Wars as Large Depreciation Shocks*

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Abstract

In this paper, we propose a theoretical framework to investigate the impact of conflicts and wars on key macroeconomic aggregates and welfare. Using a panel data with 9 countries from 1870 onwards, we first show that the consumption-to-output ratio is minimal during WWII for participants. While this can be explained by an increase in public spending in the USA, this can not be the case in other countries that participated in WWII, as they experience a large fall in output during wartime. To account for this, we build a variation of a Real Business Cycle model first proposed by Hercowitz and Sampson [1991]. We extend the initial model to account for specific shocks that destroy private and public capital stocks – as conflicts do – by assuming an (exogenously) time-varying depreciation rate of the stock of capital. In addition, the model imbeds generalized TFP shocks capturing standard technological factors as well as the potential effects of war on the labor force. The model is estimated and used (*i*) to assess the importance of depreciation shocks during war episodes, and (*ii*) to quantify the welfare effects of conflicts. We show that depreciation shocks are crucial to account for the macroeconomic dynamics of countries that have experienced large war-related destructions, and that the welfare losses from fluctuations can be quite large when considering data samples that include major war episodes.

Keywords: War, military conflicts, depreciation shocks, real business cycle model, random coefficient autoregressive model.

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1 Introduction

Wars and conflicts destroy both human and physical capital, with dramatic consequences on the economy. Yet this simple assessment received little attention in the literature on war economics. This paper is an attempt to model wars and conflicts in their destructive dimension, so as to analyze their effects on key macroeconomic aggregates and welfare.

Using post–war data for developed countries has become customary in the current macro-econometric literature. At first sight, one reason may be that the relevance of the neoclassical framework during war episodes is questionable. Wars may induce very large shocks in the economy. This is at odd with the usual practice that considers small perturbations around a deterministic steady state and uses linear approximations of equilibrium conditions to characterize models dynamics. Further, the modern macro-econometric literature typically treats government spending as unanticipated "shocks" while central policies may account for more than half of the GDP during major conflicts.

Despite these difficulties, several recent empirical works have emphasized the importance of a careful look at military and conflict data in macroeconomics. Braun and McGrattan [1993] and McGrattan and Ohanian [2010] show that properly written Real Business Cycle (RBC hereafter) models are able to capture many economic phenomena of World War II (WWII hereafter) in the USA or in the UK. One of the reason may be the following: even during war episodes the very basic needs – consumption – and means of production – capital and labor – remain and RBC models precisely rely on these basic means and needs. Also, Ramey [2011] emphasizes that much of the variability of the shocks in public expenditure is explained by military expenditures because other sources of public expenditures (education, health, ...) are much more stable over time. Hence, once trends are removed, unexpected shocks in public expenditures are mainly military. Moreover, the "narrative approach" (Ramey and Shapiro [1997]) highlights the role of war/peace episodes in the identification of unexpected fiscal shocks. Ramey [2011] argues that the distinction between military and civilian public expenditures induces major differences in the analysis of private responses to unexpected central policy shocks.

In addition, much empirical effort has been devoted to precise accounting of the costs of war. Most empirical contributions show that net effects of wars (including destructions and potential positive effects induced by larger public expenditures, R&D) are negative. For instance, Collier

[1999] argues that a civil war might cause a 2.2 percentage point loss in the annual growth rate. A welfare analysis conducted by Blomberg and Hess [2012] shows that agents would be willing to give up about 7% of permanent consumption to live in a peaceful world. Bilmes and Stiglitz [2008] count the cost of Iraq war in trillions of dollars, highlighting that globalization and technical progress make wars more costly. The massive role played by engineering and logistics problems has also been made clear for WWII while specialists of WWI put forth the major impact of human losses.

Adopting an alternative perspective, Martin, Mayer and Thoenig [2008] identify the impact of international trade on the occurrence of armed conflicts. Using an extensive data set on bilateral trade and armed conflicts, they show that increasing bilateral trade flows (through bilateral trade agreements for example) significantly reduces the probability of armed conflict with the corresponding trade partner without increasing the probability of conflicts with other trade partners. In this sense, trade openness could be seen as a peace–promoting technology. However, they show that multilateral trade openness reduces the bilateral trade dependence, and thus the cost of bilateral armed conflicts, which increases the probability of war. This mixed evidence shows that trade openness and armed conflicts are closely related in the data but that both the sign and the magnitude of the relationship depend on the specific characteristics of trade flows and agreements. To sum up, data show that major conflicts reduce international trade flows, and are therefore a possible source of economic downturns.

Finally, in two recent contributions Barro, Nakamura, Steinsson and Ursùa [2013] and Barro and Ursùa [2011] made clear that modern wars (especially WWII) have disastrous consequences on civilian economics both for "winners" and "losers". They analyze a rich panel data with 24 countries and more than 100 years. Consequences of wars on consumption are analyzed using a small neoclassical model. These extremely bad events induce a major increase in volatility measurement, that may account for the observed equity premium without relying on implausible and/or sophisticated models of risk–aversion.

In terms of reliable data during war episodes, the successive efforts of Maddison [2001] and of Barro et al. [2013] and Barro and Ursùa [2011] provide consensual figures about private consumption and GDP for several countries on an annual basis for a long period of time, that includes both WWI and WWII. We complete the data set with public spending data taken from Mitchell [1998a, 1998b, 1998c] to uncover crucial features of the dynamics of key macroeconomic variables during war episodes. While the data set of Barro and Ursùa [2011] covers the period from 1790 to 2009 for 42 countries, we collect reliable public spending data from 1870 to 1993 for Denmark, France, Germany, Italy, Japan, Spain, Sweden, the UK and the USA. This leaves us with 9 countries with exploitable data from 1870 to 1993. Unfortunately, public spending data are missing during major war episodes for most countries, except for Denmark, Sweden, the UK and the USA.

We thus exploit data for Denmark, France, Germany, Italy, Japan, Spain, Sweden, the UK and the USA between 1870 and 2009 for GDP and consumption, and between 1870 and 1993 for public spending over GDP. While this set of countries is not very large, it includes countries with a variety of situations during both WWI and WWII. Denmark, Spain and Sweden remained mostly neutral during those periods. France, Germany, Italy and the UK participated actively to both WWI and WWII. The USA were part of both WWI and WWII but experienced little if any battles on their national soil. Finally, Japan was part of both WWI and WWII but experienced large war-related destructions only during WWII. One of the main features of war episodes is that the share of private consumption in GDP falls dramatically. We contrast this feature of the data in Table 1 below. For each country, Table 1 gives the year for which the consumption-to-output ratio was the lowest, reports the corresponding minimal value and reports the value of the ratio 5 years after the ratio was minimal. In addition, when the data is complete (i.e. includes war episodes), we report the year the public spending to GDP ratio was maximal, as well as its value. Finally, we report the log-deviation of output, obtained by detrending the data with a linear filter, one year after C/Y is minimal, and output recovery five years after.

First, Table 1 shows that most countries that actively participated to WWII experienced the lowest consumption-to-product ratio during this period. The minimal consumption-to-output ratio is reached in the 2000's for nordic countries like Denmark and Sweden, reflecting the increasing trend in public spending to GDP, while it is reached in 1936 for Spain, during the Spanish Civil War. In addition, five years after the minimum of the consumption-to-product ratio was reached, all countries experienced much larger ratios.

Second, for the UK and the USA, there is a coincidence between the minimum of the consumption-to-output ratio and the maximal public spending in GDP ratio. This points to the importance of public spending in explaining the dynamics of those countries during WWII (see Braun and McGrattan [1993]). This is further confirmed by looking at column VI and VII of Table 1, that

Table 1: Key features of the data.

	C/Y			G/Y		Log-dev. of output	
	I	II	III	IV	V	VI	VII
Denmark	2001	45.66	48.21	1982	52.90	-1.53	-1.12
France	1943	38.98	60.34	–	–	-86.46	61.14
Germany	1944	22.63	52.22	–	–	-78.52	28.96
Italy	1943	49.69	66.86	–	–	-46.17	7.25
Japan	1945	25.67	55.27	–	–	-87.64	28.98
Spain	1936	50.97	61.34	–	–	-45.49	9.27
Sweden	2008	46.64	NaN	1993	39.18	0.00	NaN
United Kingdom	1943	43.21	61.08	1944	68.15	0.62	-14.42
USA	1944	46.18	65.30	1945	45.92	21.59	-19.35

Notes: I: Year of minimum value, II: Minimum value, III: Value 5 years after the minimum, IV: Year of maximum value, V: Maximum value , VI: Linear trend, 1 year after C/Y is minimum (%), VII: Linear trend, 5 year after C/Y is minimum minus 1 year after (%). Data source for GDP and consumption: Barro and Ursùa [2011]. We use GDP and consumption in levels in 2006 (the base year of the data set) from the OECD national account database to build the time series in levels. Data source for public spending over GDP: Mitchell [1998a, 1998b, 1998c]. For most countries except Denmark, Sweden, the UK and the USA, data points are missing during war episodes.

show that output was above or close to its trend value during WWII.

Third, the situation of countries that experienced war episodes on their soil contrasts with the situation of the USA. In those countries, the minimum of the consumption-to-output ratio coincides with huge deviations of output from the trend, the UK being an exception. Five years after, output was largely above its wartime level in all those countries, experiencing a very strong recovery effect. This massive contraction of output followed by a large economic recovery can not be rationalized by considering only an increase in public spending in GDP.

Looking at the complete time series further reveals that output and consumption fell very sharply and persistently from 1939 to 1945 in most countries affected by war-related destructions, such as France, Germany, Italy, and Japan.[1] The same pattern characterizes data for Spain, but the fall in output and consumption occurred in 1936, again with a very large persistence. Neutral countries such as Denmark or Sweden also experienced a drop in output and consumption but the magnitude was two or three times lower as compared to war participants. A different pattern characterizes the USA: consumption fell but output increased, probably driven by a massive increase in public spending (see Braun and McGrattan [1993]). The profile of consumption and

[1]See Figure 6, 7, and 8 in Appendix A and the Section on estimation for a description of the data.

output for the UK was also different. Consumption fell by a larger amount during WWII while output increased during the war period but shrank in the immediate post-war. Concerning WWI, Japan and the USA were almost not affected in terms of GDP or private consumption, while European countries like Denmark, France, Germany, and Sweden experienced an important fall in output and consumption (although less important than during WWII). Only in Italy, and in the UK, output increased likely driven by massive increases in public spending.

In this paper, we show that depreciation shocks that affect the stock of public and private capital play an important role in accounting for the dynamics of the economy during war times. First, if war episodes were modeled as negative generalized TFP shocks only, output would fall in all economies while consumption-to-output would remain constant (in our model) or would increase (in the standard permanent income model). If war were modeled as positive public spending shocks only, consumption-to-output ratios would fall, but output would increase in all countries. As increases in the depreciation rate of capital lead the consumption-to-output to fall along with output, they are a good additional candidate to assess the macroeconomic effects of war episodes. Second, while those shocks are most probably not the only driver of the economy during war episodes, they may help capturing an important aspect of the data, especially after WWII. Indeed, depreciation shocks (*i*) induce a lot of persistence by themselves, and (*ii*) alter the transmission of other shocks (generalized TFP and public consumption shocks) by affecting the inner dynamics of capital accumulation.

We build a simple variation of the standard RBC model proposed by Hercowitz and Sampson [1991] that is able to account for the macroeconomic effects of wars. The model admits a closed-form solution, which allows to accurately quantify the effects of large shocks. We extend the initial model to account for specific shocks that destroy private and public capital stocks, by assuming an exogenously time-varying depreciation rate of the stock of capital. Shocks increasing the depreciation of the capital stock capture destructions of the capital stock, and induce large increases in private and public investment expenditure. In addition to these shocks, the model also imbeds generalized TFP shocks and public consumption shocks. Indeed, we introduce an exogenous enrollment mechanism by which a fraction of the labor force may become unproductive (human losses, drafts) that affects the economy just as negative TFP shocks.

The model is estimated using Bayesian techniques and tested against a counterfactual model that considers a constant depreciation rate of capital. We show that the model with depreciation shocks outperforms the model with a constant depreciation rate, and that the difference in marginal densities is larger for countries that engaged in major conflicts than for countries that remained neutral. Further, a variance decomposition reveals that depreciation shocks explain a significant share of the dynamics of GDP and many variables in almost all countries. Additionally, we present an extraction of smoothed shocks that sheds light on the type of shocks that account for the dynamics of the economy during war episodes. These exercises show that depreciation shocks crucially affected economies that experienced large war-related destructions (France, Germany, Japan or Italy) but not economies that, in spite of their participation to WWII, did not experience such destructions (the USA).

Finally, we use our general equilibrium model to assess the welfare losses from business cycles over different data samples, as well as the instantaneous welfare losses from war episodes. We shed new light on the traditional views about the size of the welfare losses from fluctuations (see Lucas [1987]) by looking at a longer data sample that includes war episodes as large as WWI and WWII. Over the sample 1870-1993, the welfare losses from business cycles can rise up to almost 4% of steady-state consumption for Japan. Finally, according to our estimations, the instantaneous equivalent fall in consumption associated with WWII is very large for countries like Japan, France, Germany and Italy (between 13% and 50%). A similar effect is estimated for Spain during the Civil War in 1936. For other countries, like Denmark, Sweden, the UK or the USA, the instantaneous equivalent fall in consumption associated with WWII is much lower, between 2% and 4%.

The paper is organized as follows. Section 2 details the model. Section 3 proposes an inference strategy to estimate the parameters of the model and to extract smoothed shocks. Section 4 is devoted to the analysis of the economic mechanisms implied by our model and proceeds to a welfare analysis. Section 5 concludes.

2 The model

In this section, we develop a simple representative agent model that allows for (exogenously) time-varying depreciation rate of the stock of capital.

