1.00	0.68	0.17	-0.16	0.17	0.64	0.62	0.17
Q	8.54	5.46	0.90	0.94	1.00	0.94	0.90	0.05	0.03	-0.06	-0.13	-0.09
CA	1.61	1.03	0.32	0.58	1.00	0.58	0.32	0.39	0.38	0.03	-0.29	-0.31

Note: \tilde{Y} , \tilde{C} , \tilde{I} , \tilde{G} , \tilde{X} , \tilde{M} and \tilde{H} are the business cycle components of the HP-filtered series Y , C , I , G , X , M and H in natural logs with the smoothness parameter, λ , set to 100. See Appendix A for a detailed description of the data set and exact definitions of variables.

The figures in Table 1 compare well with Englund et al. (1992) and Hassler et al. (1994) in several respects, but there are some exceptions. First of all, while the variability in \tilde{Y} is unchanged, the variability of \tilde{C} , \tilde{I} and \tilde{H} relative to \tilde{Y} is larger than previously reported due to the deep recession in the 1990s. In standard real business cycle models for closed economies, the volatility of consumption is lower than the volatility in output since agents want to smooth consumption over time, a feature that is clearly at odds with Swedish postwar data. Unlike Hassler et al. (1994), we find evidence that exports, \tilde{X} , and the current account, CA , lead the business cycle while \tilde{H} tend to lag the business cycle when including the most recent experience.

¹² It should be emphasized that the series used for hours worked have been detrended with the HP-filter although it is stationary in the model. On U.S. data, it is no problem to treat hours of work as a stationary variable; the standard deviation of hours worked is roughly the same as output for U.S. data, see e.g. Cooley and Prescott (1995). On Swedish data, treating hours of work per worker as a stationary variable in the data leads to big problems because there is a strong negative trend in hours worked during the postwar period (see Figure 1). If hours worked, in accordance with the theoretical model, is not HP-filtered, the standard deviation of hours worked is about 5.2 times higher than the standard deviation of output. This number is unfeasible to match for any currently written down model in the RBC-literature when it is solved around a constant steady-state, and would severely distort the SMM estimation results. Therefore, I have chosen to follow JK96 and subject hours of work per worker in logs to the HP-filter.

Although \tilde{X} is positively correlated with \tilde{Y} contemporaneously, CA is not because imports, \tilde{M} , has a very strong positive contemporaneous correlation with \tilde{Y} which tends to deteriorate the CA and thus the contemporaneous correlation of CA with \tilde{Y} .

IV. Estimation and calibration

The parameters in the model are estimated in two ways. The deep parameters in the model are chosen so that the estimated models' steady-state properties are consistent with average features in Swedish postwar data. The fiscal policy VAR(p) model is estimated with maximum likelihood. The parameters in the processes for the foreign real interest rate, R_t^* , the stochastic part of foreign demand, \tilde{Y}_t^* , and the domestic technology level, Z_t , are estimated with SMM, since no direct accessible data exist for these variables. There are two nested alternatives I could have pursued: (a) include also the deep parameters in the SMM estimation, or (b) calibrate also the parameters in the stochastic processes. My view is that approach (b) is not desirable because one could presumably come up with very different estimates of these series, which would strongly affect the conclusions. And since the answer to the questions that this paper addresses are heavily dependent on these parameters, SMM has the advantage that it provides us with an "objective" set of parameters. I am more positive to approach (a), but in practice, due to data limitations (we only have 46 observations), this approach could easily lead to problems because of too few degrees of freedom. Another potential problem is that the loss function that one tries to minimize is not sufficiently concave for all the deep parameters, and one could easily end up in local minima, depending on the starting point. A final problem when estimating all parameters with SMM is that one can end up with unreasonable estimates for some deep parameters, i.e. parameters that are inconsistent with growth facts.

As noted by e.g. Ingram et al. (1994), there must be as many shocks as endogenous variables

in the equilibrium model, otherwise the model exhibit stochastic singularity and is impossible to estimate. Since the models considered here exhibit this property of stochastic singularity (in particular, this is true for the model without fiscal policy), I have overcome this problem by adding measurement errors to all the variables in the aggregate resource constraint in equation (16) as in Söderlind and Vredin (1996). These measurement errors have been set to match the measurement errors in the Swedish national accounts for these components that existed prior to 1991.

