The Great Depression in Belgium: an Open-Economy Analysis

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Abstract

This paper studies the Great Depression in Belgium within the open-economy dynamic general equilibrium approach. Results from the simulations show that a two-good model with total factor productivity shocks and nominal exchange rate shocks can account for most of the 1929-1934 output drop. The data mimicking ability of the model is good along other dimensions as well, most notably hours worked, the consumption price index and the terms of trade. The model is also able to catch some of the dynamics of imports and exports.

Keywords: Great Depression, Belgium, Dynamic Stochastic General Equilibrium, Open Economy

JEL Classification: N14 F41 E13

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1 Introduction

Recent years have witnessed a revival of interest for the Great Depression of the 1930s. In a seminal contribution, Cole and Ohanian (1999) have for the first time applied the dynamic general equilibrium (DGE) analysis to the interpretation of the US Great Depression. Thereafter, several authors have entered this promising field, with major contributions by Bordo, Erceg, and Evans (2000), Christiano, Motto, and Rostagno (2004), Cole and Ohanian (2004), Kehoe and Prescott (2002), Weder (2006), among others.[1] For all the questions that such a methodology arises in historical analysis,[2] it is doubtless that the emergence of this new stream of literature has opened interesting new perspectives on the theme.

A controversial feature of this literature is its main focus on a closed-economy, nation-by-nation analysis. Although the international dimension of the Great Depression has long been recognised as a fundamental trait of the event by historians,[3] DGE macroeconomists have instead mostly concentrated on idiosyncratic shocks for single countries in a closed-economy perspective.[4]

The aim of this paper is to move this literature one step forward, by taking in consideration an open-economy scenario for the analysis of the Belgian case.

To encompass the open-economy dimension is likely to be important for Belgium. Openness to international trade in goods and services has traditionally been a distinctive feature of the Belgian economy. Data shows that during the 1930s both the ratios imports/output and exports/output were around 30%, a high value by the standards of the time.[5] In 1931, Belgium was the fifth world exporter, after the United States, Germany, Great Britain and France.[6] There is unanimity among historians on the fact that a complete understanding of the Belgian Great Depression cannot be achieved without considering the additional constraints that bound Belgium as a consequence of its open-economy nature.[7]

Accordingly, the Belgian case is in principle suitable for analysis within the small-open-economy framework in modern macroeconomics. Originally

[1] See Pensieroso (2007b) for a survey.

[2] See De Vroey and Pensieroso (2006) and Temin (2008).

[3] Kindleberger (1973) Eichengreen and Temin (2000).

[4] Besides the works quoted in the main text, Beaudry and Portier (2002) deal with France, Cole and Ohanian (2002) with the United Kingdom, Fisher and Hornstein (2002) with Germany, Pensieroso (2007a) with Belgium.

[5] Data taken from Buyst (1997).

[6] See Vanthemsche (1987).

[7] See Cassiers (1989), Hogg (1986), Mommen (1994).

advanced by Mendoza (1991) in a pure real-business-cycle (RBC) set up, this class of models was recently extended by Galì and Monacelli (2005) to a New Keynesian framework, encompassing imperfect competition, price stickiness and monetary policy.

Section 3 considers the effects of unexpected TFP shocks in a model where the economy trades only in bonds with the rest of the world and takes the interest rate as given. Results shows that the pure intertemporal dimension stressed by Mendoza's analysis might have played a role in accounting for the Great Depression in Belgium.

To enrich this initial analysis, the rest of the paper takes up the challenge to adapt the model to the peculiarities of the Belgian industrial structure, as they have been singled out by the historians.

According to Cassiers (1989), the interwar Belgian economy can be thought of as sharply divided into two macro sectors, the domestic and the international sector. These two sectors were different under many respects, ranging from labour unionization to capital intensity, from the average firm dimension to the price setting process. Hence, the argument runs, the two sectors behaved differently during the Depression. In particular, they responded differently to the deflationary pressure of the 1930s. Figure 1 shows evidence for different price indices. While the cost-of-living, the retail and the wholesale price indices all decreased appreciably between 1929 and 1934, the wholesale price index plummeted more dramatically than the other two. As it is traditionally retained that the wholesale price reflects more the prices of goods that are traded internationally, while both the cost-of-living and the retail prices put more weight on domestic goods, this feature suggests that the deflation of the 1930s hit more the international than the domestic sector.

At the light of this argument, an appropriate way to model Belgium in the interwar era might be to consider an open economy with two sectors, one producing tradeable, the other non tradeable goods. This is the way I shall explore in Section 4, drawing inspiration from the work by Stockman and Tesar (1995).

The rest of the paper is structured as follows. In Section 2, I shall briefly present selected data for the interwar Belgium. In Section 3, I shall discuss a first exercise based on the Mendoza's one-good open-economy RBC framework. Section 4 extends the analysis to a benchmark two-sector, open-economy model. In Section 5, I shall present a simple framework encompassing nominal exchange rate shocks. Finally, Section 6 summarizes the argument and draws some preliminary conclusions.

2 History and data

The traditional story about the Great Depression in Belgium focuses on the exchange rate system.[8] After the Depression spread from the United States to Europe, Belgium decided to stick to the Gold Standard, together with France, the Netherlands, Switzerland, Poland and Czechoslovakia. Such a decision was natural, as Belgium orbited around France, and France feared the inflationary pressure that could result from a devaluation. On the other hand, it was also a problematic decision to take, with respect to what was contemporaneously happening in the United Kingdom. The United Kingdom, a major commercial partner for Belgium, exited the Gold Standard as early as in 1931. This put the big Belgian firms producing for the British market in an uneasy position. As they where price takers abroad, their selling price in sterling was fixed. However, as the sterling lost value with respect to the Belgian franc, their profitability was suddenly diminished. In facts, many of them faced big losses. To ease the situation of the export sector and yet keep the Belgian franc anchored to the Gold Standard, the Belgian Government implemented a series of deflationary measures. These included measures of public finance like increases in income tax, indirect taxes and tariffs, or reductions in pensions and unemployment benefits. Other measures were more directly targeted to lowering the production costs at home, in particular wages. Wage earners opposed a fierce resistance to wage reduction, even if, eventually, they accepted significant drops in the nominal wage. The unemployment rate jumped up from 1.7% in 1929 to 20.2% in 1932 (Goossens (1988)). The situation got worse and worse until the Government decided to abandon the Gold Bloc, and devaluated the Belgian franc by 28%, following the advise by the Louvain School. The devaluation prompted the recovery, with output exceeding its 1929 value already in 1937.

This traditional account finds support from the raw data.

Figure 1 shows the exchange rate of the Belgian franc with the British pound and the French franc. The value of the Belgian franc in terms of the British pound increased steadily from 1930 to 1934, to decrease after the 1935 devaluation. The value of the Belgian franc with respect to the French franc was fixed until 1934. It decreased between 1935 and 1936, to increase soon after the French devaluation.

The deflationary pressure induced by an overvalued franc, and reinforced by the deflationary policy of the Belgian government is evident from the price and interest rates data. The early 1930s were a period of strong deflation, with the retail ('cpi'), cost-of-living and wholesale ('ppi') price indices all

[8]See Baudhuin (1946) and Cassiers (1995).

falling dramatically till 1934, and increasing a bit after the 1935 devaluation of the Belgian Franc. As already mentioned above, the dynamics of the wholesale price index is much more accentuated than that of the other two.

Nominal interest rates were decreasing until 1931, then increasing till 1933 and then slightly decreasing till 1937. The behaviour of the real interest rate reflects the strong deflationary pressure. The real interest rate was high and positive in the early 1930s, and negative after the 1935 devaluation of the Belgian franc.

The real side of the economy suffered from a dramatic downturn as well. Figure 2 shows data about output and its components (top-right panel). According to these data, Belgium entered the Great Depression after 1931. In 1934, real output ('gnp' in the graph) was 10% below the 1929 level. The figure was 40 % for investments ('i'), 20% for exports ('x'), 17% for imports ('m'). Consumption ('c') witnessed only a minor decrease.

Employment ('l') dropped cumulatively of a good 20%, to witness a slight tendency to recovery from 1934 onwards. Nominal wages decreased by 20% between 1929 and 1935. Such a decrease was not enough to cope with the decreasing prices. Consequently, real wages increased by about 10% in the same period. After 1935, both the nominal and the real wage series increased appreciably.

The fact that output starts decreasing only in 1931, and the increasing pattern of all the real aggregate variables but for consumption after 1935 look like a vindication of the traditional view about the monetary origins of the Great Depression in Belgium, although the persistent high level of unemployment is hard to explain within that framework.

However, if we look at the evidence through the lens of neoclassical theory, i.e. by looking at the data in deviations from trend, a different picture emerges (top-left panel).[9]

In effect, according to this theory-based inspection of the evidence, Belgium entered the Great Depression soon after 1929, with the major drop in output being between 1930 and 1934. After that, output stayed constantly below the trend, showing no sign of recovery.

Investments decreased sharply all over the decade, up to being 65% below trend in 1939.

The depression did not affect consumption before 1931, when the series

[9] Data have been detrended using a linear filter, as in Cole and Ohanian (1999). Specifically, I have measured the average growth factor of the Belgian economy in the 20th century, after excluding World Wars I and II and the Great Depression as well. Then, after assuming 1929 as the base year, I have taken the measured trend out of the data. Obviously, neither the labour series nor the prices are detrended. The detrending technique is explained more in details in Pensieroso (2007a).

start decreasing. Thereafter, consumption followed a decreasing path, being almost 20% below trend in 1939.

Real wages ('w') were above trend in the early 1930s, but below trend from 1933 on.

The current account deficit was increasing at the beginning of the period, as exports fell faster than the decreasing imports.[10] Things are different for the late 1930s, when the faster recovery of exports with respect to imports implies a decreasing deficit in 1935, and an increasing surplus from 1936 until the end of the period. The terms of trade, here defined as the price of exports over the price of imports, had a swinging pattern, increasing till 1933, then decreasing till 1936, then increasing again.

3 The one-good model

There are two kind of gain from international trade, the intertemporal and the infratemporal gain. The intertemporal gain stems from the fact that international trade enlarges the possibility for a country to smooth consumption over time. The infratemporal gain relates to comparative advantages among countries producing different goods.

In order to provide a throughout assessment of the role of international factors in accounting for the Great Depression in Belgium, I shall explore the two aspects separately. I shall first study a model with intertemporal gains from trade only. A viable candidate is a standard small-open-economy RBC framework with technology shocks.[11] In a second step, I shall delve into the issues related to the infratemporal gains from trade, introducing a two-good open-economy framework. Finally, the two aspects will be both taken into account in a more general model.