2.1 Framework

Assuming preferences similar to King, Plosser and Rebelo [1988], the representative household maximizes its lifetime welfare

$$\Phi_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left(\log C_t + \chi \log(1 - N_t) \right), \tag{1}$$

subject to the budget constraint

$$Y_t - T_t = C_t + I_t. \tag{2}$$

In these expressions, β is the discount factor, C_t is consumption, T_t is a lump-sum tax, I_t represents private investment in physical capital, N_t is the total amount of hours worked in period t, and χ is a scaling parameter. Only a share $(1 - e_t) \in [0, 1]$ of total hours worked will be effectively used in the private production sector, while a fraction e_t will be unproductive. The fraction of unproductive hours worked e_t is determined exogenously either by demographic factors or by enrollment policies. For instance, higher e_t may account for an increase in the number of draftees or for human losses due to military conflicts. During peacetime, lower e_t can be due to a demographic boom. Capital accumulation follows an original law of motion, adapted from Hercowitz and Sampson [1991] and Collard [1999]:

$$K_t = A_K K_{t-1}^{\delta_t} I_t^{1-\delta_t}, \tag{3}$$

where $(1 - \delta_t) \in]0, 1[$ is the stochastic depreciation rate of the capital stock. This specification is a slight variation of the usual linear case, where δ_t can be interpreted as the quality of installed capital. It may also account for the presence of adjustment costs, the capital stock at time t being a concave function of investment. We use this particular specification because it allows to derive an explicit solution of the model and permits the explicit derivation of the dynamic structure of economic aggregates. An explicit solution of the model is highly valuable, as it allows to account correctly for the macroeconomic effects of large shocks, without relying on approximations around the steady state. In addition, as in Ambler and Paquet [1994], we allow for time–varying effects on the depreciation rate of capital. This allows to capture some of the effects on conflicts on the stock of productive capital. Indeed, ceteris paribus, as long as $K_{t-1}/I_t > 1$, a negative shock on δ_t increases the depreciation rate and lowers the capital stock at the end of period t. We assume constant returns to scale and the production function by

$$Y_t = K_{t-1}^{\alpha} \left((1 - e_t) A_t N_t \right)^{1-\alpha}, \tag{4}$$

where A_t is a standard labor-augmenting technological factor. Defining $A'_t = A_t(1-e_t)$, exogenous variations in the share of unproductive hours can be considered together with technological factors within a generalized productivity measure A'_t. The production function thus writes

$$Y_t = K_{t-1}^{\alpha}\left(A'_t N_t\right)^{1-\alpha}. \tag{5}$$

The household maximizes its utility with respect to C_t, N_t and K_t subject to the following modified constraint

$$K_t = A_K K_{t-1}^{\delta_t}\left(K_{t-1}^{\alpha}\left(A'_t N_t\right)^{1-\alpha} - C_t - T_t\right)^{1-\delta_t}. \tag{6}$$

First order conditions imply

$$\chi\frac{C_t}{1-N_t} = (1-\alpha)\frac{Y_t}{N_t}, \tag{7}$$

$$\frac{1}{C_t} = \lambda_t(1-\delta_t)\left(\frac{K_t}{I_t}\right), \tag{8}$$

$$\lambda_t K_t = \beta E_t\left[\lambda_{t+1}K_{t+1}\left(\delta_{t+1} + (1-\delta_{t+1})\,\alpha\frac{Y_{t+1}}{I_{t+1}}\right)\right], \tag{9}$$

where λ_t is the Lagrange multiplier associated with the budget constraint. Equation (7) is a labor supply equation equating the marginal disutility of hours to their marginal productivity. Equation (8) states that the marginal utility of consumption has to equal the marginal cost of not investing. Equation (9) describes the dynamics of wealth as a function of the depreciation rate, returns on investment and the private investment rate.

Denoting $S_t = I_t/Y_t$ as the private investment rate, these conditions can be rearranged to characterize its dynamics. Defining $X_t = \lambda_t K_t$, Equation (8) writes

$$\frac{I_t}{C_t} = X_t(1-\delta_t), \tag{10}$$

which, using the budget constraint $C_t = Y_t - I_t - T_t$ implies

$$\frac{I_t}{Y_t - I_t - T_t} = X_t(1-\delta_t). \tag{11}$$

Assuming that the government has a balanced budget, i.e. $G_t = T_t$ and defining $\psi_t = G_t/Y_t$, we get

$$S_t = \frac{X_t(1-\delta_t)(1-\psi_t)}{1+X_t(1-\delta_t)}, \tag{12}$$

where

$$X_t = \beta E_t\left[X_{t+1}\left(\delta_{t+1} + (1-\delta_{t+1})\,\alpha S_{t+1}^{-1}\right)\right]. \tag{13}$$

An immediate implication is that the private investment rate is always bounded and less than one, i.e. $S_t \in [0,1]$, as long as $X_t > 0$ and $\psi_t < 1$. These equations characterize the dynamics of the private investment rate, conditionally on the exogenous processes (δ_t, ψ_t). If the depreciation rate and the share of public spending in GDP are constant, then X_t is constant (up to bubble), and so is the private investment rate.

Finally, we assume that government spendings are composed of public consumption expenditure $\widetilde{G}_t$ and investment in public/military capital I_t^g

$$G_t = \widetilde{G}_t + I_t^g. \tag{14}$$

In the model public/military capital is not productive nor yields private utility to the households. We assume that I_t^g represents investments realized to maintain stock of public/military capital constant, i.e.

$$K_t^g = K^g = A_{K^g} \left(K^g\right)^{\delta_t} \left(I_t^g\right)^{1-\delta_t}. \tag{15}$$

Using both equations, government spendings are

$$G_t = \widetilde{G}_t + \left(A_{K^g}\right)^{\frac{1}{\delta_t - 1}} \overline{K}^g. \tag{16}$$

If we consider war related destructions of private and public capital as negative shocks on δ_t, this specification may account for an endogenous rise in military build-ups, a feature that is clearly present in the data (see McGrattan and Ohanian [2010]).[2]

2.2 Equilibrium

The equilibrium of the economy is simply defined by the system of Equations (12)-(13), together with the equations describing the dynamics of output, capital and hours worked. The latter can be derived explicitly as follows. First, use Equation (7) to express hours as a function of the private investment rate

$$N_t = \frac{(1-\alpha)}{\chi\left(1 - S_t - \psi_t\right) + (1-\alpha)}, \tag{17}$$

and substitute for hours in the production function

$$Y_t = A_t' K_{t-1}^{\alpha} \left(1 + \frac{\chi(1-S_t-\psi_t)}{(1-\alpha)}\right)^{\alpha-1}. \tag{18}$$

[2] A condition for a drop in δ_t to generate an increase in public investment is $A_{K^g} > 1$. This condition is clearly met in the estimation of A_{K^g} (see Table 3).

Denoting $u_t = \log(U_t)$, $\forall U$, $\forall t$, we get:

$$y_t = a_t' + \alpha k_{t-1} + (\alpha - 1)\log\left(1 + \tfrac{\chi(1-S_t-\psi_t)}{(1-\alpha)}\right). \tag{19}$$

The dynamics of capital accumulation is given by

$$k_t = a_K + \delta_t k_{t-1} + (1-\delta_t)\, i_t, \tag{20}$$

or, given that $i_t = s_t + y_t$ and plugging equation (19) in the previous equation:

$$k_t = (\delta_t + \alpha(1-\delta_t))\, k_{t-1} + a_{k,t} + (1-\delta_t)\, a_t', \tag{21}$$

where

$$a_{k,t} = a_K + (1-\delta_t)\left(s_t + (\alpha-1)\log\left(1 + \tfrac{\chi(1-S_t-\psi_t)}{(1-\alpha)}\right)\right). \tag{22}$$

Summarizing the equilibrium conditions, the saving rate evolves according to Equations (12)-(13), and the dynamics of hours, output and capital are respectively given by Equations (17), (19) and (21).

The stock of capital admits a Random Coefficient Autoregressive representation. The randomness of the process δ_t implies that k_t evolves according to a random autoregressive coefficient with random volatility. This particular source of randomness is the consequence of the stochastic nature of the depreciation. Ambler and Paquet [1994] obtain a similar result (see their Equation (5)).

3 Estimation

We investigate the ability of our model to account for the dynamics of the economy both during wartime and during peaceful time. In particular, we are interested in determining what are the macroeconomic shocks driving the economy during wartime. We estimate our model using Bayesian methods, adopting the approach of An and Schorfheide [2007]. This implies obtaining the posterior distribution of our estimated parameters based on the linear (exact) approximation of the model's solution using the Kalman filter. A major advantage of the approach is that it permits the extraction of the dynamics of shocks, as well as the simulated paths of endogenous variables. We will therefore have a complete quantitative evaluation of the model with respect to the data, including historical decompositions through the lens of our model. Before we present our results, we detail our data set and comment on the priors and calibrated parameters that we use to estimate the model.

3.1 Data, shocks, priors and posteriors

The complete model features three sources of economic dynamics: generalized TFP shocks, public consumption shocks and depreciation shocks. The dynamics of generalized TFP is given by

$$A'_t = \exp(a_t) \text{ where } a_t = \rho_a a_{t-1} + \varepsilon_t^a \text{ and } \varepsilon_t^a \to N(0, \sigma_a), \tag{23}$$

that of public consumption by

$$\widetilde{G}_t = \theta Y \exp(g_t) \text{ where } g_t = \rho_g g_{t-1} + \varepsilon_t^g \text{ and } \varepsilon_t^g \to N(0, \sigma_g), \tag{24}$$

and the dynamics of δ_t by

$$\delta_t = \delta \exp(d_t) \text{ where } d_t = \rho_d d_{t-1} + \varepsilon_t^d \text{ and } \varepsilon_t^d \to N(0, \sigma_d). \tag{25}$$

The estimation is conducted on annual data for Denmark, France, Germany, Italy, Japan, Spain, Sweden, the UK and the USA over a sample period from 1870 to 1993.[3] Our data set comprises GDP and consumption per capita, constructed using Barro and Ursua (2010) data. Indices are converted in levels using a measure of real GDP per capita in PPP dollars and the share of private consumption over GDP for the reference year, which is 2006. In addition, we consider public spending over GDP provided by Mitchell [1998a, 1998b, 1998c].[4] Over such a long period of time, the data features different trend growth rates for GDP, consumption and public spending. Due to the unbalanced nature of economic growth during over the sample, we choose to estimate the model on demeaned data using a linear trend, and take our model as describing the dynamics of the economy in deviation from the steady state.[5]

Before engaging in the estimation of the model, we calibrate some of the parameters of the model using relevant steady state information. The discount factor β and the capital share α are calibrated as follows. We set α based on the 1970 labor shares reported by Bentolila and Saint-Paul [2003]. For β, we use average GDP growth rates – denoted g_y – calculated on Barro and Ursùa [2011] data, and approximate discount factors by $\beta = 1/(1 + g_y)$. Collard [1999] and references therein assume $\delta = 0.98$ in a quarterly set-up. We follow them and assume

[3]For Germany, the sample starts in 1872 and ends in 1989, for Sweden it starts in 1881, for Japan it starts in 1885, and for Spain it starts in 1901 and ends in 1987.

[4]This variable is fully available for Denmark, Italy, the UK and the USA, while data points are missing for France (1914-1919 and 1939-1948), Germany (1914-1924 and 1935-1949), Japan (1940-1946), Spain (1924-1926 and 1936-1939), and Sweden (1923 and 1936). While this time series is not complete for all countries, our estimation methodology can cope with missing data, and partial information is more valuable than the absence of any information.

[5]For the share of public spending in GDP, we take the log of 100 times the share.

$\delta = 0.98^4 = 0.9224$ in our annual set-up.[6] Before using steady state relations to further calibrate some parameters of the model, we present those steady state relations. Its existence crucially rest upon the determination of X:

$$X = \frac{\alpha}{\left(1-\theta-I^g/Y\right)\left(1/\beta-\delta\right)-\alpha\left(1-\delta\right)}. \tag{26}$$

Indeed, for $X > 0$, we need

$$1 - \frac{\alpha\left(1-\delta\right)}{\left(1/\beta-\delta\right)} > \theta + I^g/Y, \tag{27}$$

a condition easily met for reasonable values of public spending in GDP, the capital income share and the discount factor. The investment rate is thus

$$S = \frac{X\left(1-\delta\right)\left(1-\theta-I^g/Y\right)}{1+X\left(1-\delta\right)}. \tag{28}$$

The steady state value of hours is derived from occupation time taken in the OECD database and the value of χ is adjusted accordingly using

$$N = \frac{\left(1-\alpha\right)}{\chi\left(1-S-\theta-I^g/Y\right)+\left(1-\alpha\right)}. \tag{29}$$

The parameter A_K is adjusted to yield a capital-to-output ratio of 2.5 using

$$\frac{K}{Y} = \left(A_K\right)^{\frac{1}{1-\delta}} S, \tag{30}$$

implying that output, assuming $A' = 1$, is

$$Y = \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} N. \tag{31}$$

Remaining parameters are estimated using a Bayesian approach. Parameter A_{K^g} is a normal. The mean value is set so as to match the share of public/military investment in GDP (I^g/Y) in the steady state, and the standard deviation is 0.1.[7] We assume that θ is a beta with an adjusted mean and standard deviation 0.1. Mean values of θ are adjusted in the following way. We compute the average share of public spending in GDP on our data in level and subtract the mean value of I^g/Y. Priors for the autoregressive parameters are beta with mean 0.9 and standard deviation 0.05. Inverse gamma distributions are chosen for the prior over the standard deviation of innovations. We adopt an agnostic view by assuming that the prior mean of each standard deviation is 0.1 with an infinite standard deviation. Table 2 summarizes our calibrated parameters and assumptions concerning the prior distribution of our parameters.

[6] We did try to estimate this parameter but estimations suffered from weak identification with respect to this parameter.

[7] Data about military spending over GDP are taken from the SIPRI Military Expenditure Database and cover the period from 1988 to 2010.

Table 2: Calibrated parameters and prior distributions for estimated parameters.

				Prior distributions for estimated parameters									
	Calibrated parameters				A_{K^g} $(\mathscr{N})$			θ $(\mathscr{B})$		ρ_a, ρ_g, ρ_d $(\mathscr{B})$		$\sigma_a, \sigma_g, \sigma_d$ $(\mathscr{IG})$	
Country	α	β	N	I^g/Y	*mean*	*s.d.*	G/Y	*mean*	*s.d.*	*mean*	*s.d.*	*mean*	*s.d.*
Denmark	0.300	0.9818	0.2830	0.0164	1.4771	0.1	0.1452	0.1287	0.05	0.9	0.05	0.1	*Inf*
France	0.324	0.9807	0.3311	0.0283	1.4162	0.1	0.1708	0.1425	0.05	0.9	0.05	0.1	*Inf*
Germany	0.359	0.9786	0.2662	0.0171	1.4723	0.1	0.1423	0.1252	0.05	0.9	0.05	0.1	*Inf*
Italy	0.329	0.9793	0.3203	0.0195	1.4577	0.1	0.2357	0.2162	0.05	0.9	0.05	0.1	*Inf*
Japan	0.425	0.9716	0.3606	0.0097	1.5383	0.1	0.3180	0.3082	0.05	0.9	0.05	0.1	*Inf*
Spain	0.324	0.9812	0.3114	0.0137	1.4985	0.1	0.1086	0.0949	0.05	0.9	0.05	0.1	*Inf*
Sweden	0.303	0.9794	0.2957	0.0195	1.4575	0.1	0.1712	0.1516	0.05	0.9	0.05	0.1	*Inf*
United Kingdom	0.286	0.9862	0.3081	0.0292	1.4126	0.1	0.2369	0.2077	0.05	0.9	0.05	0.1	*Inf*
USA	0.303	0.9791	0.3247	0.0409	1.3761	0.1	0.1131	0.0721	0.05	0.9	0.05	0.1	*Inf*

Table 3 reports posterior means and standard deviations based on 200 000 replications.[8] As an important robustness check, we also present the results of an estimation of the model without depreciation shocks, i.e with a constant δ. The methodology remains the very same except we now assume $\sigma_d = \rho_d = 0$ and add a measurement error shock to the aggregate accounting equation.