Calibration

The deterministic steady-state growth rate for output, γ , is set to 0.021, which is the average growth rate for Y in the sample. The share of gross capital income to output, θ , is set equal to 0.355, which is 1 minus the average gross wage sum as a fraction of Y in the data. The share of intermediate inputs in the production function, θ_{IM} , and the share of total consumption that are domestic goods, η , are taken from Statistics Sweden's (1985) input-output tables and set equal to 0.166 and 0.774, respectively. ϵ^X , the price elasticity of foreign demand w.r.t. the real exchange rate, is set equal to 1 which is an average value of Johansson's (1998) estimates for manufactured goods and services sectors. To calibrate δ , I exploited the law of motion for capital in the steady state written as $\delta = \frac{\bar{I}}{\bar{Y}} \frac{\bar{Y}}{\bar{K}} - \gamma$, and used the estimated capital stock in Hansson (1991), GDP at factor costs and gross investment (private as well as public) for the time period 1960-1988 to compute $\delta = 0.122$ on average. The utility function parameter α is set to 0.33 for reasons discussed in Kydland (1995). σ , which measure the agents' risk aversion is set to 2, and β , the subjective discount factor is set to 0.96. Both these values are standard in the literature. The steady-state value for public expenditure, \bar{G} , is calibrated so that steady-state public expenditure as a fraction of output, \bar{g} , equal 0.299, which is the sample mean of g_t . I set

$\bar{\tau}^c = 0.177$ and $\bar{\tau}^w = 0.176$ which are the sample means for τ_t^c and τ_t^w , respectively. Finally, steady-state foreign income is by construction equal to the value of exports.¹³

The fiscal policy VAR(p) model

In the estimation of the fiscal policy VAR(p) model, I demeaned the variables in (17) prior to estimation. Different specification tests and information criteria suggested setting $p = 1$. The estimate of $\hat{\varphi}_1$ in (17) shows that the autocorrelations for τ_t^c and τ_t^w are high, 0.933 and 0.975 respectively, while the autocorrelation for HP-filtered public expenditure in natural logs, \tilde{G}_t , is considerably lower (0.568). The notably high autocorrelations for τ_t^c and τ_t^w are of course a consequence of not detrending them, although they exhibit strong trends.¹⁴

The SMM estimation

Broadly speaking, the SMM estimator (see Lee and Ingram, 1991) chooses estimates of the unknown parameters so as to make the chosen moments in the model mimic the corresponding moments in the data. Let \mathbf{m}_T denote a $j \times 1$ vector with j sample moments in data and $\mathbf{m}_N(\hat{\beta})$ the corresponding simulated moments in the model, where T denotes the number of observations in the data, N the considered number of simulated observations in the model and $\hat{\beta}$ the $k \times 1$ vector with estimated parameters. The SMM estimator minimizes the loss-function

$$T * \left(\mathbf{m}_T - \mathbf{m}_N(\hat{\beta}) \right)' \mathbf{W}_T * \left(\mathbf{m}_T - \mathbf{m}_N(\hat{\beta}) \right) \quad (18)$$

which is χ^2 -distributed with $j - k$ degrees of freedom if \mathbf{W}_T in (18) is a positive definite weighting matrix chosen to give the minimum asymptotic variance of $\hat{\beta}$.¹⁵

¹³ This implies that I consider a steady state where $\bar{B}^* = 0$ and $\bar{Q} = 1$.

¹⁴ For a constant steady state to exist in the model, it is required that all eigenvalues z satisfy $\det(\mathbf{I}_3 z - \varphi_1) \in (-1, 1)$. This condition is met for the estimate of φ_1 in (17).

¹⁵ Since I have implemented SMM the same way as JK96, see their excellent summary of SMM in Appendix B for more technical details. However, there are two things worth mentioning in addition to their exposition there. The first thing is that I have followed Newey and West's (1994) recommendation in setting the bandwidth $p = 4(T/100)^{2/9}$ for the Bartlett kernel in the calculation of the variance-covariance matrix. Second, I have simulated the model 400 times and skipped the first 100 numbers in each simulation to get a stochastic initial state. Thus $N = 300$ and $T = 46$.

Since the number of observations to compute the moments in the data are only 45, we face a potential small sample problem when testing the models' empirical fit with the data using the asymptotic critical values for the χ^2 test-statistic in (18). To examine the importance of the small sample problem, I have computed the correct critical values for the test-statistic in (18) under the null hypothesis that the data used to compute the moments \mathbf{m}_T are generated by the equilibrium model using the SMM estimates in $\hat{\beta}$.¹⁶