3.1 The model

The model economy produces one good, Y, using capital K and labour L, according to a Cobb-Douglas production function

$$y_t = e^{s_t} k_t^{\alpha} (\mu_t l_t)^{1-\alpha} \tag{1}$$

It is assumed that the economy can exchange assets with the rest of the world. These assets pay a constant real interest rate r^*. The small-open-

[10] Belgium current account was in deficit (between 2% and 4% of GNP) throughout the 1929-1935 period and in surplus (between 1% and 2% of GNP) later on.

[11] The model is similar to Mendoza (1991).

economy assumption implies that the domestic economy cannot influence the value of r^*. No labour migration is allowed.

Let b_t be the value of per-capita net foreign assets held by the representative household at the end of period $t-1$. I define the current account balance in period t, CA_t, as the variation of the net claims of a country over the rest of the world:

$$CA_t \equiv b_{t+1} - b_t.$$

The economy is populated by infinitely living representative households, who choose per-capita consumption, c, and leisure, $1-l$, so as to maximise their utility function, subject to a budget constraint.

$$\max_{\{c_t, l_t, k_{t+1}, b_{t+1}\}_{t=0}^{\infty}} E_t \sum_{t=0}^{\infty} \beta^t \left[\ln(c_t) + \phi \ln(1 - l_t)\right], \tag{2}$$

under the constraints:

$$\begin{gathered}
c_t + k_{t+1} + b_{t+1} \leq (1-\delta)k_t + y_t + (1+r^*)b_t, \\
y_t = e^{s_t} k_t^{\alpha} (\mu_t l_t)^{1-\alpha}, \\
s_t = \rho s_{t-1} + v_t, \\
\mu_t = \gamma^t \mu_0 \\
0 < \rho < 1, \\
k_0 = \text{given}, \\
b_0 = \text{given}, \\
s_0 = \text{given}.
\end{gathered}$$

In the formulation above, lowercase letters stand for per capita.

The economy is trend stationary, with γ being the growth factor of the labour augmenting technological progress, μ. I assumed that the stochastic component of total factor productivity, e^s, follows an autoregressive process of order one. The residuals from such a process, v, are the technology shock I will feed in the model.

I assume rational expectations. Computing the first order conditions of this problem, and detrending all the variable, the relevant equations for characterising a solution are:

$$\frac{1}{\tilde{c}_t} = \frac{\beta}{\gamma}(1+r^*)\frac{1}{\tilde{c}_{t+1}}; \tag{3}$$

$$1 - \delta + \alpha e^{s_{t+1}} \left(\frac{\tilde{k}_{t+1}}{l_{t+1}} \right)^{\alpha - 1} = 1 + r^*; \tag{4}$$

$$\gamma(\tilde{k}_{t+1} + \tilde{b}_{t+1}) = (1 + r^*)\tilde{b}_t + (1 - \delta)\tilde{k}_t + e^{s_t}\tilde{k}_t^{\alpha} l_t^{1-\alpha} - \tilde{c}_t; \tag{5}$$

$$\frac{\phi}{1 - l_t} = \frac{1}{\tilde{c}_t} e^{s_t}(1 - \alpha) \left(\frac{\tilde{k}_t}{l_t} \right)^{\alpha}; \tag{6}$$

Equation (4) is a no-arbitrage condition between home capital and bonds, whereas Equations (3), (5) and (6) are the open-economy version of the standard Euler equation, budget constraint and labour supply, respectively.

The steady state of this class of open-economy models turns out to be consistent with any initial level of net assets (Correia, Neves, and Rebelo (1995), Kim and Kose (2003)). This multiple-equilibria feature introduces a stationarity problem in the model: at steady state, a country with higher net assets holdings will be able to afford higher trade deficits, and therefore higher consumption levels. As a consequence, any shock, even if trend-stationary, will have permanent effects on assets and therefore on consumption. This introduces a random-walk component in the model.

Many ways exist to solve this problem (Schmitt-Grohé and Uribe (2003)). I chose to impose a risk premium on the real interest rate paid or received by the domestic economy. The idea is that the lower the net asset holding of the country, or, when b is negative, the higher its foreign debt, the higher the interest rate it has to pay to borrow more will be. So, in the model above, we can substitute r^* with

$$r_t = r^* + \psi(e^{-b_t} - 1). \tag{7}$$

This formulation stationarises the model, as the steady state level of b is now determined by the Euler equation, and turns out to be a function of r^* and ψ only.

3.2 Calibration and simulation

The model's structural parameters are calibrated as shown in Table 1. The unit period is the year. The parameters α, the capital share in the Cobb Douglas production function, and δ, the depreciation rate of capital, are fixed accordingly, as in Cole and Ohanian (1999).

The parameter β is calibrated so that the steady-state real interest rate, net of the depreciation rate δ is equal to 5.6%, which is the average measured value for Belgium in the 1929-1938 period.

The secular growth factor of the Belgian economy, γ, is obtained by taking the average growth rate of the Belgian GDP per capita between 1900-1994, excluding World Wars I and II, and the Great Depression as well.

The preference for leisure, ϕ, is calibrated so that hours worked are 1/3 in equilibrium.

The autoregressive coefficient of TFP, ρ, is calibrated by running an AR(1) regression on the log of the measured detrended TFP.

The calibration of the parameter ψ was somewhat problematic. The 0.001 value was chosen so that the absolute value of the negative interest rate differential between Belgium and the rest of the World does not exceed 10 basis points, which is the limit spread suggested by Benigno and Thoenissen (2006).[12]

The steady-state world interest rate is given at $r^* = \frac{\gamma}{\beta} - 1$. I assume the economy to be in steady state in 1929. In the model, the steady-state value of current account is assumed to be 0, as are the initial and steady-state values of net foreign assets. I feed in the vector of TFP shocks obtained after regressing the log of detrended TFP as an AR(1).[13]

Figure 3 shows the results of this simulation, and compare them with the result of a simulation run on the closed-economy version of this model, e.g. the same model without bonds, where the interest rate is endogenous.

The model is able to account for about 35% of the peak-to-trough drop in the output data, and for almost 50% of the consumption drop.

The model fully accounts for the behaviour of investments in the 1929-1934 period. After 1934, the investment patterns in the model is far too volatile to be compared to the data.[14]

[12] I considered also two other possible values: 0.465, the value that allows the model to match the standard deviation of $\frac{CA}{Y}$ in the data; and 0.000742, the value for a similar model calibrated by Schmitt-Grohé and Uribe (2003) on contemporary Canadian data. In the case of $\psi = 0.465$, results show that the model overlaps with the closed-economy version. In the case $\psi = 0.000742$, the model's reaction to the TFP shock is more pronounced than in the benchmark calibration. This leads to conclude that the lower the value of ψ, the stronger the autocorrelation in the variable b, and therefore the stronger the propagation mechanism of the model. All in all, the benchmark value chosen in the text is conservative, although in line with the accepted practice in the literature, which is to assign a low value to this parameter.

[13] Simulations are run assuming rational expectations, but not perfect foresight of the shock. Agents are surprised by the contemporary shock, and assume future shocks to be zero. Kehoe and Prescott (2008) refers to this assumption as myopic foresight.

[14] Such a feature is in full accordance with standard results in the literature: small-open-economy RBC models tend to accentuate the investments volatility. The typical small open economy RBC model encompasses adjustment costs on capital to obviate this problem. Intuitively, the presence of adjustment costs on capital will kill the excess volatility shown by the model at the end of the decade. At the same time, it is likely to worsen the

β	0.975
γ	1.03
δ	0.1
α	0.33
ϕ	1.78
ρ	0.99
ψ	0.001
r^*	$\frac{\gamma}{\beta} - 1$

Table 1: Calibration of parameters

The labour dynamics is not accounted for by the model.

As is evident from the comparison with the closed-economy simulation, the qualitative behaviour of the model economy is on the whole comparable to that of a standard closed-economy RBC model. We notice, however, a slight improvement in the quantitative dimension, especially as far as output and consumption are concerned: generally speaking, the model is more responsive to the impulse. The labour dynamics is poorly accounted for by both the models, while the open-economy model fares much better in accounting for the investment drop, yet at the price of having a too volatile investment behaviour after 1934.

The open-economy model also improves slightly on its close-economy counterpart in accounting for the long-duration of the Great Depression in Belgium.

On the minus side, the fact that the model economy is now slightly more responsive to the technological shock makes it more at variance with the data than its closed-economy counterpart when the onset of the Great Depression is concerned. In facts, both output and consumption accentuate their above-trend path in the early 1930s.

From this exercise, I conclude that the extension of the closed-economy analysis to a scenario that considers only the intertemporal gains from international trade is a useful refinement of the model.

As the historians put much weight on the trade-related aspects of the Great Depression in Belgium, next section is devoted to the task of enriching this analysis, so as to take into account the infratemporal as well as the intertemporal gains from trade.

predictive capacity of the model for the initial drop.

4 The two-good model

In this section, I shall introduce a two-sector structure in the model. The idea is to allow the model economy to have the kind of sectorial unbalances that are considered important by Cassiers (1989) and Hogg (1986) to understand the Belgian Great Depression. To this end, I modelled the Belgian economy as an open economy with two sectors, one producing a tradeable good, y^T, the other a non-tradeable one, y^N.[15] Production functions in both sectors are Cobb-Douglas with constant return to scale:

$$y^N = e^{s^N} \left(k^N\right)^{\iota} \left(l^N\right)^{1-\iota}; \tag{8}$$

$$y^T = e^{s^T} \left(k^T\right)^{\nu} \left(l^T\right)^{1-\nu}. \tag{9}$$

The variable s^j stands for total factor productivity in sector j, for $j = N, T$. Both labour and capital are assumed to be mobile across sectors, but not internationally. To begin with, and in order to isolate the effects of the infratemporal gains from trade only, I shall temporarily exclude assets from the model. This means that the interest rate is endogenous.

The tradeable good can be exported, x, consumed, c^T, or invested in both the sectors. I labeled $i^{T,j}$ the tradeable good invested in sector j. The non-tradeable good can be consumed, c^N, or invested in both the sectors, $i^{N,j}$.

The economy imports consumption and investment goods, c^M and i^M respectively.

Aggregate consumption, c, is expressed as a Cobb-Douglas index of c^N, c^T and c^M:

$$c = (c^N)^{a_c} (c^T)^{b_c} (c^M)^{(1-a_c-b_c)}. \tag{10}$$

Aggregate investment in sector j is expressed as a Cobb-Douglas index of $i^{N,j}$, $i^{T,j}$ and $i^{M,j}$:

$$i^j = (i^{N,j})^{a_{i,j}} (i^{T,j})^{b_{i,j}} (i^{M,j})^{(1-a_{i,j}-b_{i,j})}. \tag{11}$$

All variables are per capita, and when suitable, detrended. Prices are expressed in terms of the tradeable good, whose price is therefore taken as the numéraire ($p^T = 1$). I assumed perfect competition.