Table 3 shows that all estimated structural parameters are significant, and well identified from the data. An exception is the persistence of generalized TFP shocks ρ_a, for which the estimation is non-informative.[9] In addition, based on the data marginal densities, the model with a time-varying depreciation of capital performs better than the model with a constant depreciation for all countries. Noticeably, based on this indicator, the baseline model outperforms the model with constant depreciation by much more for countries that have experienced war episodes than for countries that remained neutral, such as Denmark or Sweden. We take it as a sign that depreciation shocks are more helpful in fitting the data for countries that suffered from large war-related destructions, and therefore as a validation of our modeling assumption.

[8] Prior and posterior densities are available in Appendix B.

[9] In the graphs of Appendix B, the prior and posterior distributions of ρ_a are basically the same.

Table 3: Parameter estimation. Posterior means with 90% confidence intervals.

Parameters	A_{K^g}	θ	ρ_a	ρ_g	ρ_d	σ_a	σ_g	σ_d	$\mathscr{L}^{(a)}$
	Baseline model								
Denmark	1.8306	0.0941	0.9004	0.8430	0.7739	0.0600	0.1401	0.0180	473.84
	[1.7440,1.9136]	[0.0637,0.1261]	[0.8273,0.9774]	[0.7898,0.8950]	[0.6910,0.8624]	[0.0539,0.0664]	[0.1256,0.1556]	[0.0156,0.0203]	
France	1.7709	0.1118	0.8996	0.8990	0.7668	0.0850	0.1154	0.0225	406.02
	[1.6887,1.8592]	[0.0720,0.1493]	[0.8241,0.9771]	[0.8604,0.9380]	[0.6784,0.8609]	[0.0757,0.0934]	[0.1011,0.1295]	[0.0195,0.0254]	
Germany	1.6811	0.0562	0.9001	0.8729	0.8639	0.1076	0.1380	0.0335	302.21
	[1.5951,1.7693]	[0.0298,0.0803]	[0.8239,0.9781]	[0.8235,0.9261]	[0.7984,0.9317]	[0.0964,0.1199]	[0.1175,0.1586]	[0.0282,0.0386]	
Italy	1.7442	0.0567	0.8995	0.8879	0.8887	0.0528	0.2222	0.0169	455.61
	[1.6649,1.8198]	[0.0384,0.0733]	[0.8253,0.9758]	[0.8457,0.9301]	[0.8268,0.9543]	[0.0472,0.0585]	[0.1983,0.2474]	[0.0141,0.0198]	
Japan	1.7119	0.1371	0.8995	0.9231	0.8697	0.0810	0.1769	0.0244	311.33
	[1.6146,1.8055]	[0.1055,0.1713]	[0.8253,0.9777]	[0.8915,0.9557]	[0.7901,0.9523]	[0.0717,0.0906]	[0.1523,0.1979]	[0.0203,0.0283]	
Spain	1.8036	0.0830	0.8991	0.8833	0.7946	0.0991	0.1889	0.0193	249.94
	[1.7072,1.9003]	[0.0508,0.1146]	[0.8251,0.9768]	[0.8323,0.9322]	[0.6958,0.8970]	[0.0865,0.1115]	[0.1622,0.2151]	[0.0161,0.0224]	
Sweden	1.7981	0.0757	0.9013	0.8342	0.8428	0.0548	0.1328	0.0149	479.33
	[1.7164,1.8782]	[0.0511,0.1014]	[0.8269,0.9770]	[0.7740,0.8907]	[0.7722,0.9130]	[0.0487,0.0608]	[0.1177,0.1478]	[0.0128,0.0169]	
UK	1.6931	0.0796	0.8997	0.8931	0.8023	0.0302	0.2041	0.0155	536.14
	[1.6184,1.7667]	[0.0595,0.0992]	[0.8279,0.9782]	[0.8538,0.9337]	[0.7384,0.8705]	[0.0271,0.0334]	[0.1810,0.2263]	[0.0137,0.0174]	
USA	1.7293	0.0424	0.9002	0.8903	0.8373	0.0583	0.2639	0.0174	423.09
	[1.6590,1.7973]	[0.0237,0.0606]	[0.8267,0.9782]	[0.8495,0.9328]	[0.7793,0.8999]	[0.0519,0.0642]	[0.2348,0.2931]	[0.0152,0.0195]	
	Model with constant $\delta^{(b)}$								
Denmark	1.5582	0.0565	0.9009	0.8492	–	0.0552	0.1585	–	465.10
	[1.4449,]	[0.0329,0.0806]	[0.8301,0.9778]	[0.7986,0.8980]		[0.0494,0.0608]	[0.1282,0.1899]		
France	1.5319	0.0554	0.8995	0.8605	–	0.0982	0.1296	–	376.49
	[1.4205,1.6419]	[0.0271,0.0804]	[0.8273,0.9809]	[0.8104,0.9059]		[0.0881,0.1081]	[0.1023,0.1594]		
Germany	1.5520	0.0731	0.8991	0.8587	–	0.1828	0.1531	–	180.47
	[1.4225,1.6845]	[0.0208,0.1181]	[0.8280,0.9791]	[0.8072,0.9128]		[0.1624,0.2019]	[0.1153,0.1854]		
Italy	1.5511	0.1003	0.8992	0.8603	–	0.0719	0.2347	–	385.82
	[1.4391,1.6640]	[0.0812,0.1205]	[0.8214,0.9760]	[0.8129,0.9053]		[0.0642,0.0790]	[0.2028,0.2676]		
Japan	1.5870	0.1886	0.8966	0.9059	–	0.1177	0.1999	–	254.07
	[1.4549,1.7208]	[0.1651,0.2107]	[0.8168,0.9771]	[0.8703,0.9399]		[0.1042,0.1307]	[0.1706,0.2270]		
Spain	1.5586	0.0528	0.8998	0.9100	–	0.0714	0.2127	–	281.37
	[1.4255,1.6861]	[0.0231,0.0795]	[0.8260,0.9764]	[0.8729,0.9498]		[0.0626,0.0799]	[0.1616,0.2644]		
Sweden	1.5699	0.0497	0.8987	0.8179	–	0.0534	0.1501	–	443.65
	[1.4543,1.6853]	[0.0285,0.0705]	[0.8230,0.9766]	[0.7594,0.8769]		[0.0474,0.0596]	[0.1206,0.1777]		
UK	1.5200	0.1017	0.8997	0.8506	–	0.0403	0.2227	–	459.36
	[1.4043,1.6329]	[0.0828,0.1197]	[0.8209,0.9749]	[0.8023,0.9005]		[0.0361,0.0445]	[0.1845,0.2556]		
USA	1.4547	0.0657	0.8995	0.8586	–	0.0722	0.3490	–	352.73
	[1.3572,1.5532]	[0.0422,0.0870]	[0.8247,0.9799]	[0.8095,0.9069]		[0.0645,0.0793]	[0.2454,0.4625]		

Notes: Results based on 200 000 replications of the Metroplis Hasting algorithm

$\mathscr{L}$: marginal data density

(a) Modified harmonic mean of the data marginal density

(b) Adding a measurement error shock to the aggregate accounting equation

3.2 Shocks and variance decomposition

We now present the chronic of generalized TFP, depreciation and public spending smoothed shocks implied by our estimations in the different countries of our sample, and proceed to a variance decomposition of key variables of the model.

Figure 1, 2, and 3 present the smoothed shocks extracted from our estimated model.

Figure 1: Shocks on δ_t

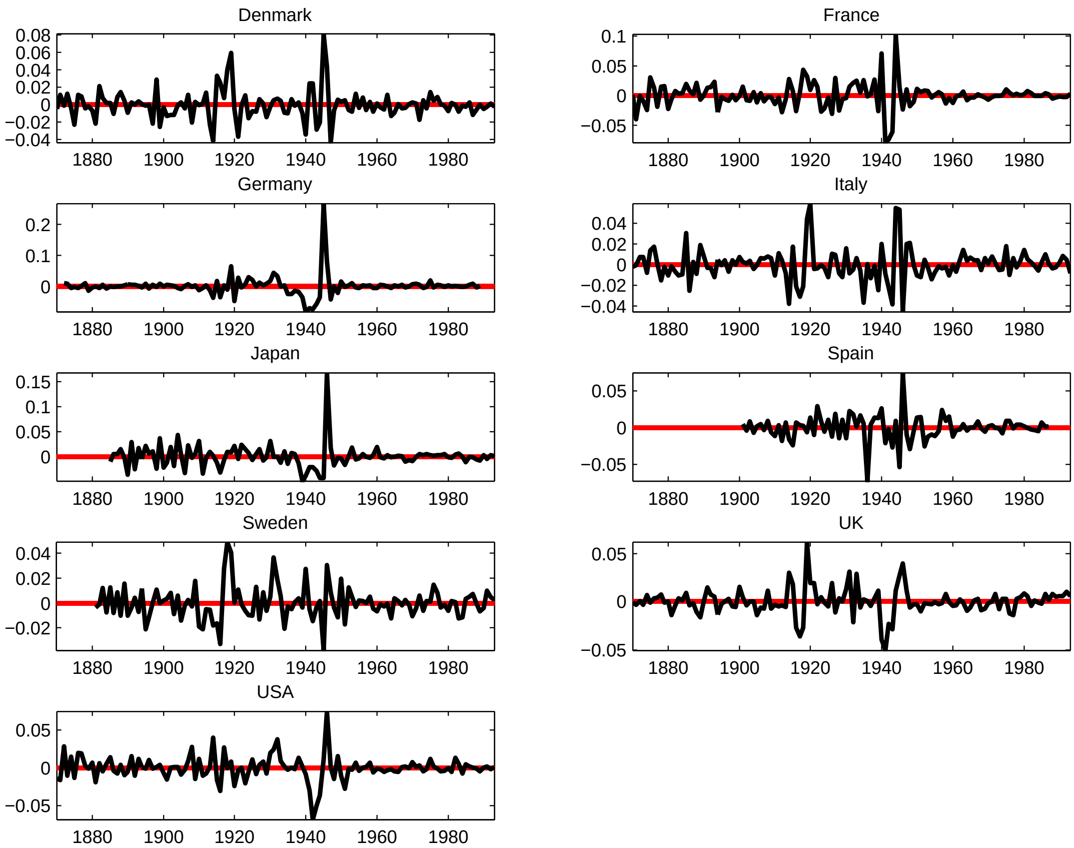
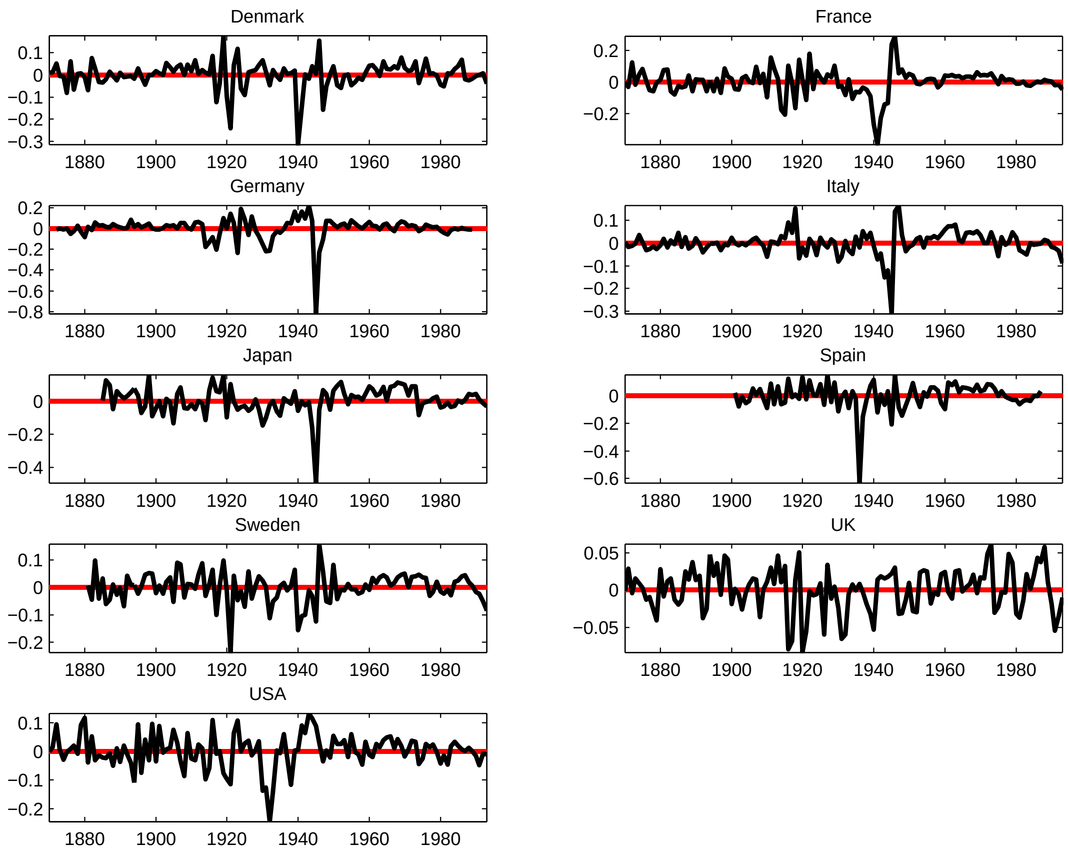


Figure 1 shows that major war episodes are associated with large innovations in the process of δ_t. This does not come as a surprise, as shocks on δ_t are meant to capture the effects of conflicts on private and public capital (war equipments and buildings are considered as public capital). This is particularly true for WWII participants (all countries except Denmark and Sweden) and to a lesser extent for WWI participants (France, Germany, Italy, and the UK). As we will see later in the variance decomposition, even tough those innovations are small in absolute terms, their impact on the economy is massive, as they affect the economy directly but also indirectly, altering the diffusion of other shocks to the economy.