I have chosen to use moments which highlight three dimensions in the model: the volatility dimension, the contemporaneous correlation dimension, and the autocorrelation dimension. I have also followed the convention in the literature and related volatilities and contemporaneous correlations for the different variables (consumption, investment, hours worked, real exchange rate, and the current account) to output. Thus, the following 17 moments are included in the SMM estimation¹⁷

$$\mathbf{m} = \left[\begin{array}{c} \text{std}(\tilde{Y}_t), \frac{\text{std}(\tilde{C}_t)}{\text{std}(\tilde{Y}_t)}, \frac{\text{std}(\tilde{I}_t)}{\text{std}(\tilde{Y}_t)}, \frac{\text{std}(\tilde{H}_t)}{\text{std}(\tilde{Y}_t)}, \frac{\text{std}(Q_t)}{\text{std}(\tilde{Y}_t)}, \frac{\text{std}(CA_t)}{\text{std}(\tilde{Y}_t)}, \\ \text{corr}(\tilde{C}_t, \tilde{Y}_t), \text{corr}(\tilde{I}_t, \tilde{Y}_t), \text{corr}(\tilde{H}_t, \tilde{Y}_t), \text{corr}(Q_t, \tilde{Y}_t), \text{corr}(CA_t, \tilde{Y}_t), \\ \text{corr}(\tilde{Y}_t, \tilde{Y}_{t-1}), \text{corr}(\tilde{C}_t, \tilde{C}_{t-1}), \text{corr}(\tilde{I}_t, \tilde{I}_{t-1}), \text{corr}(\tilde{H}_t, \tilde{H}_{t-1}), \text{corr}(Q_t, Q_{t-1}), \text{corr}(CA_t, CA_{t-1}) \end{array} \right] \quad (19)$$

V. Empirical results

SMM estimation of the models

The results of the SMM estimation are reported in Tables 2 and 3.

¹⁶ More specifically, the procedure in the Monte-Carlo simulations have been as follows. First, generate an artificial sample of 45 observations by simulating the estimated equilibrium model. Second, I reestimate the fiscal policy VAR(1)-model on the simulated data. Third, using the same values for the deep parameters and the reestimated VAR(1)-model, I reestimate the equilibrium model with SMM and record the SMM estimate and the value of the χ^2 -statistic. By repeating step 1 to 3 1000 times, we obtain distributions with SMM estimates and χ^2 -statistics. From these distributions, it is straightforward to compute the small sample critical values for the χ^2 -statistic and standard errors for the SMM estimates.

¹⁷ Of course, it would be of interest to extend the moment set for the model with fiscal policy with the variables \tilde{G}_t , τ_t^c and τ_t^w to be able to ensure that the propagation mechanisms in the model are correct. But since they are not the target variables here, and it is of interest to compare the goodness-of-fit criterion in the model with fiscal policy with the one without, I have chosen not to include them.

Table 2: SMM estimates.

Model version	SMM point estimate of					
	ρ_{R^*}	$\sigma_{R^*}^2$	$\rho_{\tilde{Y}^*}$	$\sigma_{\tilde{Y}^*}^2$	$\rho_{\ln Z}$	$\sigma_{\ln Z}^2$
No Fiscal Policy	0.012 (0.165)	0.00064 (0.00076)	0.721 (0.072)	0.00487 (0.00140)	0.928 (0.036)	0.00064 (0.00004)
With Fiscal Policy	0.492 (0.115)	0.00165 (0.00185)	0.694 (0.112)	0.00233 (0.00153)	0.722 (0.076)	0.00014 (0.00006)

Note: Standard errors in parentheses. The standard errors have been generated by means of a Monte-Carlo simulation described in Section 4.3.1.

The point estimates in Table 2 are very reasonable for the model with fiscal policy shocks included, and could have been the outcome of an ordinary calibration procedure. For the model without fiscal policy, the estimated persistence in the foreign real interest rate seems unreasonably low, which is an indication that this model is misspecified.¹⁸ As expected we also see that the estimates for the domestic technology level are very different, both estimated persistence and variance are much higher in the model without fiscal policy included. The reason for this is that in the absence of fiscal policy shocks, technology shocks must account for more of the fluctuations in the economy.

Table 3 reports the estimated moments and their empirical counterparts along with the chi-square goodness-of-fit statistic. As in JK96, the introduction of stochastic fiscal policy clearly improves the empirical fit of the model, although it does not change the results significantly in this open economy framework. None of the models are rejected by the data when small-sample (correct) adjusted critical values are used, and both models are strongly rejected using asymptotic significance levels.