The model can be solved adopting a stepwise procedure. First, in each period t, given preferences, endowments and technical conditions, households

[15] A similar model was proposed by Perri and Quadrini (2002) for the Great Depression in Italy.

determine the optimal allocation between different kind of goods, given the total amount of consumption and investment. This problem is static by its nature.

Second, households have to decide how to allocate wealth intertemporally, thereby determining the consumption and savings plans. This is the dynamic part of the model.

The two parts together fully determine the intertemporal path of all the variables involved.

4.1 The static problem

4.1.1 Firms

The firm in sector j chooses capital and labour so as to maximize its profits in period t,

$$\Pi^j = p^j y^j - w^j l^j - p^{i,j} r^j k^j, \tag{12}$$

given the constraints (8) and (9). In the profit equation (12), $p^{i,j}$ is the price index for aggregate investment in sector j, and will be defined later on.

The first order conditions for this problem gives the demand schedules for labour and capital in sector j:

$$w^N = \frac{p^N(1-\iota)y^N}{l^N}; \tag{13}$$

$$w^T = \frac{(1-\nu)y^T}{l^T}; \tag{14}$$

$$r^N p^{i,N} = \frac{p^N \iota y^N}{k^N}; \tag{15}$$

$$r^T p^{i,T} = \frac{\nu y^T}{k^T}. \tag{16}$$

4.1.2 Households

Given total consumption c_t, households choose to consume non-tradeable, tradeable and imported goods so as to maximize equation (10), subject to

$$p^N c^N + c^T + p^M c^M = p^c c.$$

The solution to this problem gives the infratemporal demand for c^N, c^T and c^M as a function of both their respective price relative to p^c and total consumption c:

$$c^N = \frac{a_c c p^c}{p^N}; \tag{17}$$

$$c^T = b_c c p^c; \tag{18}$$

$$c^M = \frac{(1 - a_c - b_c) c p^c}{p^M}. \tag{19}$$

The price index p^c is defined as the minimum expenditure $Z \equiv p^c c$ such that $c = 1$. This amounts to

$$p^c = \frac{\left(p^N\right)^{a_c} \left(p^M\right)^{1-a_c-b_c}}{(a_c)^{a_c} (b_c)^{b_c} \left(1 - a_c - b_c\right)^{1-a_c-b_c}}. \tag{20}$$

The same procedure is implemented to find the infratemporal demand functions for the different kind of investment goods, as well as for their price indexes. Recall that in the following $i^{j,N}$ is the amount of the j-type investment good in the production of i^N.

$$i^{N,N} = \frac{a_{i,N}(i^N)(p^{i,N})}{p^N}; \tag{21}$$

$$i^{T,N} = b_{i,N}(i^N)(p^{i,N}); \tag{22}$$

$$i^{M,N} = \frac{(1 - a_{i,N} - b_{i,N})(i^N)(p^{i,N})}{p^M}; \tag{23}$$

$$p^{i,N} = \frac{\left(p^N\right)^{a_{i,N}} \left(p^M\right)^{1-a_{i,N}-b_{i,N}}}{(a_{i,N})^{a_{i,N}} (b_{i,N})^{b_{i,N}} \left(1 - a_{i,N} - b_{i,N}\right)^{1-a_{i,N}-b_{i,N}}}; \tag{24}$$

$$i^{N,T} = \frac{a_{i,T}(i^T)(p^{i,T})}{p^N}; \tag{25}$$

$$i^{T,T} = b_{i,T}(i^T)(p^{i,T}); \tag{26}$$

$$i^{M,T} = \frac{(1 - a_{i,T} - b_{i,T})(i^T)(p^{i,T})}{p^M}; \tag{27}$$

$$p^{i,T} = \frac{\left(p^N\right)^{a_{i,T}} \left(p^M\right)^{1-a_{i,T}-b_{i,T}}}{(a_{i,T})^{a_{i,T}} (b_{i,T})^{b_{i,T}} \left(1 - a_{i,T} - b_{i,T}\right)^{1-a_{i,T}-b_{i,T}}}. \tag{28}$$

4.2 The dynamic problem

Households take their saving decisions by solving the following maximization problem:

$$\max_{\{c_t, l_t^N, l_t^T, k_{t+1}^N, k_{t+1}^T\}_{t=0}^{\infty}} E_t \sum_{t=0}^{\infty} \beta^t \left[\ln(c_t) + \phi \ln(1 - l_t)\right], \tag{29}$$

subject to

$$\gamma k_{t+1}^N = (1-\delta)k_t^N + i_t^N; \tag{30}$$

$$\gamma k_{t+1}^T = (1-\delta)k_t^T + i_t^T; \tag{31}$$

$$w_t^N l_t^N + w_t^T l_t^T + r_t^N (p^{i,N}) k_t^N + r_t^T (p^{i,T}) k_t^T = (p_t^c) c_t + (p_t^{i,N}) i_t^N + (p_t^{i,T}) i_t^T; \tag{32}$$

$$l_t = l_t^N + l_t^T. \tag{33}$$

Here, I have assumed a log-log utility function in total consumption and leisure.

The solution to problem (29) gives the rules for the intertemporal allocation of consumption, e.g. the Euler equations for k^N and k^T, and the labour supply schedules.

$$\frac{\gamma}{c_t} \frac{p_t^{i,N}}{p_t^c} = \beta E_t \left((1 + r_{t+1}^N - \delta) \frac{1}{c_{t+1}} \frac{p_{t+1}^{i,N}}{p_{t+1}^c} \right); \tag{34}$$

$$\frac{\gamma}{c_t} \frac{p_t^{i,T}}{p_t^c} = \beta E_t \left((1 + r_{t+1}^T - \delta) \frac{1}{c_{t+1}} \frac{p_{t+1}^{i,T}}{p_{t+1}^c} \right); \tag{35}$$

$$\frac{\phi}{1 - l_t} = \frac{1}{c_t p_t^c} w_t^N; \tag{36}$$

$$\frac{\phi}{1 - l_t} = \frac{1}{c_t p_t^c} w_t^T; \tag{37}$$

4.3 Equilibrium conditions

To close the model, I need to specify the demand for exports and the equilibrium conditions for the trade account.

Concerning the trade account, I assumed

$$x_t = p_t^M (c_t^M + i_t^{M,N} + i_t^{M,T}), \tag{38}$$

meaning that the trade account is balanced in any period. This is consistent with the hypothesis of internationally immobile capital.

The specification of the demand for export is somewhat troublesome, as I have not modelled the behavior of the rest of the World. In the following, I shall assume

$$x_t = am \left(\frac{1}{p_t^M} \right)^{\zeta}, \tag{39}$$

where $\zeta < 0$ is the elasticity of export demand from the rest of the world to the terms of trade (remember that $p_t^T = 1, \forall t$). The variable am stands for the "autonomous" components of the export demand.

Finally, I need to add the equilibrium conditions equating the productions of tradeable and non-tradeable goods to their respective demands.

$$y_t^N = c_t^N + i_t^{N,N} + i_t^{N,T}, \tag{40}$$

$$y_t^T = c_t^T + i_t^{T,N} + i_t^{T,T} + x_t. \tag{41}$$

4.4 Calibration

Table 2 shows the chosen calibration for the structural parameters of the model.

The values of β, γ and δ are fixed as in Section 3.

The values of ν and ι are calibrated so as to reproduce a specific aspect of the Belgian interwar economy. According to Cassiers (1989), in 1930, the international, or "unsheltered" sector employed 56% of the total number of employees. I have taken this to mean that in the model, the ratio $\frac{l^T}{l}$ should be 0.56 in steady state, and calibrated ν and ι accordingly. They turn out to be 0.49 and 0.66 respectively. [16]

[16] In Stockman and Tesar (1995), who estimate them as an average value for Germany, Italy, USA, Canada and Japan, the values for ν and ι are 0.49 and 0.54, respectively. Results from a simulation run with the values from Stockman and Tesar (1995) show no appreciable difference with respect to those obtained with the calibration advanced in the text.

β	0.975
am	0.08
γ	1.03
δ	0.1
ν	0.49
ι	0.66
ζ	-1
ϕ	1.59
ρ^N	0.99
ρ^T	0.99
a_c	0.61
b_c	0.29
$a_{i,N}$	0.78
$b_{i,N}$	0.22
$a_{i,T}$	0.37
$b_{i,T}$	0.10
λ	0.49

Table 2: Calibration of parameters.

The preference for leisure, ϕ, is calibrated so that in the steady state total hours worked are 1/3 of total available time.

The autonomous component of export demand, am, is calibrated so that $p^M = 1$ in steady state.

The elasticity of export demand to the terms of trade, ζ, is fixed to -1, consistently with the Cobb-Douglas structure of the import demand.

The share parameters a_c, b_c, $a_{i,N}$, $b_{i,N}$, $a_{i,T}$ and $b_{i,T}$ are calibrated using the 1965 input-output matrix for Belgium (Institut National de Statistique (1970)). The attribution of sectors to the tradeable or non tradeable category follows Plasmans, Michalak, and Fornero (2006). The parameters a_c and b_c are computed as the share of domestic tradeable and non-tradeable goods on total final domestic consumption. The parameters $a_{i,N}$, $b_{i,N}$, $a_{i,T}$ and $b_{i,T}$ are calibrated as follows. Using data for the gross fixed capital formation, I have computed the shares $\frac{I^{M,N}}{I^N}$, $\frac{I^{M,T}}{I^T}$, and $\frac{I^N}{I^T}$. Then, I have made the assumption that $\frac{a_{i,N}}{b_{i,N}} = \frac{a_{i,T}}{b_{i,T}} = \frac{I^N}{I^T}$. In other words, I have assumed that $\frac{I^{N,N}}{I^{T,N}} = \frac{I^{N,T}}{I^{T,T}} = \frac{I^N}{I^T}$. Given that the share of imported investments in sector j, $\frac{I^{M,j}}{I^j}$, is the complement to 1 of $a_{i,j}$ and $b_{i,j}$, and given the values of I^N and I^T, for $j = (N, T)$ I have a system of two equations that can be solved for

$a_{i,j}$ and $b_{i,j}$.[17]

I shall assume that the sectorial TFPs are subject to zero-mean i.i.d shocks of the AR(1) kind.

$$s_t^N = \rho^N s_{t-1}^N + v_t^N, \tag{42}$$

$$s_t^T = \rho^T s_{t-1}^T + v_t^T. \tag{43}$$

We do not have a clear-cut empirical counterpart for sectorial productivity s^N and s^T. In their stead, I used the aggregate productivity shock estimated in Pensieroso (2007a). I assumed the following relationship between sectorial and aggregate TFP:

$$s_t = \lambda s_t^N + (1 - \lambda) s_t^T,$$

with $\lambda = 0.49$ being the weight of the on tradeable sector in the 1965 input-output matrix. I also took ρ^N and ρ^T from Pensieroso (2007a), assuming that the sectorial autoregressive coefficient for TFP is the same as the one estimated there for the whole economy.