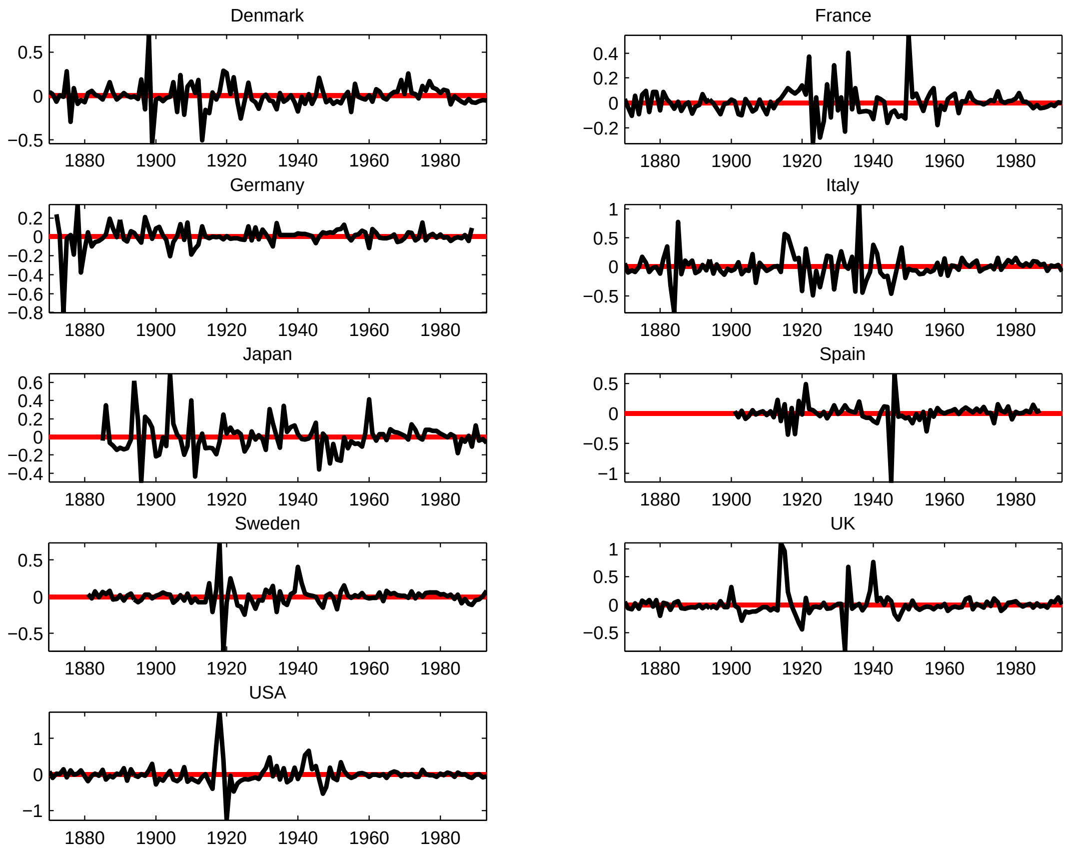
Figure 2: Generalized TFP shocks



In addition, Figure 2 shows that war episodes are not only captured by shocks on δ_t but result from a combination of a large drop in δ_t and an important fall in TFP. Focusing on WWII, major participants that experienced large war damages (France, Germany, Japan, and Italy) all witness large negative TFP shocks while this is not the case for other countries (Denmark, Spain, Sweden, the UK and the USA). Spain experiences a large negative TFP shock in 1936 along with a negative shock on δ_t, that corresponds to the Spanish Civil War. In the USA, the largest adverse shock on TFP happens in the early 30's and captures the effects of the Great Depression, but TFP shocks remain small during WWII. For other countries, there is no remarkable pattern of TFP shocks during WWII.

Finally, Figure 3 shows that public expenditure also contribute to the understanding of the

Figure 3: Public consumption shocks



dynamics of the economy during war times, in the form of an increase in public consumption. Even though the results should be interpreted with care as we lack of data for most countries during war episodes (except for Denmark, Sweden, the UK and the USA), war episodes are associated with large increases in public consumption, especially in the UK and in the USA both during WWI and WWII. Under the combined effects of an increase in public consumption and in public investment (due to negative shocks on δ_t), total public spending in GDP thus rises massively during war episodes.

Summarizing and focusing on WWII, the different dynamic patterns highlighted previously can be rationalized as follows. Neutral countries have experienced small shocks leading to moderate falls in GDP and consumption. The UK and the USA have experienced negative shocks on δ_t, combined with an increase in public consumption. Therefore, in those countries, the large fall in the consumption-to-output ratio comes together with an increase in GDP – although GDP drops in the immediate post-war period in the UK. Other major WWII participants, experienced the combination of a large negative shock on δ_t and a large drop in TFP, leading the consumption-to-output ratio to fall along with GDP.

We argue that our estimated model is able to account for the macroeconomic effects of major war episodes, and for the variety of adjustment profiles to such events (neutral countries vs. participants, USA and to a lesser extent the UK vs. other participants).

Further, a variance decomposition over the whole sample for each country is proposed in Table 4.

Table 4: Variance decomposition of key variables

	Y			S			C/Y			G/Y			$Utility$		
	ε_a	ε_g	ε_d	ε_a	ε_g	ε_d	ε_a	ε_g	ε_d	ε_a	ε_g	ε_d	ε_a	ε_g	ε_d
Denmark	50.57	1.07	48.36	0.07	0.58	99.34	1.43	8.45	90.11	11.94	74.77	13.29	26.94	2.48	70.58
France	60.17	1.06	38.76	0.14	0.72	99.14	3.21	10.73	86.06	18.50	66.87	14.63	35.39	2.96	61.65
Germany	24.38	0.12	75.50	0.02	0.11	99.87	0.38	1.27	98.35	8.15	29.94	61.90	11.16	0.29	88.55
Italy	20.22	0.91	78.87	0.01	0.62	99.37	0.33	9.77	89.91	2.34	75.51	22.15	9.55	2.07	88.39
Japan	24.07	1.76	74.17	0.08	1.47	98.45	1.70	14.69	83.61	6.48	63.54	29.98	11.62	4.44	83.94
Spain	65.70	0.92	33.38	0.12	1.02	98.86	2.65	14.10	83.25	13.45	77.11	9.43	42.11	3.02	54.88
Sweden	39.20	0.73	60.06	0.05	0.56	99.39	0.91	7.71	91.38	8.05	72.16	19.79	20.43	1.73	77.83
UK	26.26	4.65	69.09	0.02	1.36	98.62	0.37	20.49	79.14	1.54	90.09	8.38	10.59	7.44	81.97
USA	47.63	0.85	51.52	0.02	0.60	99.39	0.44	11.56	88.00	3.13	85.77	11.10	26.42	2.47	71.11

Several reasons account for the large share of variance explained by depreciation shocks. Let us start with the private investment rate, S_t. As shown by Equation (12), S_t depends on δ_t and on $\psi_t = G_t/Y_t$. However, the latter ratio itself also partly depends on δ_t through public investment. The variance decomposition shows that depreciation shocks almost entirely account for the variance of the private investment rate. Second, the relative importance of depreciation shocks vs. public consumption shocks in the variance decomposition of G_t/Y_t exhibits more variations from a country to another. While depreciation shocks account for a large share of the variance of the ratio for Germany (62%), it is less so for Italy and Japan (22% and 30% respectively) and even less for other countries (less than 20%). Further, in addition to their "direct effects", depreciation shocks also alter the transmission of remaining shocks, as shown by Equation (21). Therefore those shocks account for a large share of the variance of output, the consumption-to-output ratio and utility, especially for Germany, Italy and Japan where depreciation shocks account for about 75% of the variance of output, and to a lesser extent for other countries (less than 60% of the variance of output). Overall, the variance decomposition is consistent with our model structure and highlights the key importance of depreciation shocks over the sample.

4 Impulse responses and welfare exercises

In this section, we investigate the underlying economic mechanism that drives our results. We also use our estimated model to assess the welfare costs of conflicts.

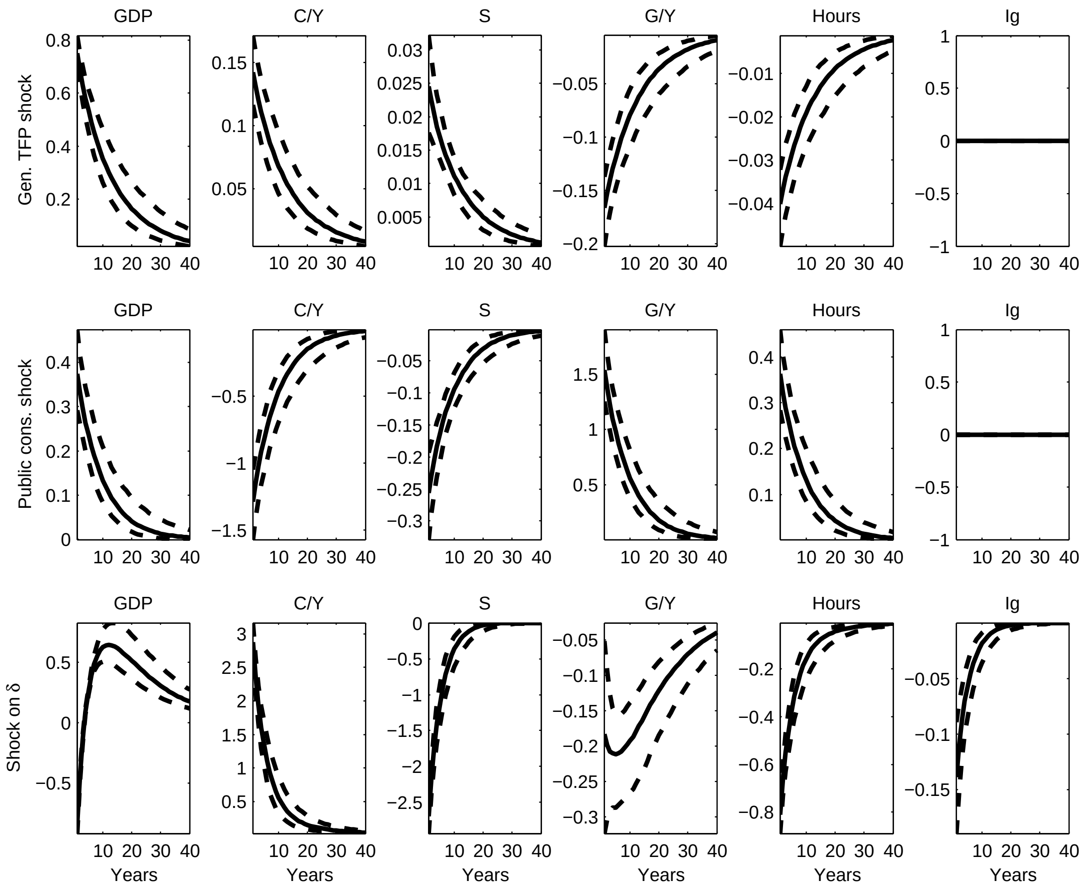
4.1 Impulse response functions

Figure 4 presents the impulse response functions (solid lines) to a one standard deviation shock in either generalized TFP, public consumption and δ_t for the UK, as well as the 90% confidence bands (dotted lines). Indeed, while IRFs are quantitatively different for each country they all exhibit the very same qualitative pattern, so we focus on only one country.[10]

After a generalized TFP shock, output increases, as well as investment, consumption and savings. Because we consider a constant level of public consumption and because δ_t is constant, the level of public spending is constant. As a consequence, the public spending to output ratio falls, crowding-in private consumption and investment. Lastly, the dynamics of hours can be analyzed by looking at Equation (17). Because G_t/Y_t falls more than the private investment rate increases, hours fall. If we had we considered a constant public spending to output ratio, the consumption-to-output ratio and the private investment rate would have remained constant after a TFP shock. Under this alternative assumption, hours worked would have increased.

[10]The complete set of IRFs is available in Appendix C.

Figure 4: Impulse response functions for UK after a one sd shock (in %)



After a public consumption shock, output increases but private consumption and investment are crowded-out, which lead the consumption-to-output ratio and the private investment rate to fall. Finally, hours worked increase. Those effects of public consumption shocks are perfectly in line with standard theory.

Lastly, after an increase in δ_t, the depreciation rate of capital falls. It induces a pronounced fall in the private investment rate, as well as a drop in public investment. The corresponding massive decrease in savings is reflected in the large increase in the consumption-to-output ratio. The latter produces a large wealth effect, that leads hours worked to fall. The dynamics of output reflects the opposite dynamics of investment on the one hand and consumption on the other. It falls initially, because labor supply falls dramatically as a byproduct of the increase in consumption, and rises after 2 or 3 periods. The effects of a negative shock on δ_t, that we argue to be a good representation of war-related destructions of public and private capital, are simply the negative mirror image of the IRFs reported in the last row of Figure 4.

4.2 Welfare analysis

We now use our estimated model to engage in an evaluation of the welfare costs of business cycles. We quantify the welfare losses from business cycles, as compared to a situation where the economy remains at the steady state. Welfare is expressed as the percentage of steady state consumption that agents would be willing to give up to live in a world without fluctuations, and denote this percentage by Λ

$$(1-\beta)\,\Phi_0 = U\left((1-\Lambda)C, N\right), \tag{32}$$

where C and N are the steady state values of consumption and hours worked respectively, and $U\left(C_t, N_t\right)$ is the path of welfare implied by the historical paths of smoothed shocks. Using a second-order approximation of the utility function,

$$U\left(C_t, N_t\right) \simeq U\left(C, N\right) + U_c\left(C_t - C\right) + \frac{U_{cc}}{2}\left(C_t - C\right)^2 + U_N\left(N_t - N\right) + \frac{U_{NN}}{2}\left(N_t - N\right)^2, \tag{33}$$

we get the following approximation of $(1-\beta)\,\Phi_t$

$$(1-\beta)\,\Phi_0 \simeq \log C + \chi\log(1-N) + E\left(\widehat{C}_t\right) - \frac{\chi}{1-N}E\left(\widehat{N}_t\right) - \frac{1}{2}var\left(\widehat{C}_t\right) - \frac{\chi N^2}{2\left(1-N\right)^2}var\left(\widehat{N}_t\right), \tag{34}$$

where hats denote log-deviations from the steady state. Using $E\left(\widehat{C}_t\right) = E\left(\widehat{N}_t\right) = 0$, we get

$$\Lambda = 100\cdot\left(1 - \exp\left[-\frac{1}{2}var\left(\widehat{C}_t\right) - \frac{\chi N^2}{2\left(1-N\right)^2}var\left(\widehat{N}_t\right)\right]\right). \tag{35}$$

We compute the welfare losses from fluctuations with all shocks (Λ^{tot}) and the welfare losses implied by each type of shocks ($\Lambda^a, \Lambda^g, \Lambda^d$) by running counterfactual simulations where only one driving force of the business cycle is considered. We also compute the welfare losses considering only a post-war sample, i.e. from 1960 to 1993. The results are reported in Table 5.

Table 5: Welfare losses from fluctuations, in % of steady state consumption.