In particular, we note that the model with fiscal policy replicates the behavior of the variables \tilde{Y} , Q and CA very well, which is a good thing since we are particularly interested in investigating what the forces are behind the fluctuations in these variables. For the variables \tilde{C} , \tilde{I} and \tilde{H} ,

¹⁸ There are both theoretical and empirical arguments why the real interest rate should be positively autocorrelated. The theoretical argument is that if foreign business cycles are driven by positively autocorrelated technology shocks (which is the case according to the RBC-literature), the equilibrium real interest rate will be positively autocorrelated as well. The empirical evidence supports this view. Laubach and Williams (2002) estimate the real interest rate for the U.S., and find that it is highly persistent using both the one- and two-sided Kalman filter (see their Figure 1).

the model performs less well; but before rejecting the properties of the model in this sense, the impact of the deep recession in the 1990s should be kept in mind.

Table 3: SMM estimated moments and goodness-of-fit statistics.

Moment	Estimate in model with		Empirical
	No fiscal policy	Fiscal policy	
$\text{std}(\tilde{Y}_t) * 100$	1.28	1.44	1.56
$\text{std}(\tilde{C}_t) / \text{std}(\tilde{Y}_t)$	1.19	1.20	1.44
$\text{std}(\tilde{I}_t) / \text{std}(\tilde{Y}_t)$	2.74	3.21	6.04
$\text{std}(\tilde{H}_t) / \text{std}(\tilde{Y}_t)$	0.41	0.83	1.03
$\text{std}(Q_t) / \text{std}(\tilde{Y}_t)$	6.23	5.03	5.49
$\text{std}(CA_t) / \text{std}(\tilde{Y}_t)$	1.18	0.72	1.08
$\text{corr}(\tilde{C}_t, \tilde{Y}_t)$	0.67	0.66	0.49
$\text{corr}(\tilde{I}_t, \tilde{Y}_t)$	0.70	0.70	0.77
$\text{corr}(\tilde{H}_t, \tilde{Y}_t)$	0.55	0.64	0.64
$\text{corr}(Q_t, \tilde{Y}_t)$	0.22	0.21	-0.06
$\text{corr}(CA_t, \tilde{Y}_t)$	-0.04	0.02	0.02
$\text{corr}(\tilde{Y}_t, \tilde{Y}_{t-1})$	0.49	0.40	0.38
$\text{corr}(\tilde{C}_t, \tilde{C}_{t-1})$	0.17	0.40	0.46
$\text{corr}(\tilde{I}_t, \tilde{I}_{t-1})$	0.38	0.28	0.48
$\text{corr}(\tilde{H}_t, \tilde{H}_{t-1})$	0.37	0.46	0.68
$\text{corr}(Q_t, Q_{t-1})$	0.91	0.86	0.94
$\text{corr}(CA_t, CA_{t-1})$	0.65	0.53	0.58
χ_{obs}^2	136.39	41.35	
$p_{\text{asy}}\text{-value}$	0.00	0.00	
$p_{\text{obs}}\text{-value}$	0.39	0.79	

Note: The standard deviation in \tilde{Y} and the relative standard deviations in \tilde{C} , \tilde{I} , \tilde{H} , Q and CA to \tilde{Y} are somewhat different than the one reported in Table 1, since the first year in the data set has been left out here for estimation technical reasons (due to the computation of the weighting matrix \mathbf{W}_T). The same explanation applies for the contemporaneous correlations between these variables. \tilde{C}/\tilde{I} include consumption/investment of both domestic and foreign goods. The p_{obs} - and p_{asy} -values measures the probability of getting a higher value of χ^2 than χ_{obs}^2 using small-sample adjusted/asymptotic critical values.

Variance decomposition of the volatilities

To investigate the relative importance of foreign and domestic shocks for the key macro variables \tilde{Y} , Q and CA , I follow Sims (1980) and use the variance decomposition method to measure the fraction of simulated volatility in a variable k years ahead accounted for by different shocks. In general, this method has the big drawback that the identifying assumptions, i.e. the order of the variables/shocks in the system, are of substantial importance since the estimated disturbance vector is orthogonalized by a Cholesky decomposition. But since the focus of the paper is to investigate the relative importance between foreign and domestic shocks, and thus the fiscal policy innovations as a whole rather than the relative importance among them, the effects of different ordering of the innovations have no importance here due to the assumption that the processes for R^* , \tilde{Y}^* and $\ln Z$ are univariate AR(1)-processes. Completely arbitrarily, then, I chose the following order: R^* , \tilde{Y}^* , $\ln Z$, \tilde{G} , τ^c and τ^w .

Table 4: Variance decomposition k years ahead.