4.5 Impulse response functions

Before applying the model to the Great Depression in Belgium, it is useful to study the impulse response functions (IRF) to the technology shock in the tradeable sector. This will help our understanding of the working of this model and the subsequent ones as well.

Figures 4, 5, 6 and 7 show the IRF of the model to a 1% standard deviation positive shock to productivity in the tradeable sector v_t^T. Only the variables affected by the shock are graphed.

The increase in productivity in the tradeable sector has an obvious direct effect on y^T ('yt' in the graphs). Given the production function (9), this implies an increase in labour and capital demand in the tradeable sector ('lt', 'kt'). Obviously, as capital is a stock, it is the correspondent flow variable to bear the brunt of adjustment: investment in the tradeable sector ('it') must

[17] The use of modern data to single out the sectorial structure of the economy in the 1930s is obviously questionable. In particular, such a practice is likely to overestimate the weight of the non tradeable sector, for the latter includes services, whose value added was possibly higher in the 1960s than in the 1930s. For comparison, I report here the value of the share parameters in the work by Perri and Quadrini (2002), who analyse the Great Depression in Italy: $a_c = 0.6$, $b_c = 0.2$, $a_{i,N} = 0.6$, $b_{i,N} = 0.2$, $a_{i,T} = 0.3$ and $b_{i,T} = 2/5$. (I thank Fabrizio Perri for providing me their Gauss code, from which I have deduced those numbers).

increase. Given the labour supply (37), wages in the tradeable sector must increase to cope with the excess demand of labour. The increase in investment causes the interest rate in the tradeable sector ('rt') to increase, so as to equate saving and investment, according to the Euler equation (35). Note that, accordingly, the pattern of aggregate consumption ('c') is increasing in time, before reverting toward the steady state.

The increased efficiency in the tradeable sector causes a decrease in the price of the tradeable good. As the latter is the numéraire here, such a decrease will translate to an increase in all the other prices. This leads to a substitution effect from non-tradeable and imported goods towards tradeables. However, an income (wealth) effect is also at work here. The increase in the TFP of the tradeable sector makes households richer. They will buy relatively more tradeable goods, but they will also buy more goods in general. Moreover, as tradeable goods are used also in the accumulation of capital in the non-tradeable sector, there is a further transmission mechanism for the shock to influence the non-tradeable production ('yn') as well. This explains why i_t^N ('in') increases as well. Such a mechanism is reinforced by the fact that also the accumulation of capital in the tradeable sector is made upon the three goods, which in Equation (11) are assumed to be imperfect substitutes.

Note that Equations (36) and (37) ensure that wages in terms of tradeable good are equal in both sector, which is a logical consequence of the labour mobility assumption. Plugging such equality into the labour demands (13) and (14) gives us a better understanding of what is happening in the non-tradeable sector. As p_t^N ('pn') is increasing, the wage in terms of non-tradeable good - i.e. the labour cost in terms of production good - is decreasing, which adds to the income effect mentioned above, and helps to explain why l_t^N ('lno') increases even more than l_t^T. Such a feature also explain why both i_t^N and r_t^N ('rn') move more than i_t^T and r_t^T, respectively: the higher level of employment implies an higher capital demand.

Concerning the trade account, total import m, defined as $m = c^M + i^{M,N} + i^{M,T}$, is constant, meaning that its components move in such way to offset each other. The reason is that the increase in p^M ('pm') causes export ('x') to increase as well, as clear from equation (39). What is more, given $|\zeta| = 1$, export must move on a one-to-one basis with the price of import. This requires the total amount of import to be constant, if the equilibrium of the trade balance is to be preserved.

4.6 Simulation: the Great Depression

In this section, the time series of aggregate variables from the simulated model are plotted against selected evidence on the Great Depression in Belgium. The objective is to assess how much of the Belgian Great Depression can be accounted for by plugging the measured productivity shock into the model developed above.

As this model is intended to test the view of the historians based on sectorial asymmetries and external shocks, I have assumed that the productivity shock hit only the tradeable sector, and calibrated the vector $\mathbf{s^T}$ such that $\mathbf{s^T}$=$\mathbf{s}$.

I assume that the economy was in steady state in 1929. Then, I fed in the computed $\{v^T\}_{1929}^{1939}$ series, and run the simulation.

Results from the simulation are shown in Figures 8, 9, 10 and 11 (green line).

The measured pattern for the TFP shock is positive in the first three years of the Depression, and negative thereafter. This explains the qualitative behaviour of consumption, export, output in the tradeable sector, investment, real wages and the price indices. In the model, all these variables witness a boom in 1930-31, a pattern at variance with the data. The model-economy do not return to trend after the 1935 devaluation, a pattern in accordance with the data.

Quantitatively, the model fails to account for the dynamics of both capital related variables and labour. In the model, the cumulative drop in consumption between 1929 and 1934 in only about 2%, compared with more than 15% in the detrended data. Results are better for what concerns output. The cumulative drop of the tradeable production is about 12%, compared with an overall fall in detrended output of over 20%. Output in the non-tradeable sector barely moves in the simulation.

Export falls cumulatively of a good 10%, accounting for roughly a third of the observed drop in the data. As expected, import do no move in the model, whereas they decrease by almost 30% in the data.

Both the terms of trade and the consumption price index are accounted for reasonably well, but for the initial downturn. On the contrary, the model is not able to reproduce a key feature of the data, the pattern of the CPI/PPI index, expressed in the model by p_t^N.

The lesson to be drawn from this exercise is twofold. First, the two-sector structure is a promising framework to analyse the Great Depression in Belgium. It allows us to partially account for many trade-related variables and price indices, while still being reasonably simple. Second, the absence of bonds is a major shortcoming of the model. On top of implying a trade balance constantly in equilibrium - which is at variance with the data - such an assumption makes the model missing the behaviour of import by construction. This suggests that the intertemporal gain from trade might have played a non-negligible role for Belgium in the 1930s.

4.7 The model with bonds

For this reason, I shall now reintroduce the possibility for the model economy to exchange assets with the rest of the world, as in Section 3. These assets are denominated in terms of the tradeable good, and pay a constant real interest rate of r^*, which is assumed to be exogenously determined. Using the notation from Section 3, equation (38) becomes accordingly

$$x_t = p_t^M (c_t^M + i_t^{M,N} + i_t^{M,T}) + \gamma b_{t+1} - b_t, \tag{44}$$

while the uncovered interest parity will hold, with the presence of a risk-premium term to ensure stationarity:

$$r_t^N = r_t^T = r^* + \psi(e^{-b_t} - 1). \tag{45}$$

The parameter ψ is calibrated as in Section 3.

Figures 12, 13, 14 and 15 show the IRF of the model to a 1% standard deviation positive shock to TFP in the tradeable sector.

Compared to the previous exercise, we do not observe significant changes in the patterns of aggregate consumption, exports, real wages and the price indices. However, there are obvious differences stemming from the different behaviour of imports. The higher demand for investment and the income effect on consumption both imply a higher demand for imported goods. The economy finance the increase in import with a deficit in the current account. This explains why the price of import increases slightly less than in the previous exercise. It also explains the short-lived increase in the interest rate in the tradeable sector: the excess demand for investment is satisfied also out of debt, and not entirely out of domestic saving anymore.

4.8 The model with bonds and real wage rigidity

A second suitable modification of the benchmark model concerns the flexible price hypothesis adopted so far. Results suggest that we need some rigidity (some additional 'wedge' in the sense of Chari, Kehoe, and McGrattan (2007)) to strengthen the transmission mechanism of the model, and get a better accounting of the data. If we look at the historical narrative, there is evidence of wage rigidity in the tradeable sector. As I have recalled in the Introduction, according to Cassiers (1989), the open-economy nature of Belgium caused it to be sharply divided into a sheltered domestic sector and an unsheltered international one. Those macro-sectors behaved differently during the contraction. Following the British Pound devaluation in 1931, firms in the international sector were forced to deflate product prices, contrary to what happened to the domestic sector, that was relatively isolated from the international turbulence. Consequently, firms in the international sector asked for full-scale wage reductions, in order to cope with the shrinking mark-up due to the price deflation. As the international sector was highly unionised, such a call met with fierce resistance by the workers. Hence, the historical plausibility of the hypothesis of real wage rigidity in the tradeable sector.

This section serves the scope of enriching the model with this additional feature.

The simplest possible way of modelling sectorial real wage rigidity is to substitute equation (37) with

$$w_t^T = \kappa w_{t-1}^T + (1-\kappa)\frac{\tilde{c}_t p_t^c \phi}{1-l_t}. \tag{46}$$

Equation (46) makes real wages in the tradeable sector a weighted average of the previous period sectorial real wage and the equilibrium sectorial real wage, with κ being the proportion of the household that sticks to the previous period wage.[18] Obviously, the higher κ, the higher the percentage of workers not behaving according to the max-utility-of-leisure criterion, and therefore the stronger the rigidity I impose on the model. I calibrated the value of κ by approximating it with the Union membership. We know from Cassiers (1989) that Union membership in Belgium was above 35% by 1920. This percentage increased by 28% between 1929 and 1933. A recent survey by Blanchflower (2007) fixes this value to 42% in 1970 and 55% at the end of the 1990s. As I have assumed that $\frac{l^T}{l}$ is 0.56 in steady state, I have chosen κ equal to 0.8, meaning that I assume that 80% and 44% of the labour force, respectively in the tradeable sector and in the whole economy was unionised, and consequently stuck to the previous period wage.[19]

To disentangle how the response of the model to the shock differs from the flexible wage scenario, Figures 16, 17, 18 and 19 plot the IRF of the model with bonds and real wage rigidity to a 1% standard deviation positive shock to TFP in the tradeable sector. It is immediately evident that wage rigidity

[18]This oversimplified formulation only serves the scope of assessing the quantitative relevance of the asymmetric wage rigidity hypothesis. As explained by Blanchard and Galì (2007), such a formulation is parsimonious and yet general, being compatible with several models of wage rigidity. Moreover, one important feature of this formulation is that wage staggering results from distortions and not from preferences, which leaves the first best solution unaffected.

[19]The benchmark value of the parameter κ in Blanchard and Galì (2007) is 0.9. They chose it such that half of the shock disappears in 6 periods. In their model, however, the wage rigidity is not limited to one sector but concerns the entire economy, and the model is calibrated on a quarterly basis. In my case, the chosen value implies that half of the shock disappear in 2 years.

in the tradeable sector enhances the quantitative response of the model to the shock. Labour supply in the tradeable sector is now more elastic than before, which makes hours worked in the tradeable sector increase more than before. Consequently, part of the labour force shifts from the non-tradeable to the tradeable sector. This causes wages to increase relatively more in the non-tradeable sector, giving start to a recovery of hours worked in the non-tradeable sector that actually overshoot the steady state level. Another consequence of wage rigidity is the stronger increase in the price levels. This is particularly important for the terms of trade ('pm'), whose increase causes export to increase more than in the benchmark case. Interestingly enough, such an increase is not enough to compensate for the excess demand for investment, resulting in an increased trade deficit. The investment boom is explained by capital accumulation in the tradeable sector.