	Full sample (1870-1993)				Reduced sample (1960-1993)			
	All	ε_a	ε_d	ε_g	All	ε_a	ε_d	ε_g
Denmark	0.2803	0.1250	0.3879	0.0091	0.1265	0.0482	0.2414	0.0104
France	1.5320	0.2416	1.7630	0.0108	0.2500	0.0334	0.3600	0.0024
Germany	1.5892	0.9621	1.0553	0.0027	0.1398	0.0739	0.1398	0.0004
Italy	0.9062	0.3343	0.5660	0.0079	0.3609	0.5597	0.3563	0.0052
Japan	3.8989	1.0865	2.5388	0.0762	0.8627	0.0654	1.0437	0.0500
Spain	1.8856	0.1113	1.8724	0.0143	0.8760	0.0377	0.8598	0.0069
Sweden	0.1903	0.1785	0.3738	0.0033	0.1052	0.0465	0.1885	0.0016
UK	0.1814	0.1597	0.2065	0.0175	0.1056	0.0572	0.0825	0.0023
USA	0.3785	0.3755	0.7012	0.0062	0.0755	0.1060	0.1151	0.0002

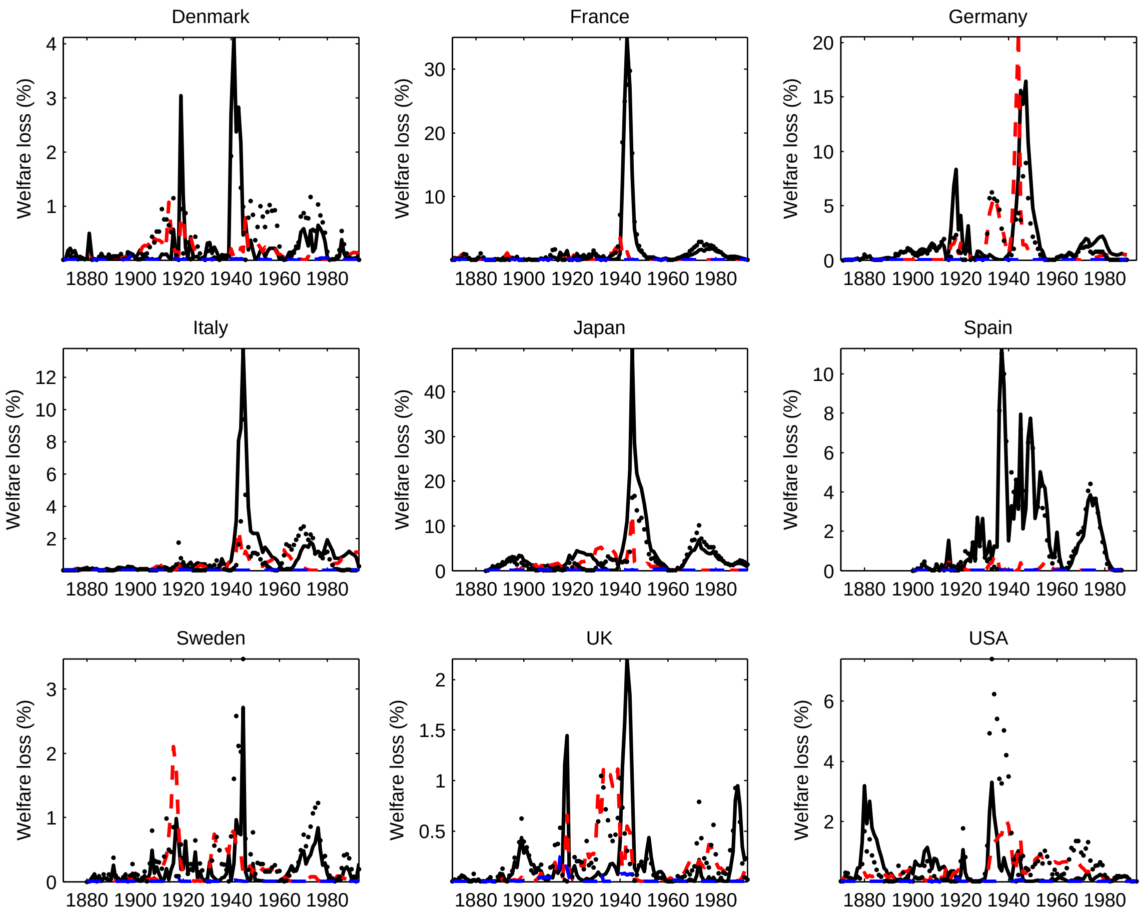
The welfare losses from fluctuations computed on a reduced sample (1960-1993) range from 0.0755% to 0.876%. It is in accordance with previous studies showing that the welfare losses from business cycles are small. The welfare loss for the USA is particularly close to the welfare loss reported by Lucas [1987], 0.0755% against 0.05% for Lucas. However, a glance at welfare losses computed on the whole sample (1870-1993) reveals that the reduced sample greatly understates the welfare losses from the business cycle. It points to the importance of troubled times, such as war episodes and civil wars, in the welfare losses from fluctuations. Overall, welfare losses are two to ten times larger than those computed on the reduced sample, and reach up to 3.90% of steady-state consumption for Japan. The difference between the total welfare losses and those computed on the reduced sample is larger for countries that have experienced war episodes. Relatedly, the contribution of depreciation shocks to the large welfare losses computed on the total sample is the most important.

Finally, we compute the instantaneous welfare loss of shifting from the steady state to grasp the instantaneous welfare impact of large macroeconomic swings, such as those implied by war episodes.

$$\Lambda_t = 100 \cdot \left(1 - \exp\left(-\frac{1}{2}\widehat{C}_t^2 - \frac{\chi N^2}{2\left(1-N\right)^2}\widehat{N}_t^2\right)\right). \tag{36}$$

Again, we report the total effect, and contrast the effects implied by counterfactual simulations. Our results are presented in Figure 5.

Figure 5: Instantaneous welfare losses, in % of steady state consumption.
Solid: All shocks, Dashed red: Shocks on δ_t
Dotted: Gen. TFP shocks, Dashed blue: Pub. cons. shocks



The welfare losses associated with "all shocks" case are very important for Japan, France, Germany and Italy (between 13% and 50% of steady state consumption) during WWII. We observe a similar effect for Spain during the Civil War. The welfare losses from WWII in Denmark, Sweden or UK are much smaller, between 2% and 4%, and the USA does not experience a large welfare loss during WWII. In the immediate pre-war period, the welfare loss from the Great Depression is evaluated at almost 4% of steady-state consumption. Welfare losses observed during WWI are much smaller than those observed during WWII, between 1% and 8%. The most affected country is Germany with an 8% welfare instantaneous loss.

These estimations shed light on the relative importance of public expenditure dedicated to avoid direct bellicose confrontations. Arguably, efforts to avoid wars are not always successful (*e.g.* the Munich agreement) and some of them may be very costly (as exemplified by the Cold War period). But compared to centralized ways to mitigate adverse effects of civilian downturns; defense, diplomatic, and cooperation spending are good competitors since, according to our estimates, the "willingness to pay" to avoid them is huge.

5 Conclusion

War typically produce large economic downturns. Yet most of the current macroeconomic models focus on post-war data. Recent papers have tried to use the large swings induced by WWII to derive precise estimates of fiscal policy and/or government spending, or to capture the effects of large downturns.

In this paper, have evaluated the impact of conflicts on macroeconomic aggregates using a panel data with 9 countries from 1870 onwards, including GDP, consumption and public spending over GDP. We have highlighted that the consumption-to-output ratio was minimal during the most important war episode, namely WWII, for war participants. While this could be explained by a very large increase in public spending over GDP in the USA, this was not the case for other participants, as they experienced a very large drop in GDP over the period.

We have build a model that captured the impact of conflicts on the economy by assuming an (exogenously) time-varying depreciation rate of the stock of private and public capital. The model also featured TFP shocks enriched with an enrollment mechanism that was able to account for the effects of conflicts on the labor force. We have estimated this model and shown that depreciation shocks played a key role in accounting for the economic dynamics of countries that experienced massive war-related destructions. Additionally, we have quantified the welfare losses from conflicts and shown that they were potentially very large. Finally, we have computed the welfare losses from fluctuations on a longer data sample, and challenged the traditional views that they were small.

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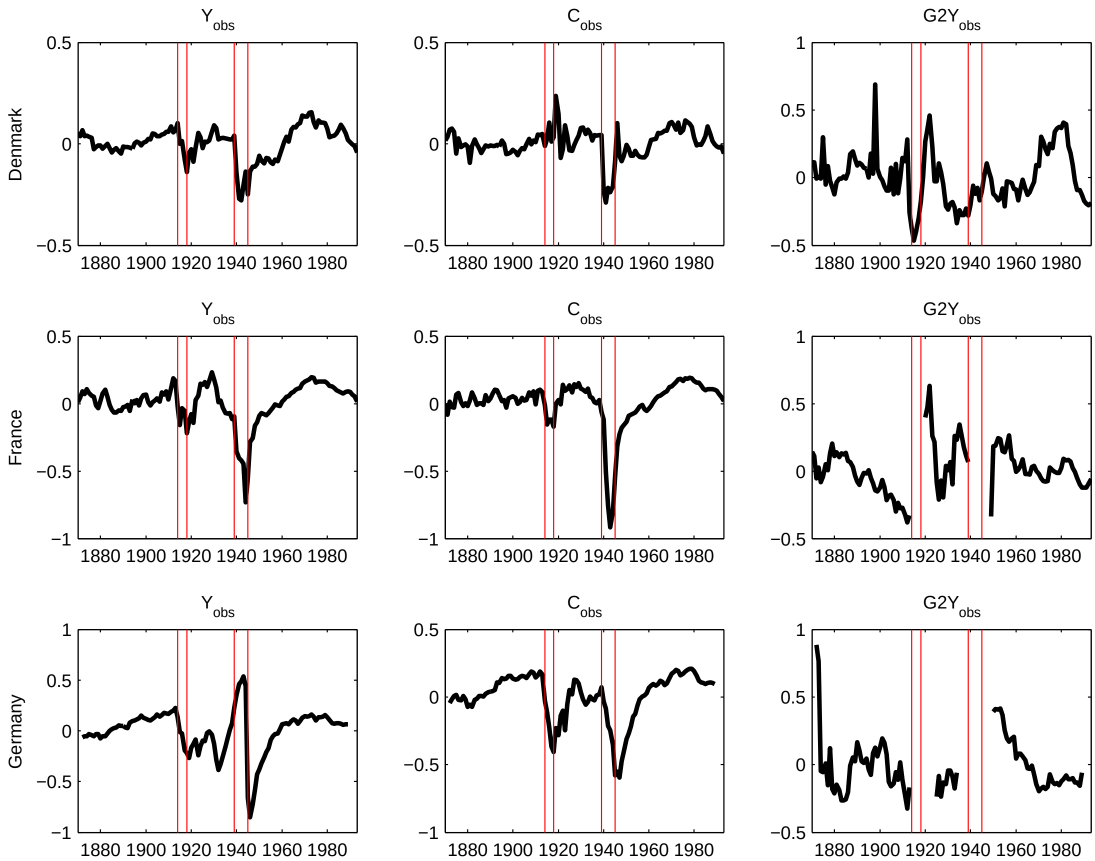
A Data

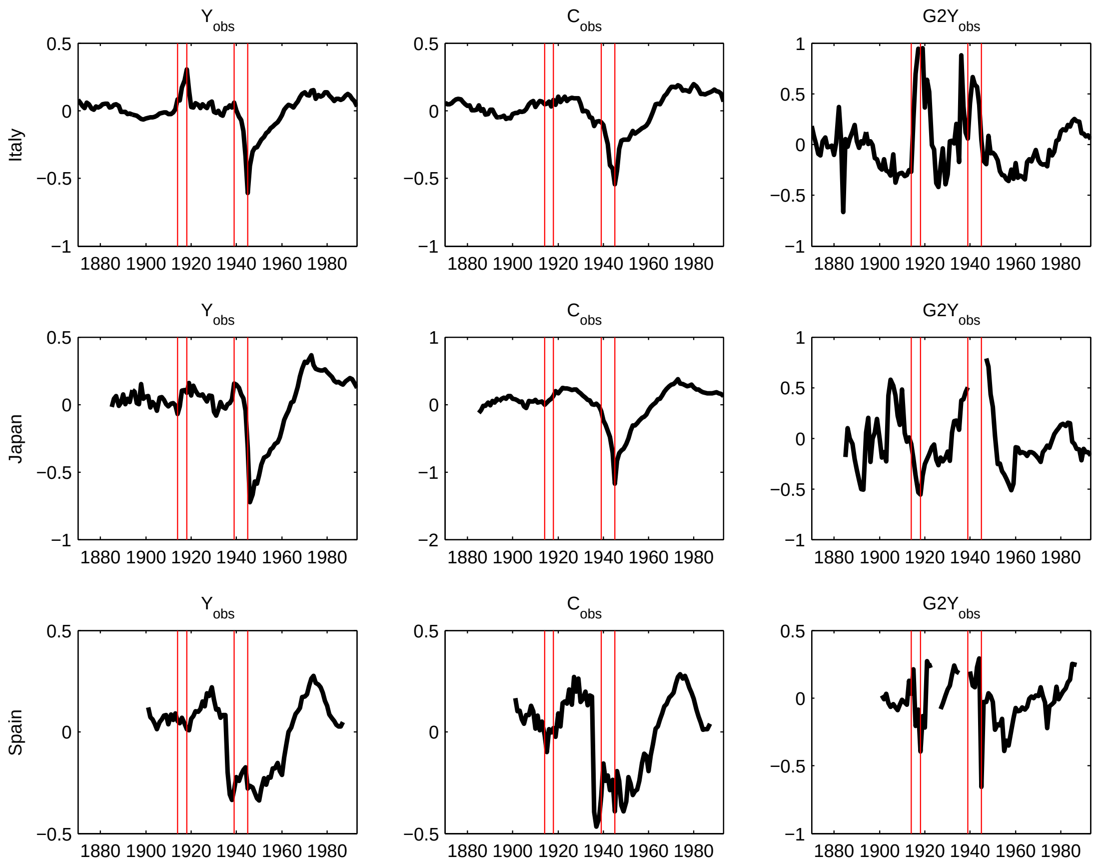
Figures 6, 7, and 8 describe our data set.