Due to shock	Fraction of simulated volatility k years ahead in variable											
	\tilde{Y}				Q				CA			
	k				k				k			
	1	5	10	50	1	5	10	50	1	5	10	50
R^*	0.12	0.12	0.10	0.07	0.71	0.42	0.35	0.27	0.36	0.29	0.29	0.29
\tilde{Y}^*	0.24	0.12	0.10	0.09	0.28	0.54	0.60	0.64	0.64	0.71	0.71	0.71
$\ln Z$	0.46	0.41	0.33	0.20	0.01	0.02	0.02	0.01	0.00	0.00	0.00	0.00
\tilde{G}	0.03	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
τ^c	0.09	0.17	0.21	0.22	0.00	0.01	0.01	0.03	0.00	0.00	0.00	0.00
τ^w	0.06	0.15	0.23	0.40	0.00	0.01	0.02	0.05	0.00	0.00	0.00	0.00
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Note: The variance decomposition has been made in natural logs for Y around its trend and in natural numbers for the stationary variables Q and CA . The fractions reported above have been calculated by analyzing the effects of a one standard deviation increase in each of the shocks at a time.

In Table 4, I present the results for different horizons. The short-run impact of a shock is captured by k equal to 1 and 5, and the long-run by k equal to 10 and 50. From the table,

we see that domestic shocks account for most of the volatility in output per capita, \tilde{Y} . In the short run, innovations in productivity are most important, and account for over 40 percent of the volatility in \tilde{Y} . But in the long run, fiscal policy shocks, in particular shocks to τ^w , become the most important source of output fluctuations.¹⁹

The results in Table 4 suggest that innovations in fiscal policy are very important for fluctuations in output, especially in the long run. However, they differ in one important aspect. JK96 found that it was innovations in the exogenous ratio of government expenditure to output, g , which contributed to most of the fluctuations in output in the long run among the fiscal policy variables. Here, with the same ordering of the fiscal policy variables I find that innovations in the level of government expenditure seems to be relatively unimportant in the long run. The explanation is that JK96, which model the ratio of government expenditure to output ($g = G/Y$) instead of G as an exogenous variable, do not HP-filter g ; *a priori* and in line with the theoretical model they treat it as a zero trend variable together with τ^c and τ^w , while I HP-filter G .

Englund et al. (1994), who use vector autoregressions (VARs) to investigate the sources of business cycles report that foreign shocks account for 13 percent of the fluctuations in \tilde{Y} in the short run and 47 percent in the long run. The corresponding figures here are 36 and 16 percent. Consequently, my point estimates are in the higher/lower end in the short/long run. Using results from the Monte-Carlo simulations, it can be shown that a 95-percent confidence interval for the long-run importance of foreign shocks is 12 – 35 percent. Thus, my findings for the postwar period suggest a smaller role for foreign shocks for output fluctuations compared to the results reported by Englund et al. (1994) for the 1871 – 1990 period. It can be shown that one important reason for our different findings is that fiscal policy shocks have been so persistent

¹⁹ I have tested the sensitivity of the results in Table 4 for the fiscal policy shocks w.r.t. the ordering of the fiscal policy variables. It turned out that the relative importance of innovations in \tilde{G} , τ^c and τ^w crucially depends on the ordering of these variables. For instance, if τ^w changes place with \tilde{G} , it becomes the only important source of fluctuations among the fiscal policy variables.

due to the expanding welfare state in Sweden in the postwar period.²⁰

Foreign shocks are much more important for fluctuations in the real exchange rate (\tilde{Q}). For the current account (\widetilde{CA}) we find that only fluctuations in foreign variables matter. Using Swedish data, Mellander et al. (1992) find that foreign shocks account for all the variability in \tilde{Q} and \widetilde{CA} in the long run, results that are replicated here within an equilibrium framework.

VI. Concluding remarks

The main results in the paper are as follows. First, I find that the introduction of fiscal policy improves the empirical fit of the model, but not significantly so when the series for hours worked is HP-filtered. None of the models are rejected by the data using correct significance levels, whereas both are strongly rejected using asymptotic levels. Second, I find that foreign shocks are important for output fluctuations in the short run, but less important in the long run. In the long run, fiscal policy shocks are found to be of decisive importance during this period. I interpret this as due to the build-up of the welfare state.

Export and import shares of GDP have increased strongly during the postwar period, from around 15 to approximately 40 percent. Likewise, it is the case that the larger public sector has crowded out private consumption in particular during the period, but to a lesser extent. These structural changes have not been taken into account in the analysis, and it is my hope that possible transition effects are of second order compared to the effects I do study. More research is warranted to investigate this issue further.