We can now repeat the exercise of Section 4.6 with the modified model. The black lines in Figures 8, 9, 10 and 11 show the result from simulating this model with bonds and real wage rigidity subject to the measured productivity shock.

The introduction of bonds and sectorial real wage rigidity causes the model to give an overall better accounting of the data. The model is in particular relatively good in accounting for the behaviour of the terms of trade and the consumption price index. It also has a better dynamics for imports and exports. Imports are more than 5% below trend in 1934 in the model, compared to a 30% in the data. For exports the numbers are a bit less than 20% and almost 30% respectively. In the model, hours worked drops cumulatively of a good 6%, compared with a 20% in the data. The decrease in real wage in the non-tradeable sector is far stronger than what is observed in the aggregate data, while the pattern of the tradeable real wage mimics the aggregate one almost perfectly. The cumulative drop in output in the tradeable sector account for almost 100% of the total output drop in the data. Output in the non-tradeable sector barely moves at all. The improvement over the benchmark model is almost not appreciable for what concerns aggregate consumption, and minor for what concerns investment and the real interest rates. The model is still not able to catch the $\frac{cpi}{ppi}$ relative price behaviour. The simulations also show a far too volatile pattern for many variables after the 1935 devaluation, suggesting that the perfect capital mobility assumption needs to be edulcorated by some kind of adjustment costs.

From this exercise, I conclude that a 'wedge' in the labour market and the intertemporal gain from trade help the model to get a better data mimicking ability. Still, there is room for improvement. The model is not able to reproduce a major part of the behaviour of investment and consumption.

Moreover, as TFP was above trend in 1930-31, we lack a plausible story for the onset of the Great Depression.

So far, the analysis has neglected the monetary dimension. However, monetary turbulencies over the nominal exchange rate has long been the historians favourite explanation of the Great Depression in Belgium. Given that the model formulated above in real terms does not fully account for the data, next section investigates whether introducing money into the model is a viable way to obtain better results.

5 The Role of the exchange rate: a simple monetary framework

This section introduce a second impulse mechanism on top of the TFP shock considered so far: the nominal exchange rate shock. The idea is to make the model suitable to consider the effects of the monetary policy carried out by the National Bank of Belgium to stick to the Gold Standard. Such a policy has traditionally been considered a major cause of the Belgian Great Depression.

The model is the same as in Section 4.8, but for the choice of the numéraire. Instead of measuring values in terms of the tradeable domestic good, which is the meaning of the assumption $p^T = 1$, I shall have variables expressed in terms of Belgian Francs. This means that p^T must be introduced back into the formulas. For instance, equations (18) and (20) becomes

$$c^T = \frac{b_c c p^c}{p^T}, \tag{47}$$

$$p^c = \frac{(p^N)^{a_c}(p^T)^{b_c}(p^M)^{1-a_c-b_c}}{(a_c)^{a_c}(b_c)^{b_c}(1-a_c-b_c)^{1-a_c-b_c}}. \tag{48}$$

All the equations concerning the tradeable sector are modified accordingly.

I have added two more equations to close the model.

$$p_t^X = p_t^T, \tag{49}$$

$$p_t^M = p_t^{*T} e_t, \tag{50}$$

The first equation formalises what was previously implicit: in perfect competition, and with no transportation costs the price in Belgian Francs of the tradeable good exported abroad must be the same as the price in

Belgian Francs of the tradeable good at home (law of one price). The second equation applies the law on one price the foreign good: its price in Belgian francs must be the same both in Belgium and abroad. The variable e is the nominal exchange rate between the Belgian franc and the 'currency' of the rest of the world. The latter should obviously be intended as a bundle of currencies. The nominal exchange rate is expressed in terms of the foreign currency (i.e. how many BF you need to have 1 unit of the bundle currency). In the simulations, the value of e is determined as a trade-weighted average of the nominal exchange rate between the Belgian Franc and a bundle of currencies from France, the Netherlands, Germany, the United Kingdom and the United States.[20] The price of foreign tradeable good is assumed to be constant and exogenous. Therefore the price level depends upon both the nominal exchange rate and the world price for tradeable. Inflation depends entirely on the nominal exchange rate.

I assumed that the (non-modelled) National Bank of Belgium has a gold parity target, and implements monetary policy accordingly. This means that the Bank cannot react to unilateral devaluations or revaluations by other countries, as doing so would imply changing the gold content of the Belgian franc. So the Bank limits herself to adjust the money supply in such a way that the nominal parity of the Belgian franc with gold is compatible with the trade balance.

Before taking the model to the Depression data, it is again interesting to study the IRF of the model to three possible shocks. To this purpose, Figures 20, 21, 22 and 23 plot the IRF to the three shocks separately. The blue line is the IRF of the model to a 1% standard deviation positive shock to the nominal exchange rate. The red line is the IRF of the model to a 1% standard deviation positive shock to the tradeable sector productivity. The black line is the IRF of the model to a 1% standard deviation positive shock to the non-tradeable sector productivity.

First consider the productivity shock to the tradeable sector. The increased efficiency in production causes the price of tradeables to decrease, as before. However, given that the tradeable good is not the numéraire anymore, such a decrease does not translate automatically into an inflationary pressure. The price of imports stays constant, as it is now determined by the nominal exchange rate and by the world price for tradeable goods, and I assumed them both constant. In the previous exercise, we were unable to make the distinction between the real and the monetary effect of the TFP variation. Here we can. If the nominal exchange rate could move in response to the TFP shock, the IRF would have the same pattern as before. As it

[20] Those Countries together received about 62% of the total Belgian exports in 1929.

happens, the constancy of the nominal exchange rate implies a deflationary pressure instead. Exports increases, a consequence of the higher efficiency of the domestic economy in producing tradeables. Imports increasing more than exports, the current account witnesses a small deficit lasting more than 10 periods. Imports increase out of an income effect.

The shock to the productivity of tradeables causes output in the tradeable sector to increase. The shift in the labour demand coupled with the wage rigidity in the tradeable sector should cause an increase in the real wage we do not apparently observe in the IRF. I say 'apparently', because what is graphed as 'wt' is the wages expressed in terms of the numéraire. So, in this model, 'wt' stands for the nominal wage. However, if the nominal wage is deflated with the consumption price, the increase in the real wage becomes appreciable. Hours worked in both sectors move little. The shock transmits to the non-tradeable sector exactly as before, i.e. via the accumulation of capital.

Consider now the productivity shock in the non-tradeable sector. A shock on the non-tradeable TFP increases production in the non-tradeable sector and decreases the relative price $\frac{P^N}{P^T}$. *Mutatis mutandis*, the transmission mechanism within the non-tradeable sector via the labour demand is the same as before. The same holds true for the transmission mechanism to the tradeable sector, via the accumulation of capital. A feature which is noteworthy is the greater overall impact of the TFP shock in the non-tradeable sector *vis à vis* the TFP shock in the tradeable sector. Such a difference is due in part to the role played by the rest of the world in influencing the dynamics of the tradeable sector. But most of the difference is explained by the major weight that non-tradeables holds in the consumption and investment aggregators.

As the nominal exchange rate remains stable, the shock to the productivity of the non-tradeables produces a decrease in exports on impact. Tradeable good production has become relatively less efficient. The initial positive income effect on imports is stronger than in the tradeable TFP shock case. The two effects combined imply a deeper deficit of the current accounts that lasts 10 years before turning into a surplus.

Finally, let us consider the IRF to the nominal exchange rate shock.[21] A positive shock on e means a devaluation of the nominal exchange rate: more Belgian francs are needed to buy one unit of the bundle-currency. As expected, this has inflationary effects on impact. Imports are costlier, exports

[21] As I have assumed that the National Bank of Belgium implemented monetary policy by pegging the nominal exchange rate to gold, in this model a nominal exchange rate shock is to be intended as a unilateral policy change by the foreign monetary authority.

cheaper, yet the current account remains fully balanced. Apparently the real exchange rate remains constant, with p^M adjusting so a to offset the variation in e. Like any monetary shock, the temporary nominal exchange rate shock has a short-lived impact on the real economy, due to the wage rigidity in the tradeable sector. Notice that Equation (46) now describes a nominal wage rigidity (wages are measured in terms of Belgian francs), as opposed to the previous real model, where it described a real wage rigidity (wages were measured in terms of tradeable good). The nominal wage rigidity in the tradeable sector implies that the inflationary shock is not balanced by a suitable increase in w^T. This implies a decrease in the real wage measured either as production cost (i.e. divided by p^T), or as purchasing power (i.e. divided by p^c). Such a decrease has an obvious positive if not enduring impact on the economy.

Now that the transmission mechanism of the model is clearer, it is time to use the model to account for the Depression data.

If we assume that the 1929 exchange rate between the Belgian Franc and the bundle currency is the equilibrium value, then we can interpret the variations of e during the 1930s as exchange rate shocks, coming from the interaction between the monetary policy of the National Bank of Belgium and those of the other monetary authorities.

Given the calibration of the parameters, I fed in both the measured exchange rate and the TFP shocks, and studied the response of the monetary model with nominal wage rigidity and bonds. Notice that, given that the exchange rate gives us already the asymmetry we wanted, there is no reason to limit the productivity shock to the tradeable sector only. Therefore, in the simulations below the TFP shock affects both the sectors.

The blue lines in Figures 8, 9, 10 and 11 show the results from the simulations.[22]

The model accounts for almost 50% of the cumulative drop in hours worked between 1929 and 1934. The decrease in tradeable production in the model accounts for almost all the observed cumulative drop of aggregate output between 1929 and 1934. In 1934, output in the non-tradeable sector is about 7% below trend in the simulation. The dynamics of imports and exports are still not accounted for in a satisfactory manner. The improvement for consumption is tiny as well. The model matches both the CPI and terms of trade reasonably well, although, like the other models above, it is not able to catch the CPI/PPI dynamics. The devaluation of the Belgian franc

[22]In an exercise not shown here, I have carried out the same simulations assuming perfect foresight of both the TFP and the exchange rate shocks, instead of rational expectations only. This was done to assess the robustness of the results, that indeed do not change appreciably.

with respect to the bundle-currency in 1934-35 makes room for a quasi-recovery in some variables in the model, a feature at variance with the data. This particularly true for hours worked, exports and output in the tradeable sector.

All in all, the presence of monetary disturbances on the nominal exchange rate increases the responsiveness of the model along some dimensions, although it is not sufficient to account for all the available evidence.

6 Conclusions

The Great Depression of the 1930s has been the most dramatic business cycle event of the last century. Once a strict domain of economic historians, it is nowadays under scrutiny by macroeconomists, who have started to apply their dynamic general equilibrium tools to the interpretation of this event.