Figure 6: Observed time series - Denmark, France, and Germany



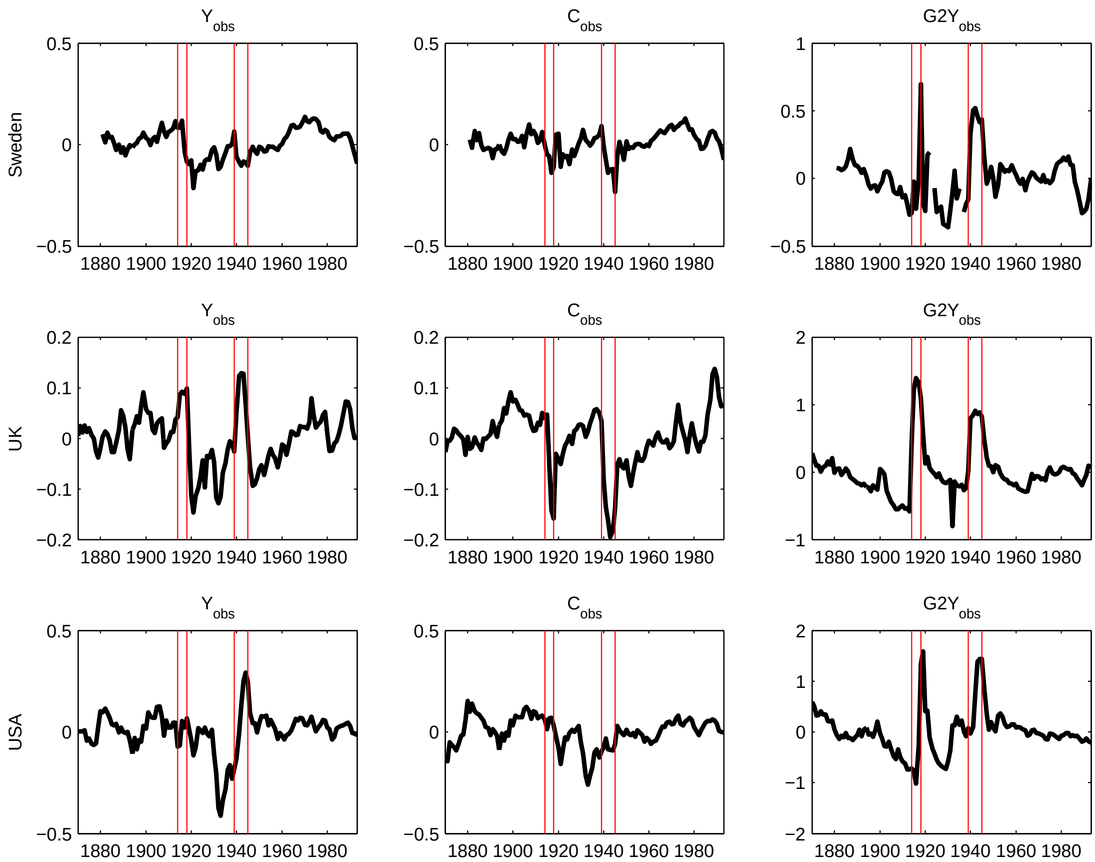
Vertical lines in 1914, 1918, 1939 and 1945