Unlike the U.S., I have also documented that hours worked per worker have dropped dramat-

²⁰ I have estimated the model with SMM when τ^c and τ^w in (17), together with Q and CA are all HP-filtered to remove the strong trends in these variables in order to provide a setting that compares more favorably to Englund et al. In this setting, we find that the importance of fiscal policy shocks for fluctuations in output are now considerably moderated in the long run, and innovations in fiscal policy are now only of equal importance as foreign and technology shocks. The results for the short-run horizon are very similar, so the effects of not detrending τ^c and τ^w mainly affects the long-run results. Moreover, in this setting it can be shown that a Monte-Carlo simulated 95-percent confidence interval for the long-run importance of foreign shocks is 29 – 52 percent, a result not inconsistent with the results by Englund et al.

ically by about 20 percent during the postwar period. It would be very interesting to examine which factors account for this large decline. One possible explanation is the build-up of the welfare state.

As in the previous literature, fiscal policy is treated as an exogenous, non-optimal process. It would be an interesting extension to consider the effects of endogenous, perhaps optimal, fiscal policy. However, for the questions addressed by this paper, which are positive rather than normative, this is not necessarily an important issue.

Another possible limitation is that there is no money in the model. The reason for this is that only real variables are of interest here, and unless one is willing to impose some rigidities, money shocks seems to be unimportant for real variables in both the short and the long run. Even if one imposes some rigidities, money only seems to have a limited effect in the short run and be neutral in the long run, see e.g. Cooley and Hansen (1995) for further details. However, one extension of the work here would be to consider the short-run effects of money shocks in a model with nominal rigidities.

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Appendix A Computation of equilibrium

A well-known feature of the solution to the model is that output, consumption, investment, public expenditure, exports, imports, capital stock and foreign bondholdings grow at the deterministic rate γ in steady state, while the share of available time spent in paid employment, the real exchange rate and the current account are constant over time; see Hansen and Prescott (1995). In this paper, I have followed the convention in the literature and growth-adjusted the model by dividing the following variables by the constant growth factor:

$$\begin{aligned}\hat{Y}_t &\equiv \frac{Y_t}{T_t^H}, \hat{C}_t = \frac{C_t}{T_t^H}, \hat{c}_t = \frac{c_t}{T_t^H}, \hat{C}_t^* = \frac{C_t^*}{T_t^H}, \hat{c}_t^* = \frac{c_t^*}{T_t^H}, \hat{I}_t = \frac{I_t}{T_t^H}, \\ \hat{i}_t &= \frac{i_t}{T_t^H}, \widehat{IM}_t = \frac{IM_t}{T_t^H}, \hat{K}_t = \frac{K_t}{T_t^H}, \hat{k}_t = \frac{k_t}{T_t^H}, \hat{B}_t^* = \frac{B_t}{T_t^H} \text{ and } \hat{b}_t^* = \frac{b_t}{T_t^H}.\end{aligned}$$

We then interpret the newly defined variables as per efficiency units of labor.

Following Hansen and Prescott (1995), the representative agent's optimization problem can then be expressed as the recursive dynamic programming problem:

$$\begin{aligned}V(\mathbf{S}_t, \hat{K}_t, \hat{B}_t^*, \hat{k}_t, \hat{b}_t^*) &\equiv \max_{\{\hat{c}_t^*, h_t, \hat{k}_{t+1}, \hat{b}_{t+1}^*\}} \left[u(\hat{c}_t, \hat{c}_t^*, h_t) + \tilde{\beta} E_t V(\mathbf{S}_{t+1}, \hat{K}_{t+1}, \hat{B}_{t+1}^*, \hat{k}_{t+1}, \hat{b}_{t+1}^*) \right] \\ & \text{s.t.} \end{aligned} \tag{A.1}$$

$$\hat{c}_t = -Q_t \hat{c}_t^* + \frac{1}{1 + \tau_t^c} \left[\frac{W_t}{1 + \tau_t^w} h_t + (1 + R_t^K - \delta) \hat{k}_t - (1 + \gamma) \hat{k}_{t+1} + TR_t + Q_t (1 + R_t^{B^*}) \hat{b}_t^* - Q_t \hat{b}_{t+1}^* \right],$$

$$\mathbf{S}_{t+1} = \mathbf{A} \mathbf{S}_t + \boldsymbol{\varepsilon}_{t+1}^{\mathbf{S}},$$

$$(1 + \gamma) \hat{K}_{t+1} = (1 - \delta) \hat{K}_t + \hat{I}_t, \quad (1 + \gamma) \hat{k}_{t+1} = (1 - \delta) \hat{k}_t + \hat{i}_t,$$

$$\hat{K}_{t+1} = \hat{K}(\hat{K}_t, \hat{B}_t^*, \mathbf{S}_t), \quad \hat{B}_{t+1}^* = \hat{B}^*(\hat{K}_t, \hat{B}_t^*, \mathbf{S}_t), \quad H_t = H(\hat{K}_t, \hat{B}_t^*, \mathbf{S}_t).$$