This paper contributes to this literature by extending the analysis of the Belgian case from a Neoclassical perspective started in a companion article (Pensieroso (2007a)) to a full-fledged open-economy dimension.

I have carried out the analysis on two benchmark scenarios, the one-good and the two-good model, with flexible prices and perfect competition.

Results show that in both the one-good and the two-good models, the possibility of issuing bonds enhances the responsiveness of the model to the TFP shock. This suggests that to catch the trade balance dynamics is likely to be important to account for the Great Depression in Belgium. Such a conclusion finds plain support in the work of leading historians.

The extended version of the two-good model that encompasses also real wage rigidity in the tradeable sector improves on the results, suggesting that the perverse combination of flexible product prices and sticky production costs might have played a role in the Depression. This result gives credit to the analysis by renown historians of the period, like Cassiers (1989).

A first extension that includes monetary features like the nominal exchange rate led to a further improvements of the results, particularly for what concerns employment and price indices.

The analysis presented in this article allows for the explicit consideration of trade related variables, price indices and the nominal exchange rate within a DGE model applied to the Great Depression in Belgium. Its results are qualitatively intriguing and quantitatively appreciable. This is a further step towards a more complete analysis of the Great Depression from a neoclassical perspective.

Several extensions of the present work are envisageable. First, the introduction of capital adjustment costs in the models with bonds could lower the excessive volatility of investment in response to technological shocks.

Second, in the model with real wage rigidity, the assumed perfect labour mobility across sectors partially offset the effect of the real wage rigidity in the tradeable sector. Relaxing this assumption could enhance the responsiveness of the model to the shocks.

A major shortcoming of all the models considered here is the slim reaction of consumption to the different shocks. A way to overcome this problem could be to assume a lower degree of substitutability between the different goods in the consumption bundle. Another possible way out is the introduction of habit persistence in the components of the consumption bundle, making reallocation between different goods slower.

Finally, this model is particularly well suited to study the effects of tariffs. As shown by Perri and Quadrini (2002) for the Italian case, tariffs and trade barriers in general were an important source of disturbance for the world economy in the 1930s. Although in my view the imposition of tariffs worldwide was more a consequence than a possible cause of the Depression, still to study the impact of tariffs on the Belgian economy might be a useful addition to the analysis presented here. Particularly, because of the specific nature of the Belgian economy, a small open economy whose industrial production was export-oriented.

These extensions are left to future research.

References

Baudhuin, F. (1946): *Histoire Economique de la Belgique 1914-1939.* Etablissements Emile Bruylant, Bruxelles.

Beaudry, P., and F. Portier (2002): "The French Depression in the 1930s," *Review of Economic Dynamics*, 5, 73–99.

Benigno, G., and C. Thoenissen (2006): "Consumption and Real Exchange Rates with Incomplete Markets and Non-traded Goods," Discussion Paper 04/05, Centre for Dynamic Macroeconomic Analysis.

Blanchard, O., and J. Galì (2007): "Real Wage Rigidities and the New Keynesian Model," *Journal of Money, Credit and Banking*, 39(1), 35–65.

Blanchflower, D. G. (2007): "International Patterns of Union Membership," *British Journal of Industrial Relations*, 45, 1–28.

Bordo, M. D., C. J. Erceg, and C. L. Evans (2000): “Money, Sticky Wages and the Great Depression,” *American Economic Review*, 90, 1447–1463.

Buyst, E. (1997): “New GNP Estimates for the Belgian Economy during the Interwar Period,” *Review of Income and Wealth*, 43, 357–375.

Cassiers, I. (1989): *Croissance, Crise et Régulation en Economie Ouverte: La Belgique entre les Deux Guerres*. De Boeck Université, Bruxelles.

——— (1995): “Managing the Franc in Belgium and France: The Economic Consequences of Exchange-Rate Policies, 1925-1936,” in *Banking, Currency and Finance in Europe between the Wars*, ed. by C. Feinstein. Clarendon Press, Oxford.

Chari, V. V., P. J. Kehoe, and E. R. McGrattan (2007): “Business Cycle Accounting,” *Econometrica*, 75(3), 781–836.

Christiano, L., R. Motto, and M. Rostagno (2004): “The Great Depression and the Friedman-Schwartz Hypothesis,” Working Paper 10255, National Bureau of Economic Research.

Cole, H. L., and L. E. Ohanian (1999): “The Great Depression in the United States from a Neoclassical Perspective,” *Federal Reserve of Minneapolis Quarterly Review*, 23, 2–24.

——— (2002): “The Great UK Depression: A Puzzle and a Possible Resolution,” *Review of Economic Dynamics*, 5, 19–44.

——— (2004): “New Deal Policies and the Persistence of the Great Depression: A General Equilibrium Analysis,” *Journal of Political Economy*, 112, 779–816.

Correia, I., J. C. Neves, and S. Rebelo (1995): “Business Cycles in a Small Open Economy,” *European Economic Review*, 39, 1089–1113.

De Vroey, M., and L. Pensieroso (2006): “Real Business Cycle Theory and the Great Depression: the Abandonement of the Abstentionist Viewpoint,” *Contributions to Macroeconomics*, 6, issue 1, article 13.

Eichengreen, B., and P. Temin (2000): “The Gold Standard and the Great Depression,” *Contemporary European History*, 9, 183–207.

Fisher, J. D. M., and A. Hornstein (2002): "The Role of Real Wages, Productivity, and Fiscal Policy in Germany's Great Depression 1928-37," *Review of Economic Dynamics*, 5, 100–127.

Galì, J., and T. Monacelli (2005): "Monetary Policy and Echange Rate Volatility in a Small Open Economy," *Review of Economic Studies*, 72, 707–734.

Goossens, M. (1988): "The Belgian Labour Market during the Interwar Period," in *The Economic Development of Belgium since 1870*, ed. by H. V. der Wee, and J. Blomme, pp. 417–429. Elgar, Cheltenham, 1997.

Hogg, R. L. (1986): *Structural Rigidities and Policy Inertia in Inter-War Belgium*. Royal Academy of Belgium, Bruxelles.

Institut National de Statistique (1970): "Tableau Entrées-Sorties de la Belgique pour 1965," Etudes Statistiques 22.

Kehoe, T. J., and E. Prescott (2008): "Using the General Equilibrium Growth Model to Study Great Depressions: a Reply to Temin," Research Department Staff Report 418, Federal Reserve Bank of Minneapolis.

Kehoe, T. J., and E. C. Prescott (2002): "Great Depressions of the 20th Century," *Review of Economic Dynamics*, 5, 1–18.

Kim, S. H., and M. A. Kose (2003): "Dynamics of Open-Economy Business-Cycle Models: Role of the Discount Factor," *Macroeconomic Dynamics*, 7, 263–290.

Kindleberger, C. P. (1973): *The World in Depression*. University of California Press, Berkley.

Mendoza, E. G. (1991): "Real Business Cycles in a Small Open Economy," *American Economic Review*, 81, 797–818.

Mommen, A. (1994): *The Belgian Economy in the Twentieth Century*. Routledge, London.

Pensieroso, L. (2007a): "The Great Depression in Belgium from a Neoclassical Perspective," Discussion Paper 2007-25, Université catholique de Louvain.

Pensieroso, L. (2007b): "Real Business Cycle Models of the Great Depression: A Critical Survey," *Journal of Economic Surveys*, 21, 110–142.

Perri, F., and V. Quadrini (2002): “The Great Depression in Italy: Trade Restrictions and Real Wage Rigidities,” *Review of Economic Dynamics*, 5, 128–151.

Plasmans, J., T. Michalak, and J. Fornero (2006): “Simulation, Estimation and Welfare Implications of Monetary Policies in a 3-Country NOEM Model,” Working Paper Research 94, National Bank of Belgium.

Schmitt-Grohé, S., and M. Uribe (2003): “Closing Small Open Economy Models,” *Journal of International Economics*, 61, 163–185.

Stockman, A. C., and L. L. Tesar (1995): “Tastes and Technology in a Two-Country Model of the Business Cycle: Explaining International Comovements,” *American Economic Review*, 85, 168–185.

Temin, P. (2008): “Real Business Cycle Views of the Great Depression and Recent Events: a Review of Timothy J. Kehoe and Edward C. Prescott’s *Great Depressions of the Twentieth Century*,” *Journal of Economic Literature*, 46, 669–684.

Vanthemsche, G. (1987): “The Economic Action of the Belgian State during the Crisis of the 1930s,” in *The Economic Development of Belgium since 1870*, ed. by H. V. der Wee, and J. Blomme, pp. 337–356. Elgar, Cheltenham, 1997.

Weder, M. (2006): “The Role of Preference Shocks and Capital Utilization in the Great Depression,” *International Economic Review*, 47, 1247–1268.

Figures

Figure 1: Data on prices, interest rates and selected exchange rates in Belgium, 1929-1938. Indices, 1929=100. Source: Pensieroso (2007a)

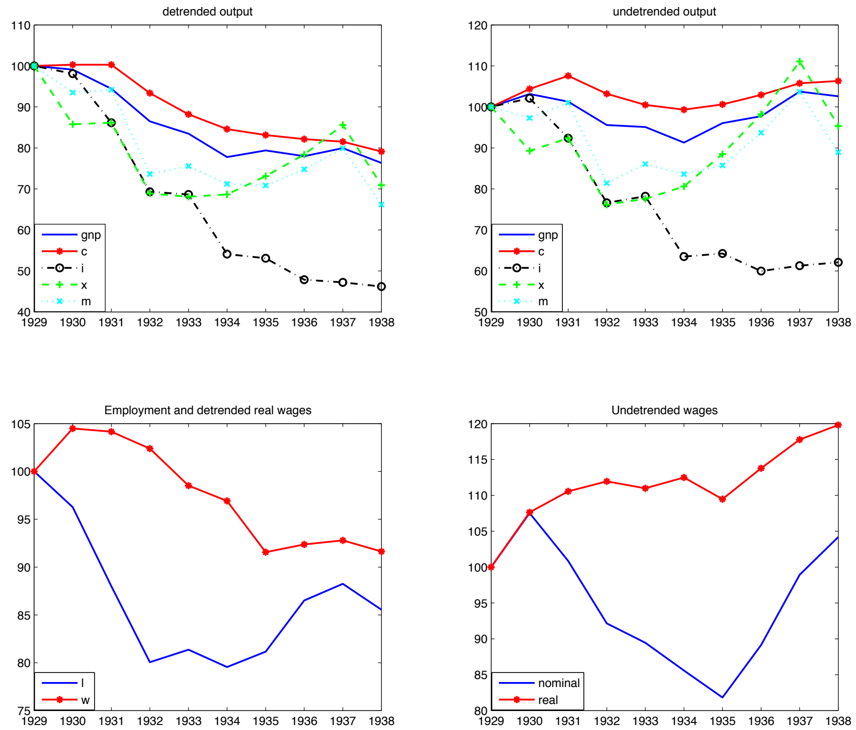

Figure 2: Data on detrended and undetrended output, its components, and the labour market in Belgium, 1929-1938. Indices, 1929 = 100. Source: Pensieroso (2007a)