Figure 7: Observed time series - Italy, Japan, and Spain



Vertical lines in 1914, 1918, 1939 and 1945

Figure 8: Observed time series - Sweden, UK, and USA



Vertical lines in 1914, 1918, 1939 and 1945

B Priors and Posteriors

Figure 9: Prior and posterior densities - Denmark

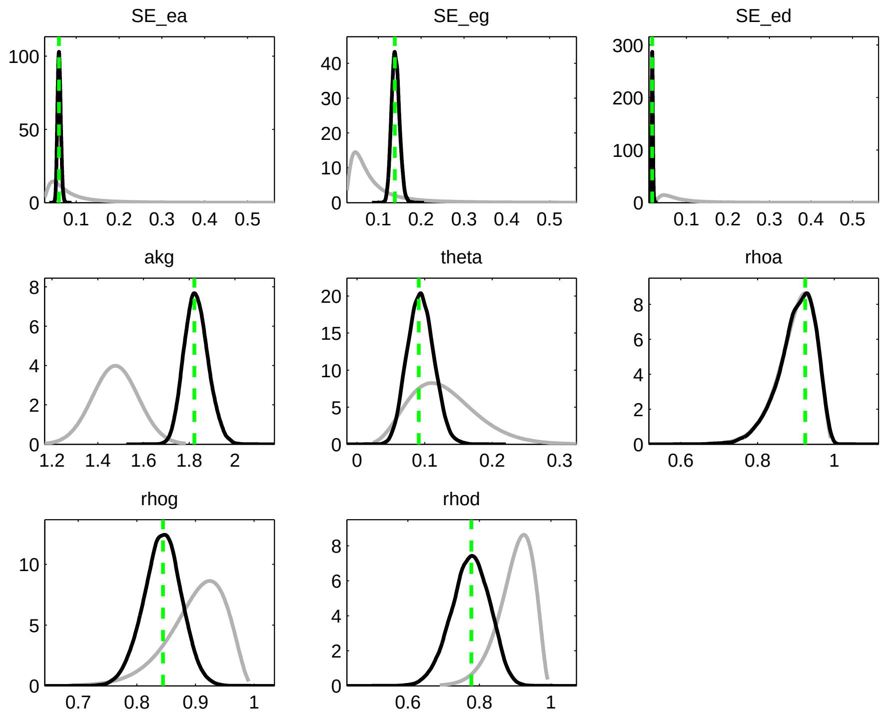


Figure 10: Prior and posterior densities - France

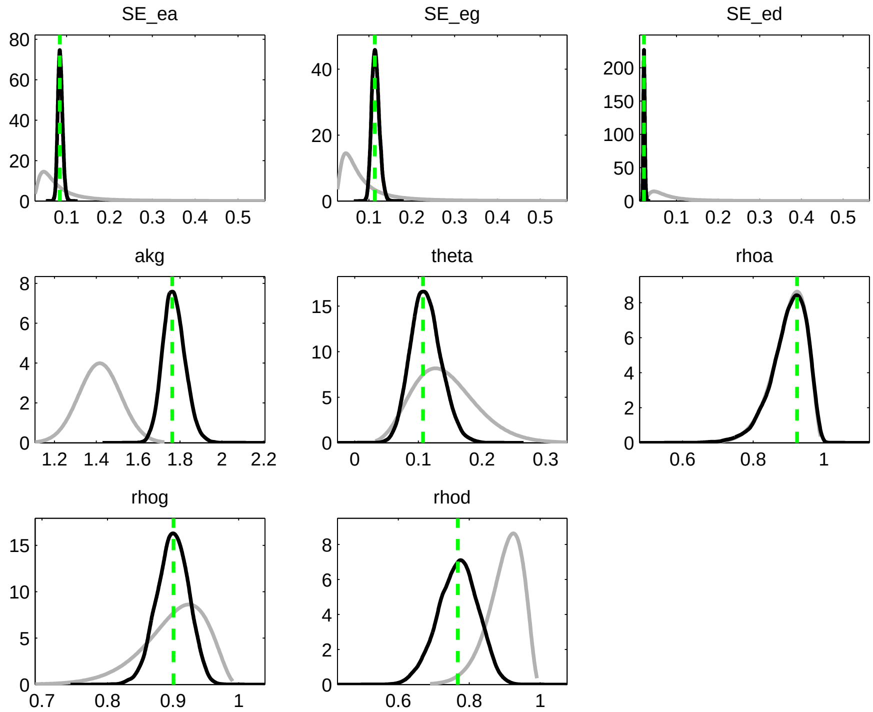


Figure 11: Prior and posterior densities - Germany

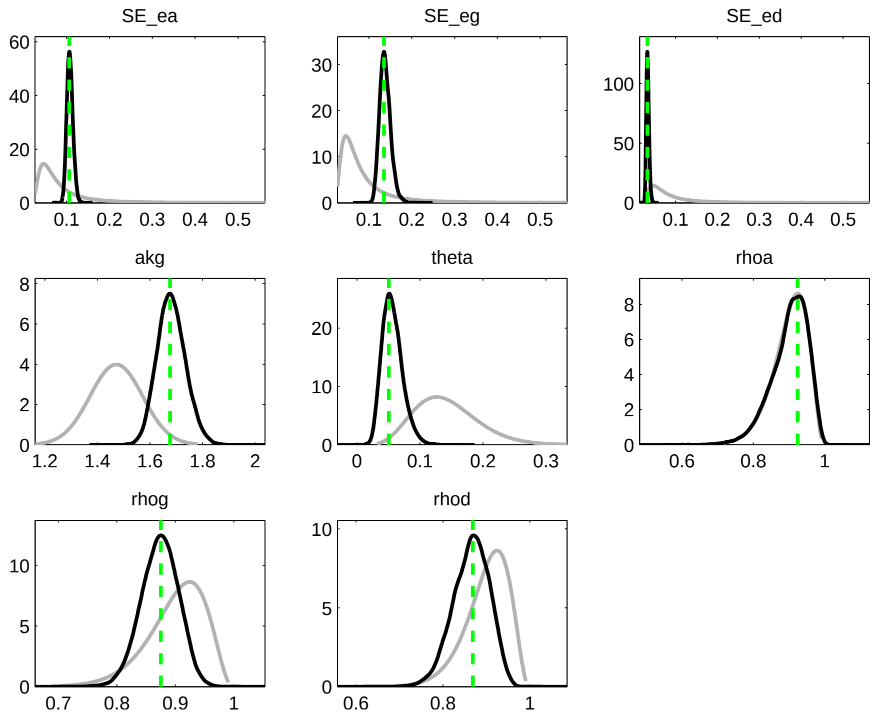


Figure 12: Prior and posterior densities - Italy

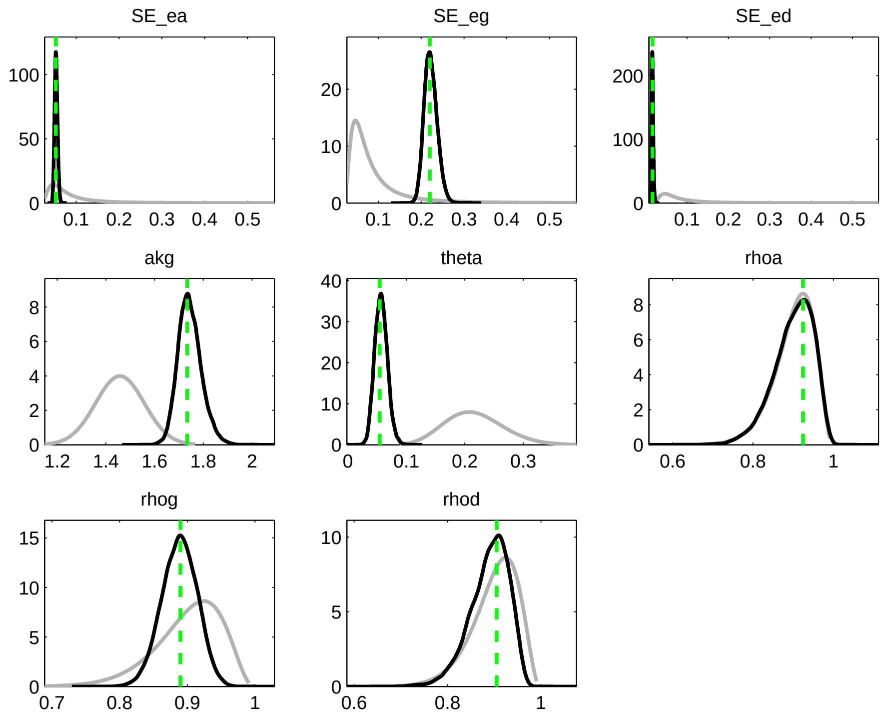


Figure 13: Prior and posterior densities - Japan

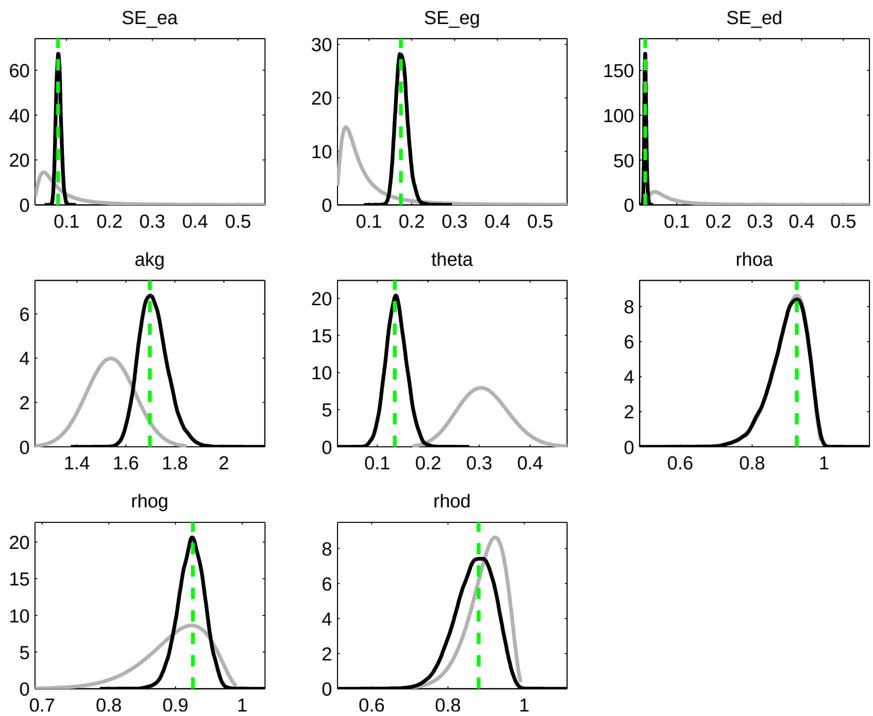


Figure 14: Prior and posterior densities - Spain

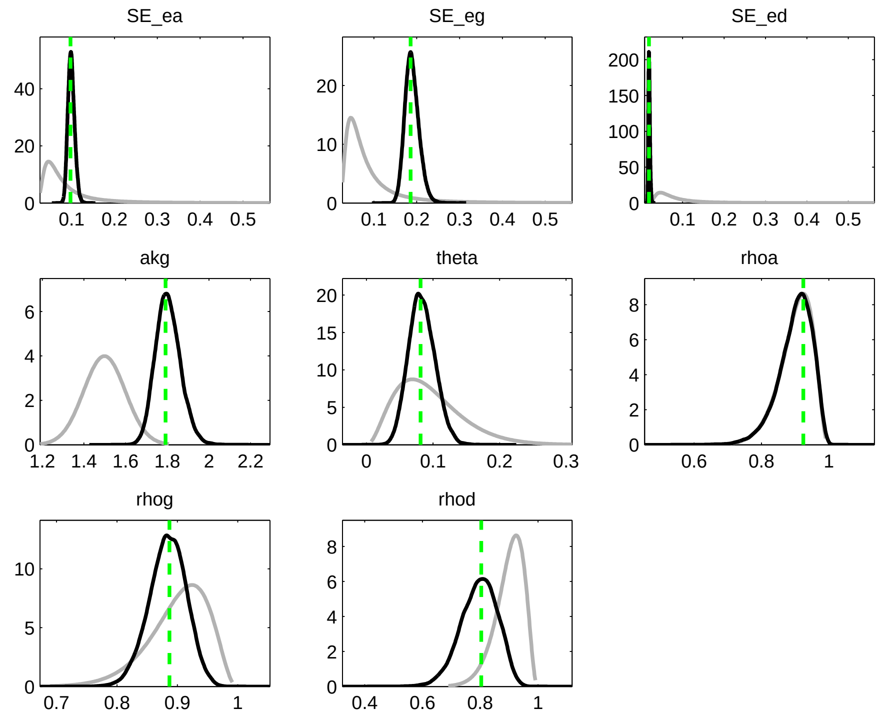


Figure 15: Prior and posterior densities - Sweden

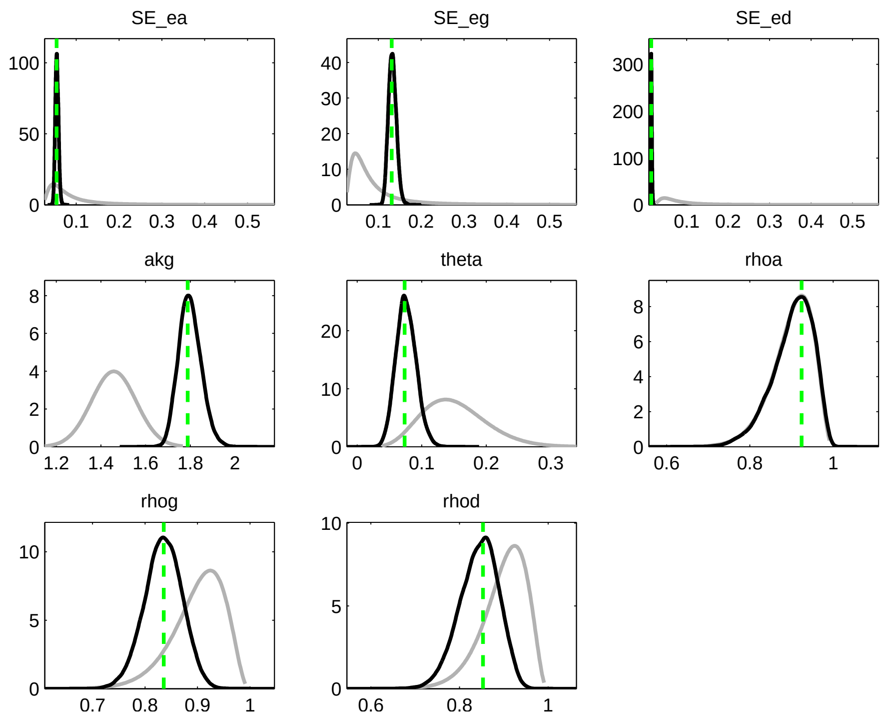


Figure 16: Prior and posterior densities - United Kingdom

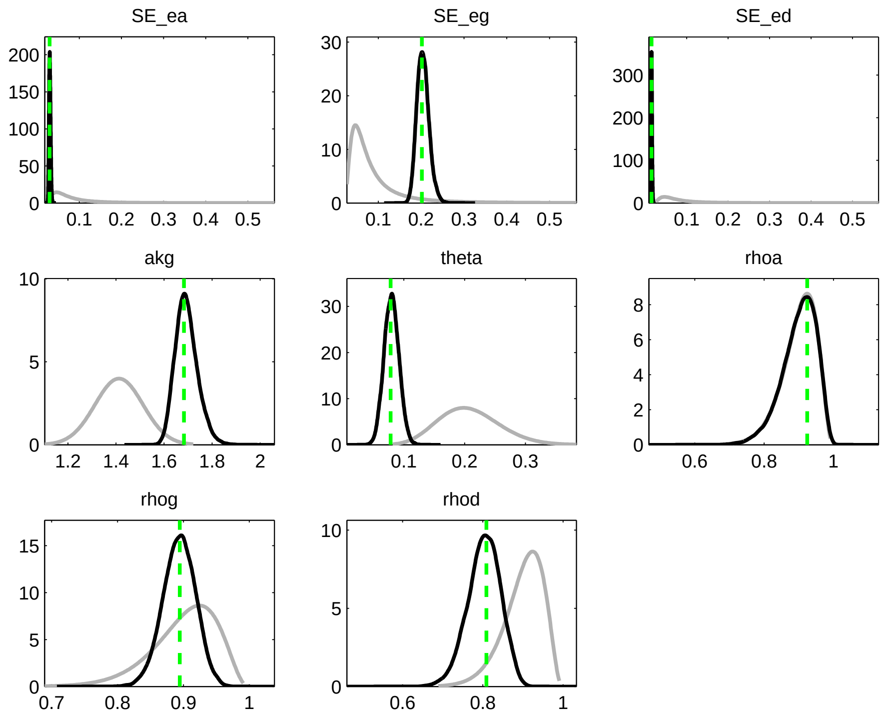
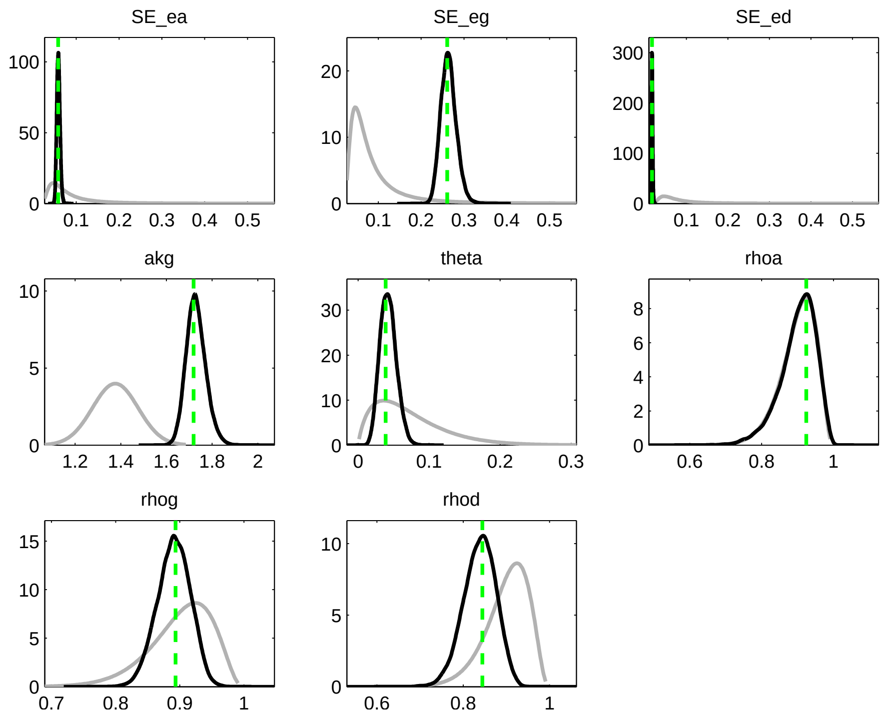


Figure 17: Prior and posterior densities - United States



C Impulse response functions

Figure 18: Impulse response functions for Denmark after a one sd shock (in %)

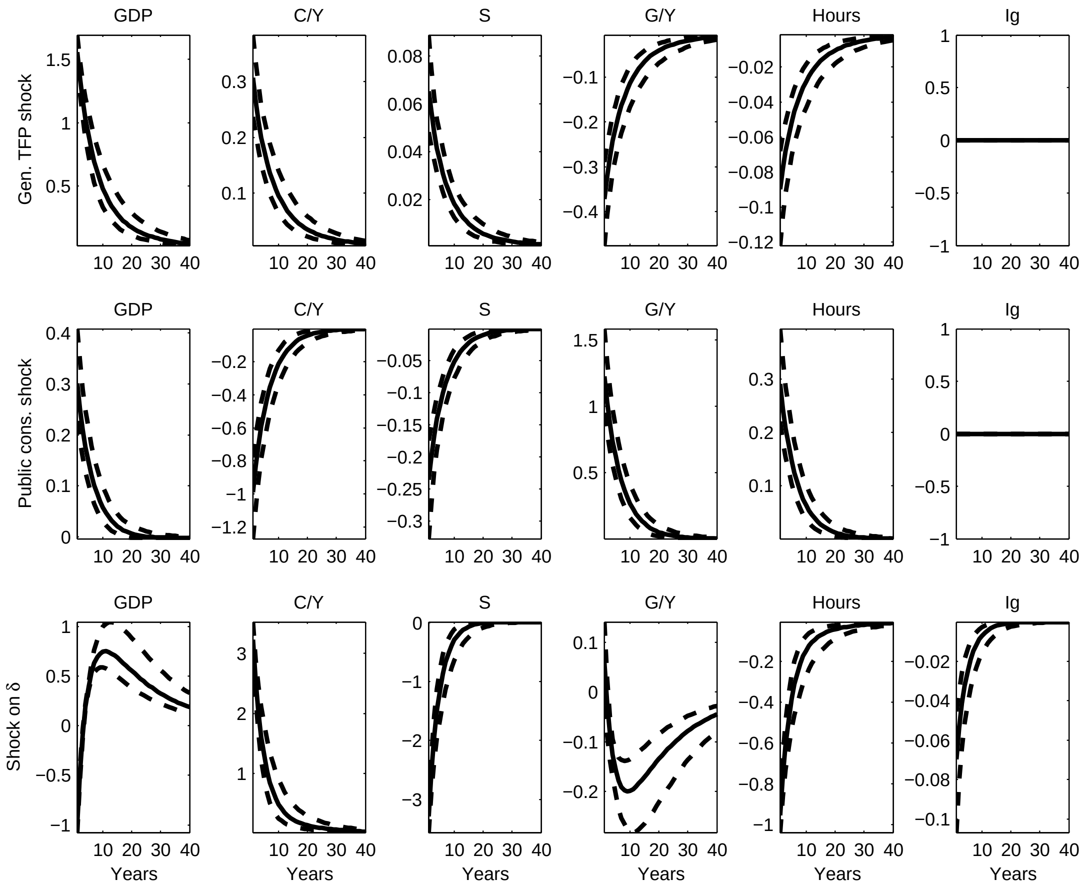


Figure 19: Impulse response functions for France after a one sd shock (in %)

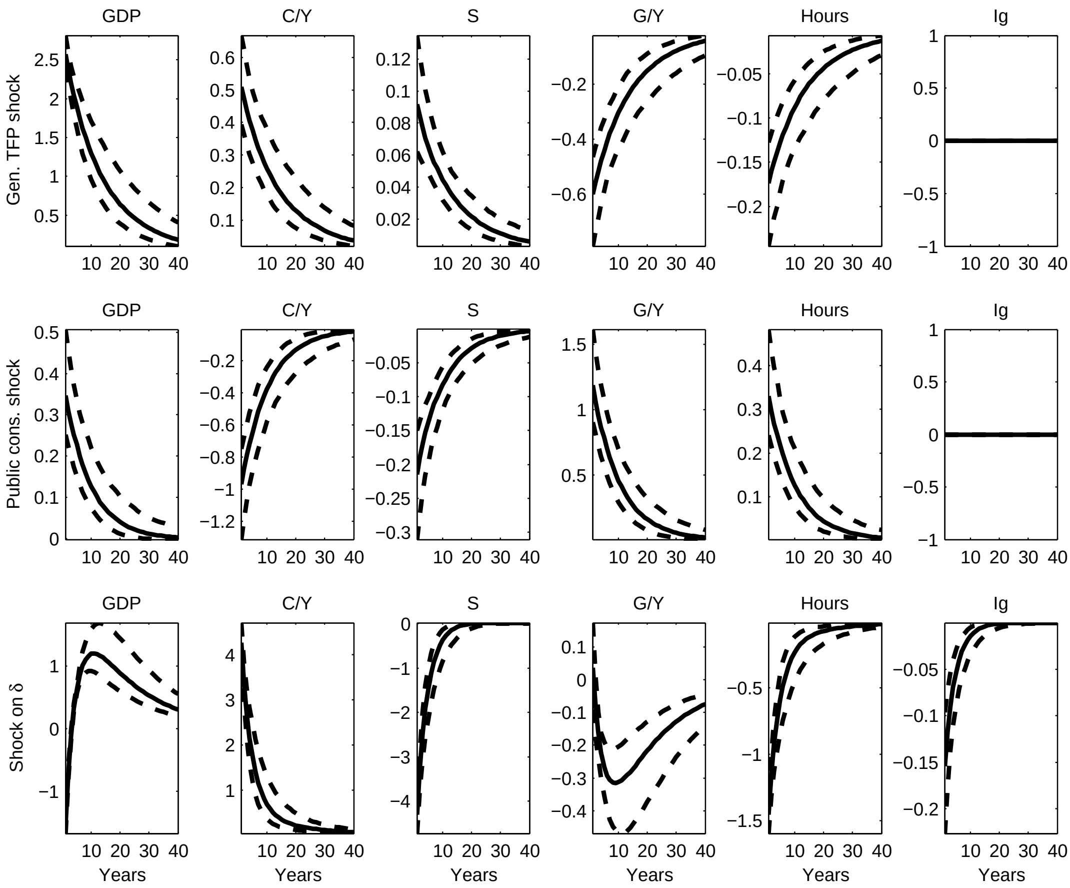


Figure 20: Impulse response functions for Germany after a one sd shock (in %)

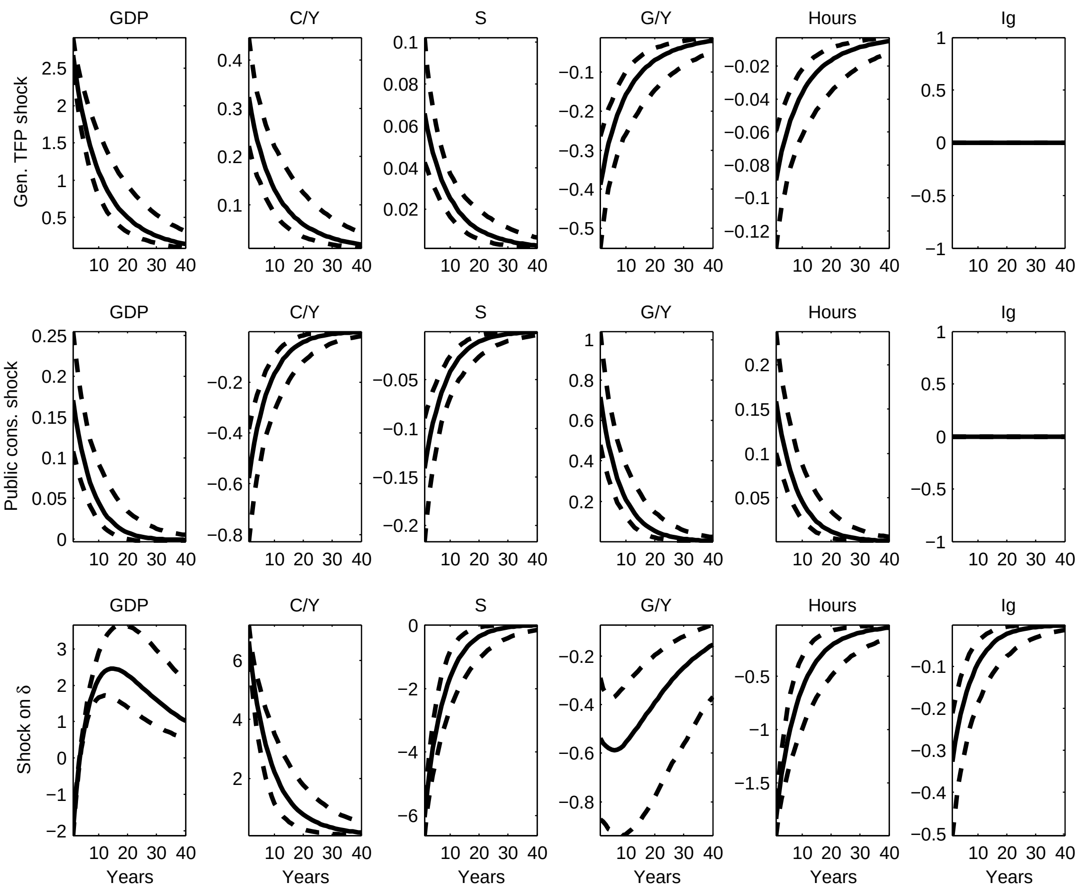


Figure 21: Impulse response functions for Italy after a one sd shock (in %)