In (A.1), $\tilde{\beta} \equiv \beta(1 + \gamma)^{\alpha(1 - \sigma)}$ is the effective subjective discounted factor and \mathbf{S}_t is a vector which contains all the exogenous aggregate state variables; for instance, if the VAR model in

(17) is of order one, then \mathbf{S}_t could be $\left[\ln Z_t, \tilde{Y}_t^*, R_t^*, \tilde{G}_t, \tau_t^c, \tau_t^w\right]^T$.²¹ In the maximizing of (A.1), the agent takes the economy-wide average variables $W_t, R_t^K, R_t^{B^*}, Q_t$ and TR_t as given. The functions \hat{K}, \hat{B}^* and H describe the relationship perceived by agents between the aggregate decision variables and the state of the economy. As the solution to the problem in (A.1), we have the individual agent's decision rules $\hat{k}_{t+1} = \hat{k}(\hat{K}_t, \hat{k}_t, \hat{B}_t^*, \hat{b}_t^*, \mathbf{S}_t)$, $\hat{b}_{t+1}^* = \hat{b}^*(\hat{K}_t, \hat{k}_t, \hat{B}_t^*, \hat{b}_t^*, \mathbf{S}_t)$ and $h_t = h(\hat{K}_t, \hat{k}_t, \hat{B}_t^*, \hat{b}_t^*, \mathbf{S}_t)$. The competitive equilibrium is obtained when the individual and average decision rules coincide for $\hat{k}_t = \hat{K}_t$ and $\hat{b}_t^* = \hat{B}_t^*$.

Since it is impossible to derive the decision rules analytically, I have used the conventional method of calculating the decision rules numerically by approximating the original problem with a second order Taylor expansion around the constant steady-state values in the growth-adjusted economy. As a consequence of this approximation, the method produces linear decision rules. The algorithm utilized is documented in Klein (1994). I have also followed the convention in the literature and solved for the decision rules in natural logs for \hat{k} and h . Hence, the competitive equilibrium is computed by solving a fixed point problem where each agent's decision rules must be optimal given the aggregate decision rules in the economy.

Appendix B Data sources and definitions

In this appendix, I present exact sources for the data set and exact definitions of the composite variables used. Table B.1 displays the exact sources of the data. In Table B.2, I provide exact definitions of composite variables, following the notation in Section 2.1.

To give a motivation for the definitions of the variables in the national account block, I start

²¹ As a consequence of the growth adjustment, the production function reads $\hat{Y}_t = e^{\ln Z_t} \left(\widehat{IM}_t^{\theta_{IM}} \hat{K}_t^{1-\theta_{IM}}\right)^\theta H_t^{1-\theta}$. Hence, the wage rate, real rental price of capital and real exchange rate are now redefined as $W_t = (1-\theta) e^{\ln Z_t} \left(\widehat{IM}_t^{\theta_{IM}} \hat{K}_t^{1-\theta_{IM}} H_t^{-1}\right)^\theta$, $R_t^K = \theta(1-\theta_{IM}) e^{\ln Z_t} \left(\widehat{IM}_t^{\theta_{IM}} \hat{K}_t^{1-\theta_{IM}} H_t^{-1}\right)^\theta \left(H_t/\hat{K}_t\right)$ and $Q_t = \theta\theta_{IM} e^{\ln Z_t} \left(\widehat{IM}_t^{\theta_{IM}} \hat{K}_t^{1-\theta_{IM}} H_t^{-1}\right)^\theta \left(H_t/\widehat{IM}_t\right)$. Similarly, we have $R_t^{B^*} = \frac{\omega_0 \bar{Y} + \omega_1 \hat{B}_t^*}{\omega_0 \bar{Y} + \hat{B}_t^*} R_t^*$.