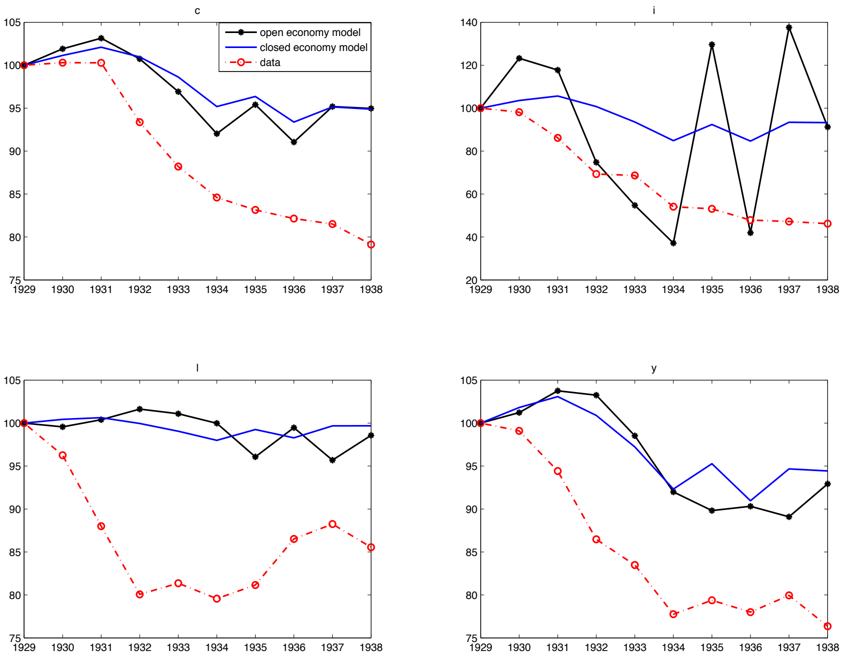

Figure 3: Simulation. One-good closed-economy versus open-economy model with estimated tfp shocks