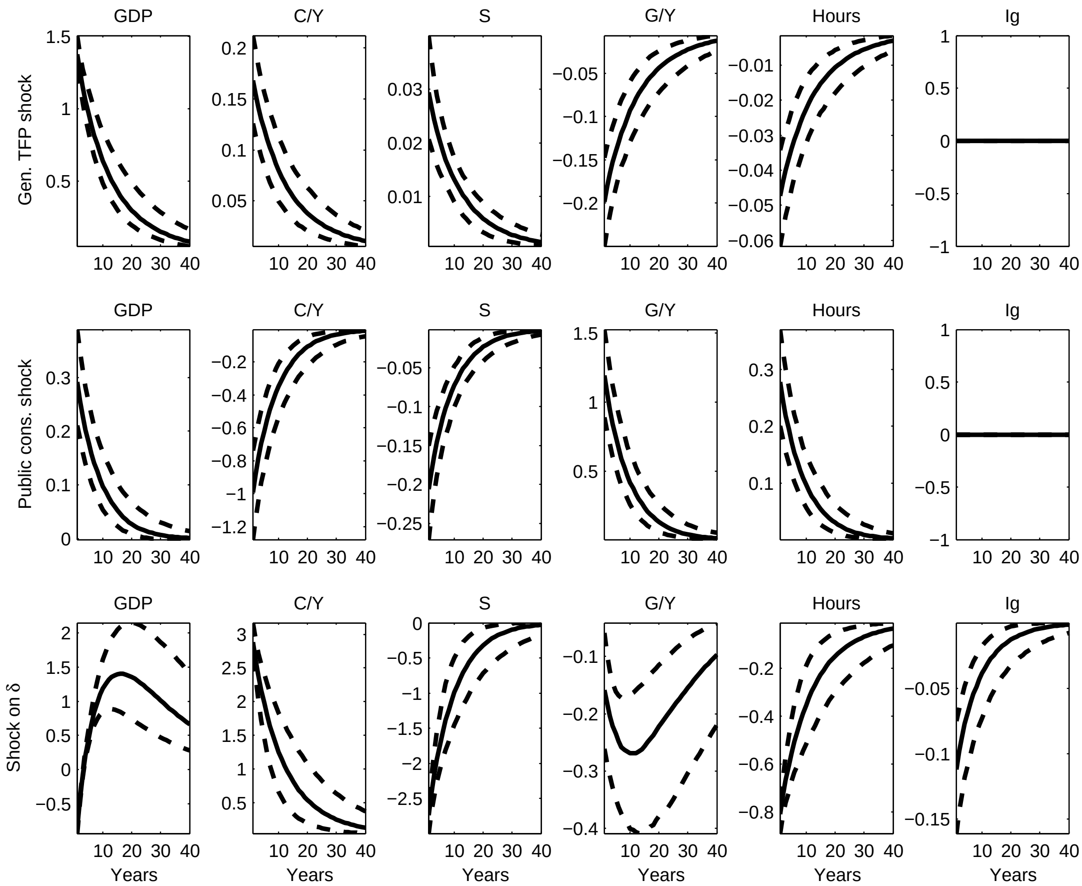


Figure 22: Impulse response functions for Japan after a one sd shock (in %)

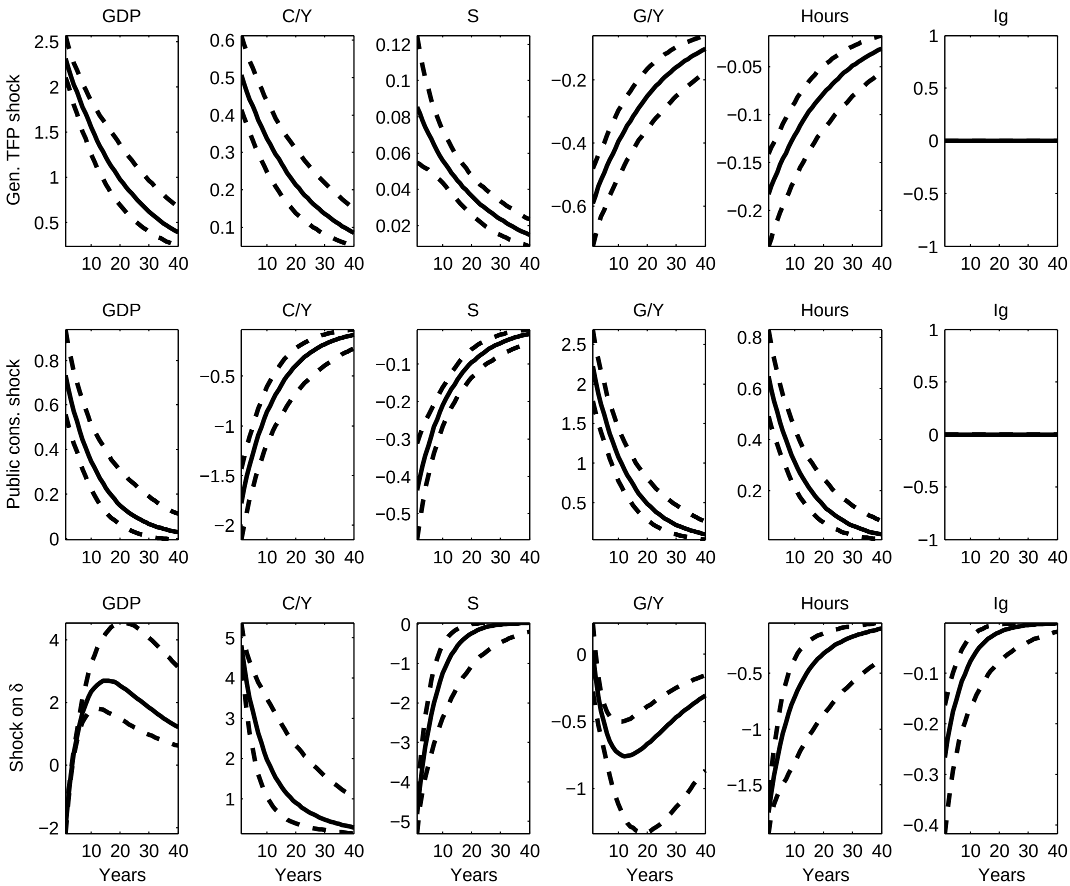


Figure 23: Impulse response functions for Spain after a one sd shock (in %)

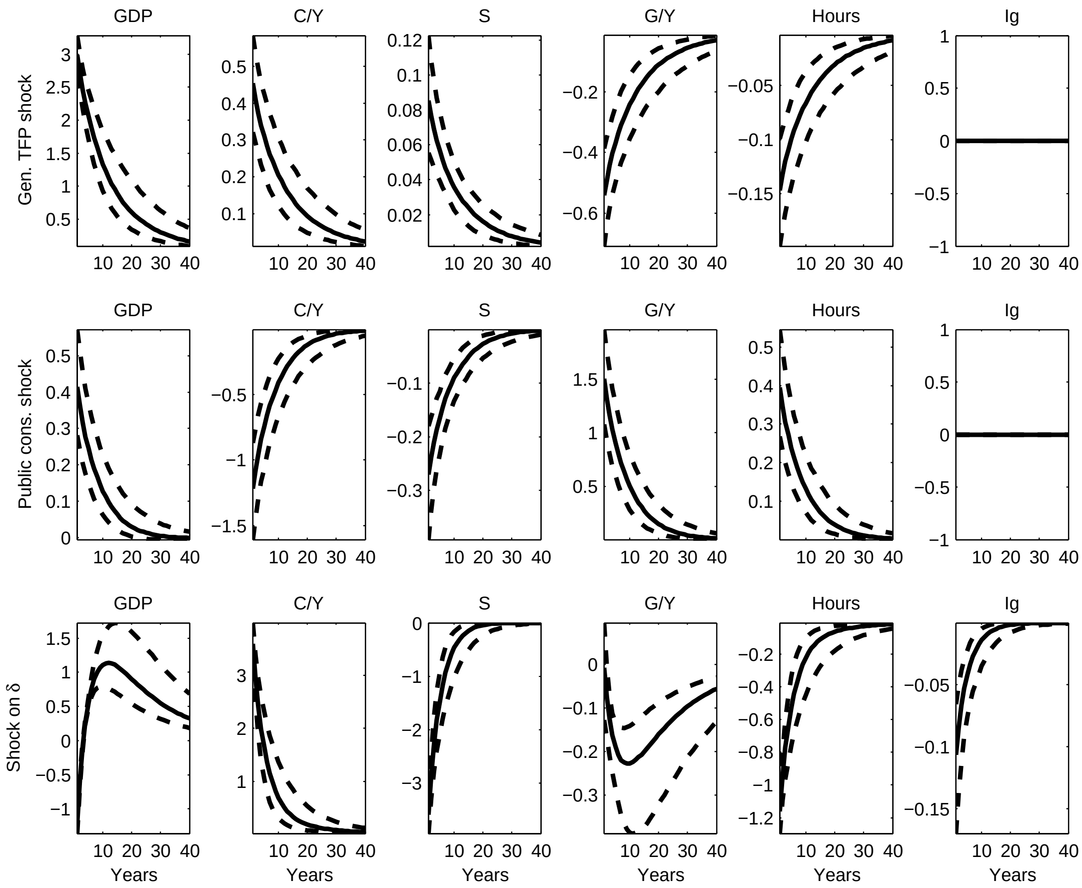


Figure 24: Impulse response functions for Sweden after a one sd shock (in %)

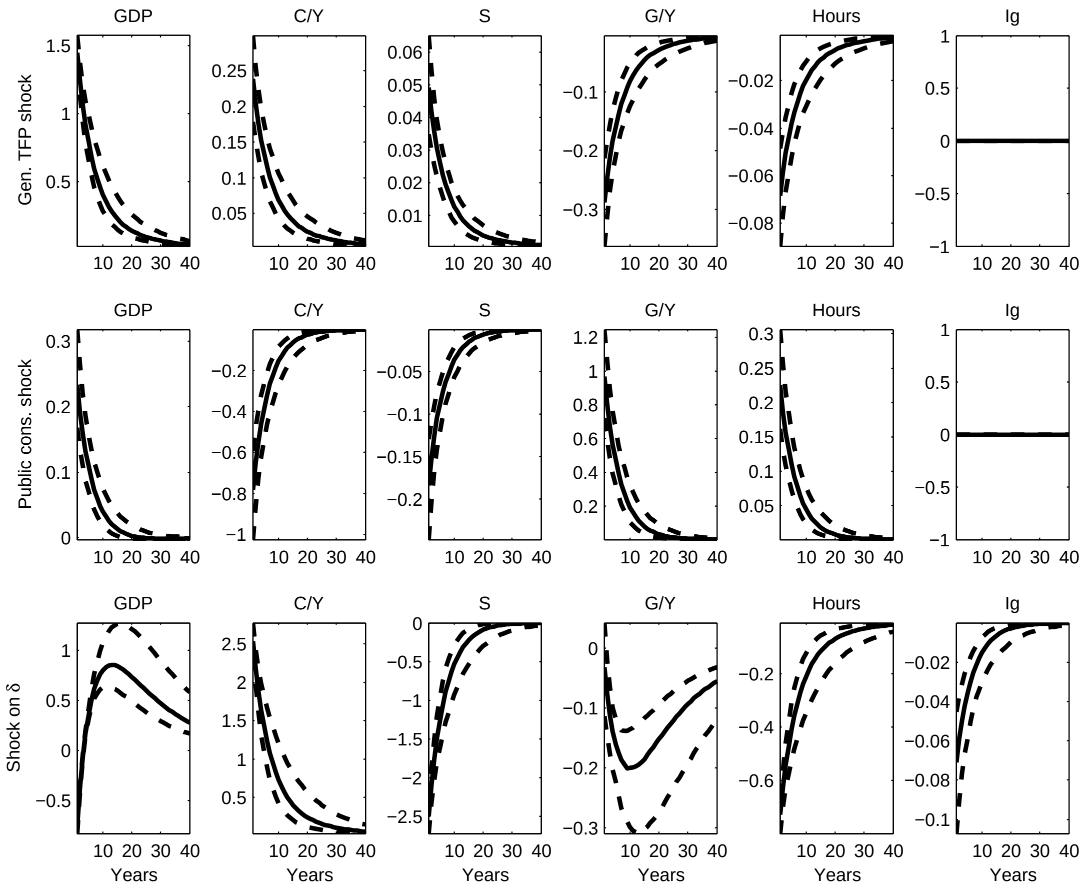


Figure 25: Impulse response functions for UK after a one sd shock (in %)

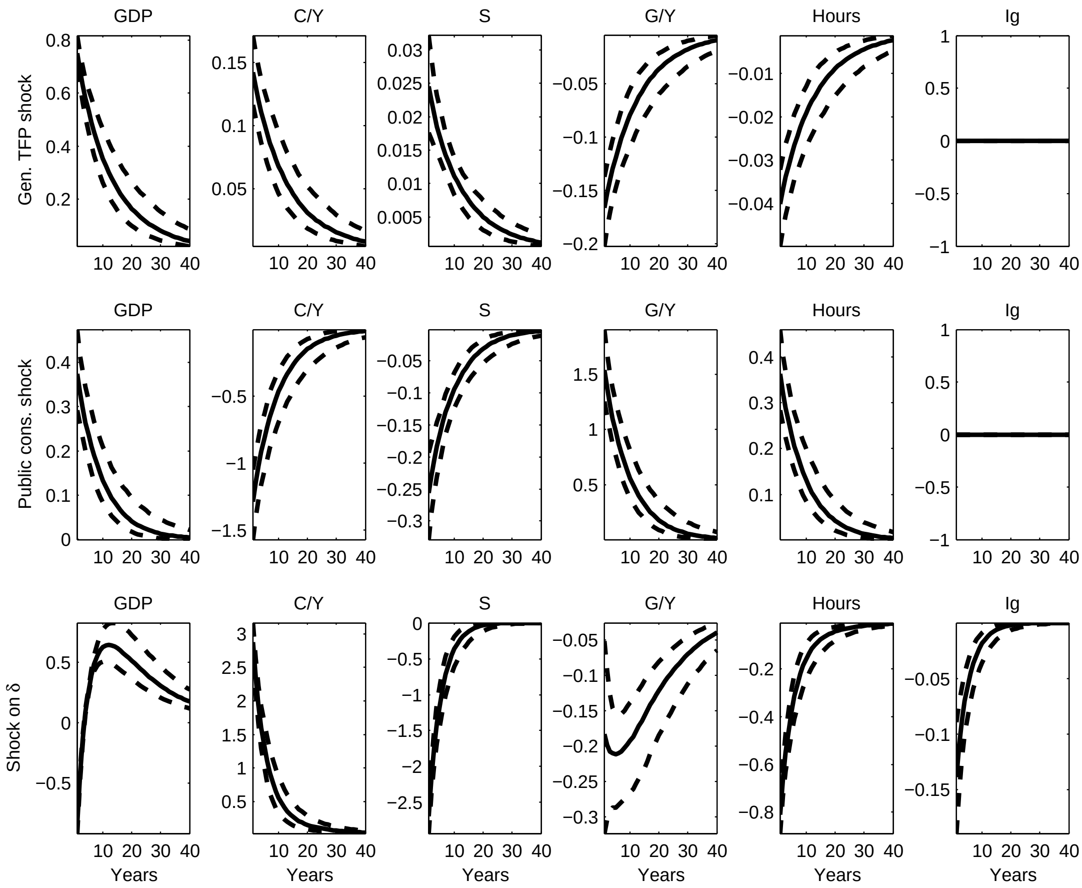


Figure 26: Impulse response functions for the USA after a one sd shock (in %)