out from the nominal

$$P_t^{YM} Y_t^M = P_t^{CP} CP_t + P_t^{CG} CG_t + P_t^{IG} IG_t + P_t^{IP} IB_t + P_t^{II} II_t + P_t^X X_t - P_t^M M_t \quad (\text{B.2})$$

and real

$$Y_t^M = CP_t + CG_t + IG_t + IB_t + II_t + X_t - M_t \quad (\text{B.3})$$

GDP identities where the nominal holds for the whole sample period while the real only holds exactly from 1991 to 1995. In addition, it is the case that

$$P_t^{YM} Y_t^M = P_t^{YF} Y_t^F + P_t^{TI} T_t^I - P_t^{TS} T_t^S \quad (\text{B.4})$$

holds in the data from 1950 to 1995. Unfortunately, no data on P_t^{YF} , Y_t^F , P_t^{TI} , T_t^I , P_t^{TS} and T_t^S exist. It is only possible to acquire data on $P_t^{YF} Y_t^F$, $P_t^{TI} T_t^I$ and $P_t^{TS} T_t^S$. This creates a data problem since the most adequate measure of production in the model, Y_t , is Y_t^F in the data. As noted in Hassler et al. (1994) and Englund et al. (1992), the way one handles this problem is also of quantitative importance. Here, I have followed the strategy in Hassler et al. (1992) and accepted the GDP-deflator at market prices, P_t^{YM} , as proxy for P_t^{YF} , P_t^{TI} and P_t^{TS} . By combining (B.3) and (B.4), I then obtain

$$\frac{P_t^{YF} Y_t^F}{P_t^{YM}} = CP_t - \frac{P_t^{TI} T_t^I - P_t^{TS} T_t^S}{P_t^{YM}} + CG_t + IG_t + IB_t + II_t + X_t - M_t \quad (\text{B.5})$$

which forms the basis for the definitions of many variables used.²²

²² However, it should be emphasized that by using (B.5), one still has a considerable measurement error between 1950 and 1989 due to the measurement error for (B.3) in the Swedish national accounts. An alternative way then to get rid of the measurement error would be to combine (B.2) and (B.4) and divide through with P_t^{YM} as in Englund et al. (1992).

Table B.1: The data set.

Variables	Sample period	Source
GDPMN and GDPM	1950-1995	SCB TSDB
GDPFN	1950-1995	SCB TSDB
TINDN and TSUBN	1950-1995	SCB TSDB
CPN and CP	1950-1995	SCB TSDB
CGN, IGN, CG and IG	1950-1995	SCB TSDB
IBN, IIN, IB and II	1950-1995	SCB TSDB
XN, MN, X and M	1950-1995	SCB TSDB
MFMT	1950-1995	SCB TSDB
HWT	1950-1969	Jonsson and Klein (1996)
HWT	1970-1979	SCB, N10 SM 8901 Table H:5 last row
HWT	1980-1995	SCB, N10 SM 9601 Table 6 last row
WSISIFN and SIFN	1950-1969	SCB, N 1971:11 Table 5 rows 1, 14
WSISIFN and SIFN	1970-1979	SCB, N10 SM 8601 Table H:12 rows 1, 19
WSISIFN and SIFN	1980-1995	SCB, N10 SM 9601 Table 7, rows 1, 19
CAN	1950-1995	Sveriges Riksbank, Fredrika Röckert

Note: All real macroeconomic variables are measured in 1991 prices in millions. SCB stands for Statistics Sweden, TSDB for SCB's time series database, Sveriges Riksbank for Bank of Sweden. Abbreviations; GDPMN and GDPM denote GDP at market prices in nominal and real terms; GDPFN nominal GDP at factor prices; TINDN and TSUBN nominal indirect tax revenues and various subsidies; CPN and CP nominal and real private consumption expenditures; CGN, IGN, CG and IG public consumption and investment in nominal and real terms; IBN, IIN, IB and II nominal and real business and inventory investments; XN, MN, X and M nominal and real exports and imports; MFMT average population in thousands; HWT total hours worked in millions; WSISIFN and SIFN total nominal wage sum including social insurance fees and nominal social insurance fees respectively; CAN the nominal current account.

Table B.2: Generation of composite data series.

Variable	Calculation formula
Y	$GDPFN / ((GDPMN / GDPM) / MFMT)$
C	$CP / MFMT - (TINDN - TSUBN) / ((GDPMN / GDPM) / MFMT)$
G	$(CG + IG) / MFMT$
g	$(CG + IG) / (GDPFN / ((GDPMN / GDPM)))$
I	$(IB + II) / MFMT$
X	$X / MFMT$
M	$M / MFMT$
H	$HWT * 1000 / MFMT$
CA	$CAN / GDPFN$
Q	$(ZN / Z) / (XN / X)$
τ^c	$(TINDN - TSUBN) / CPN$
τ^w	$SIFN / (WSISIFN - SIFN)$

Note: Y , C , G , I , X , M and H are then subject to Hodrick-Prescott filtering in natural logs, as described in Section 3.2. The ω_i weights from the TCW currency basket index are normalized so that they sum to 1.