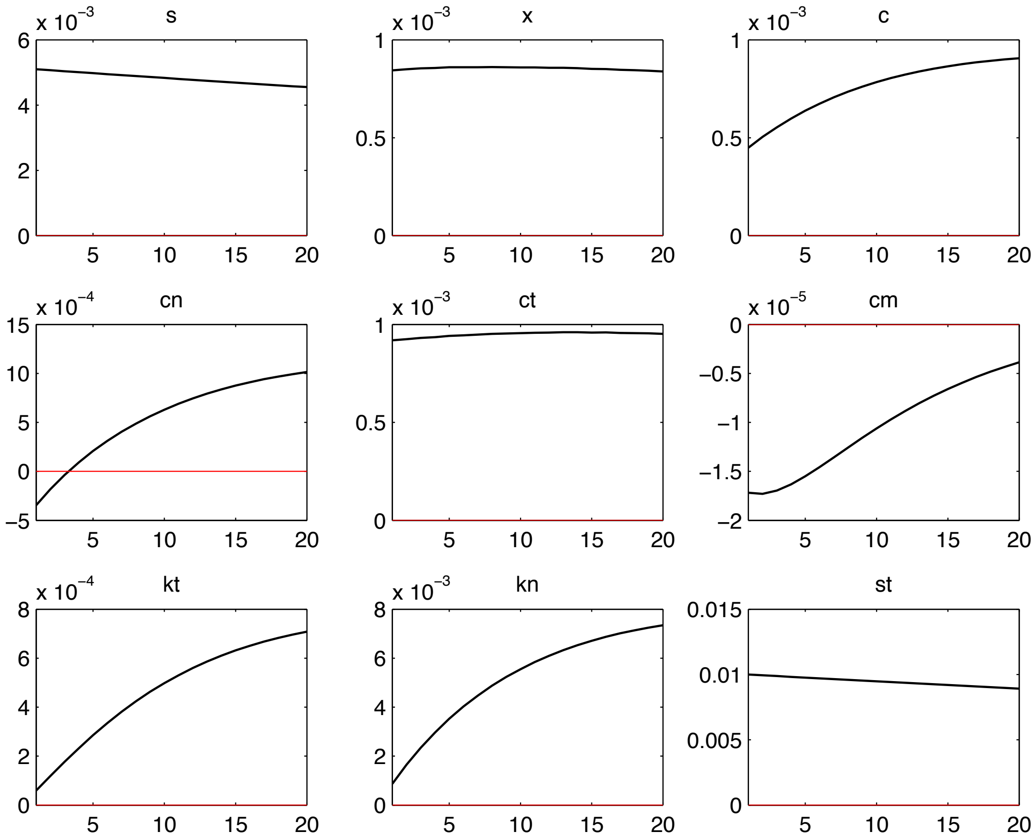

Figure 4: IRF, model with TFP shocks in the tradeable sector

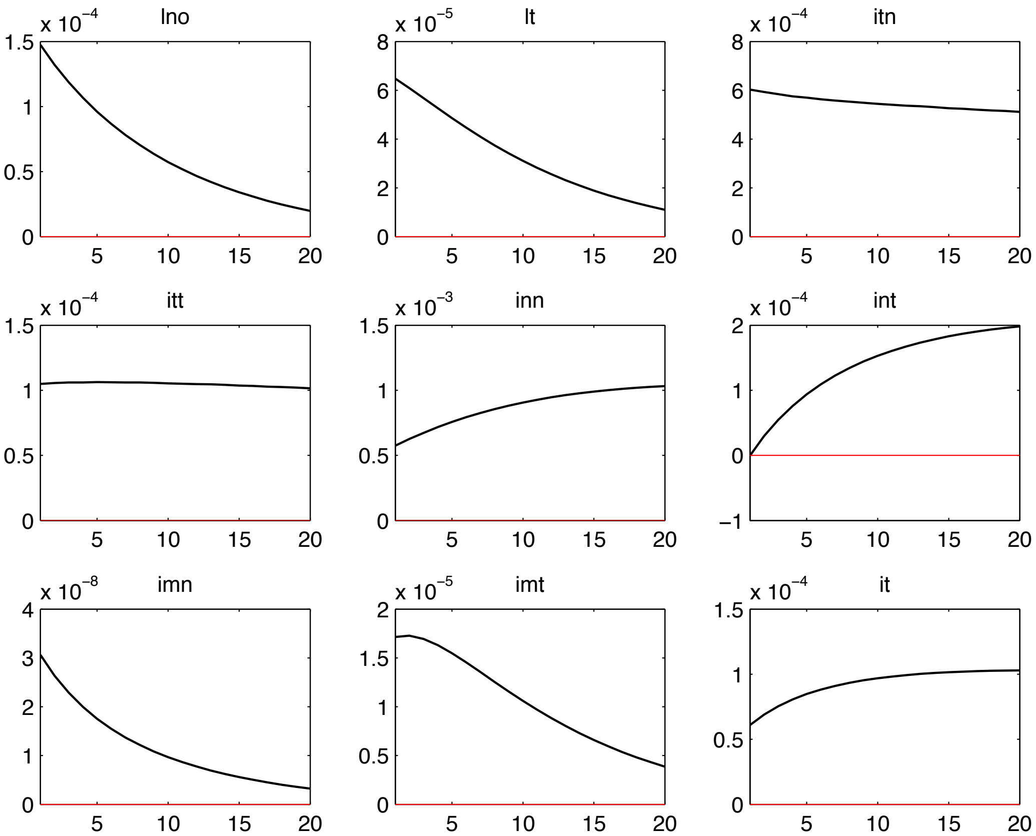

Figure 5: IRF, model with TFP shocks in the tradeable sector

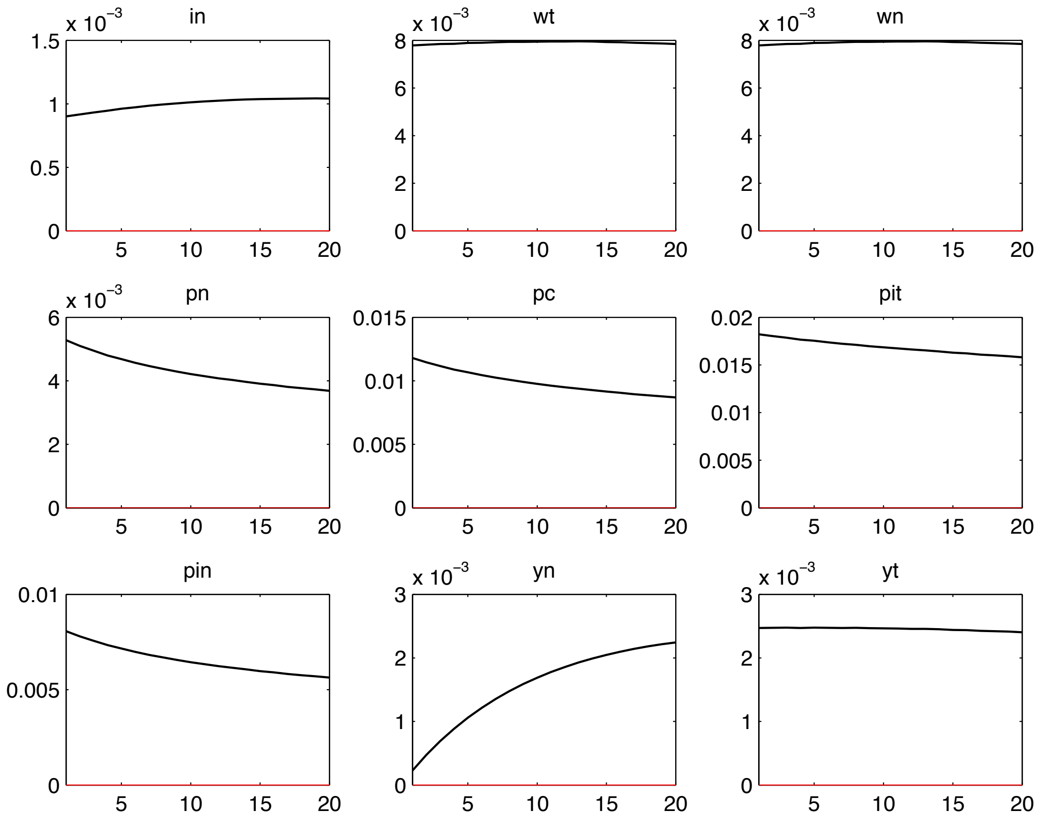

Figure 6: IRF, model with TFP shocks in the tradeable sector

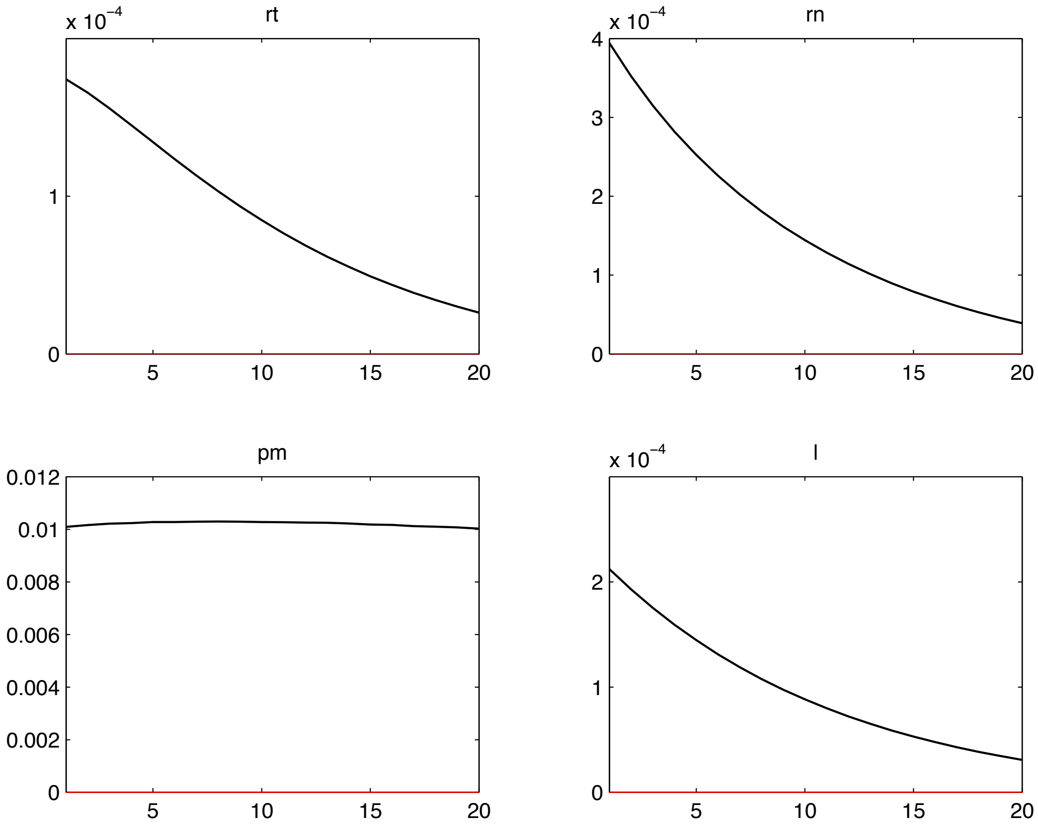

Figure 7: IRF, model with TFP shocks in the tradeable sector

Figure 8: Simulations with the two-sector models. Red line: data. Green line: model with TFP shocks in the tradeable sector. Black line: model with bonds, wage rigidity in the tradeable sector and TFP shocks in the tradeable sector. Blue line: model with money, bonds, wage rigidity in the tradeable sector, aggregate TFP shocks and exchange rate shocks.

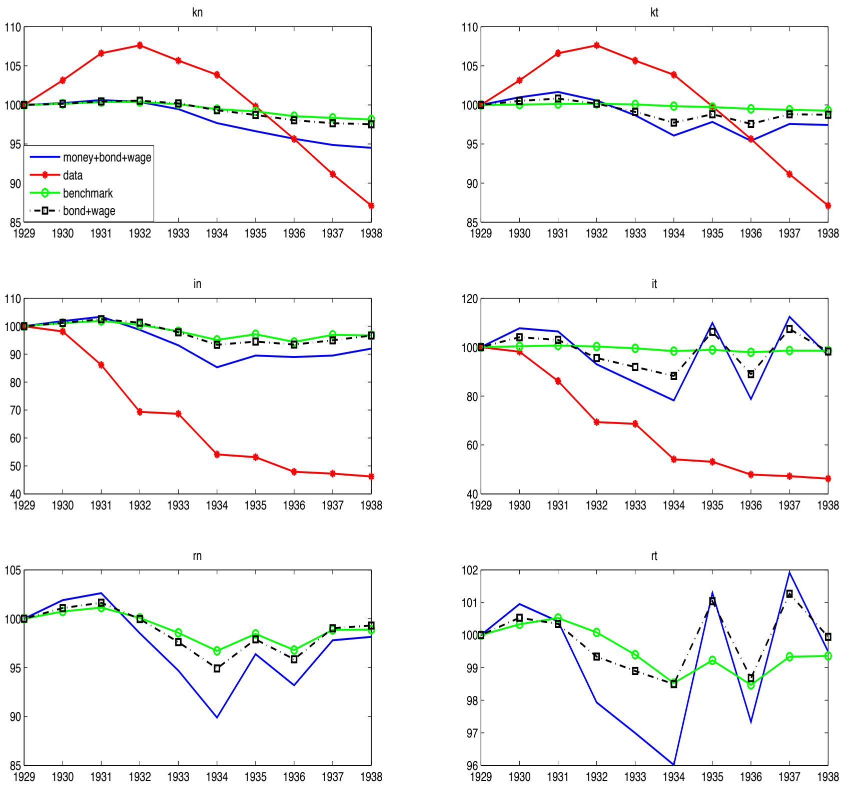

Figure 9: Simulations with the two-sector models. Red line: data. Green line: model with TFP shocks in the tradeable sector. Black line: model with bonds, wage rigidity in the tradeable sector and TFP shocks in the tradeable sector. Blue line: model with money, bonds, wage rigidity in the tradeable sector, aggregate TFP shocks and exchange rate shocks.

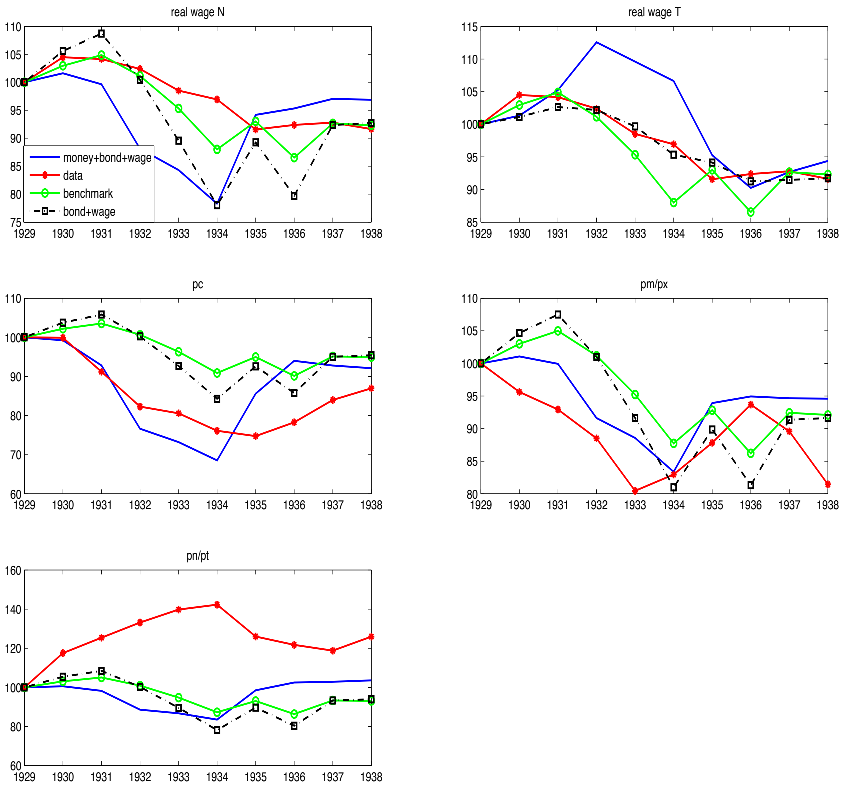

Figure 10: Simulations with the two-sector models. Red line: data. Green line: model with TFP shocks in the tradeable sector. Black line: model with bonds, wage rigidity in the tradeable sector and TFP shocks in the tradeable sector. Blue line: model with money, bonds, wage rigidity in the tradeable sector, aggregate TFP shocks and exchange rate shocks.

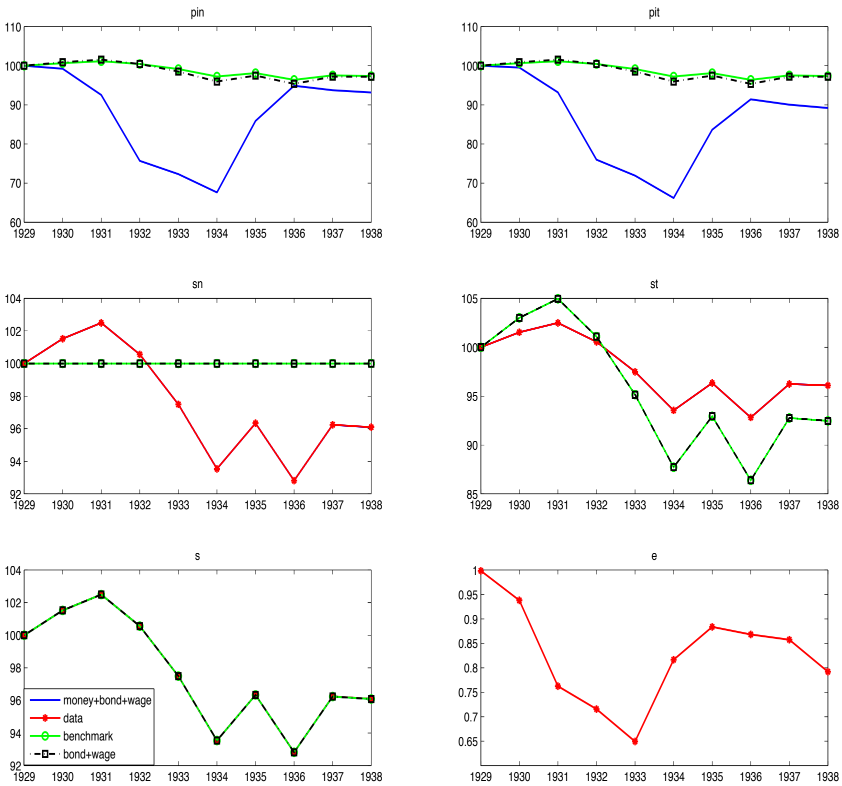

Figure 11: Simulations with the two-sector models. Red line: data. Green line: model with TFP shocks in the tradeable sector. Black line: model with bonds, wage rigidity in the tradeable sector and TFP shocks in the tradeable sector. Blue line: model with money, bonds, wage rigidity in the tradeable sector, aggregate TFP shocks and exchange rate shocks.

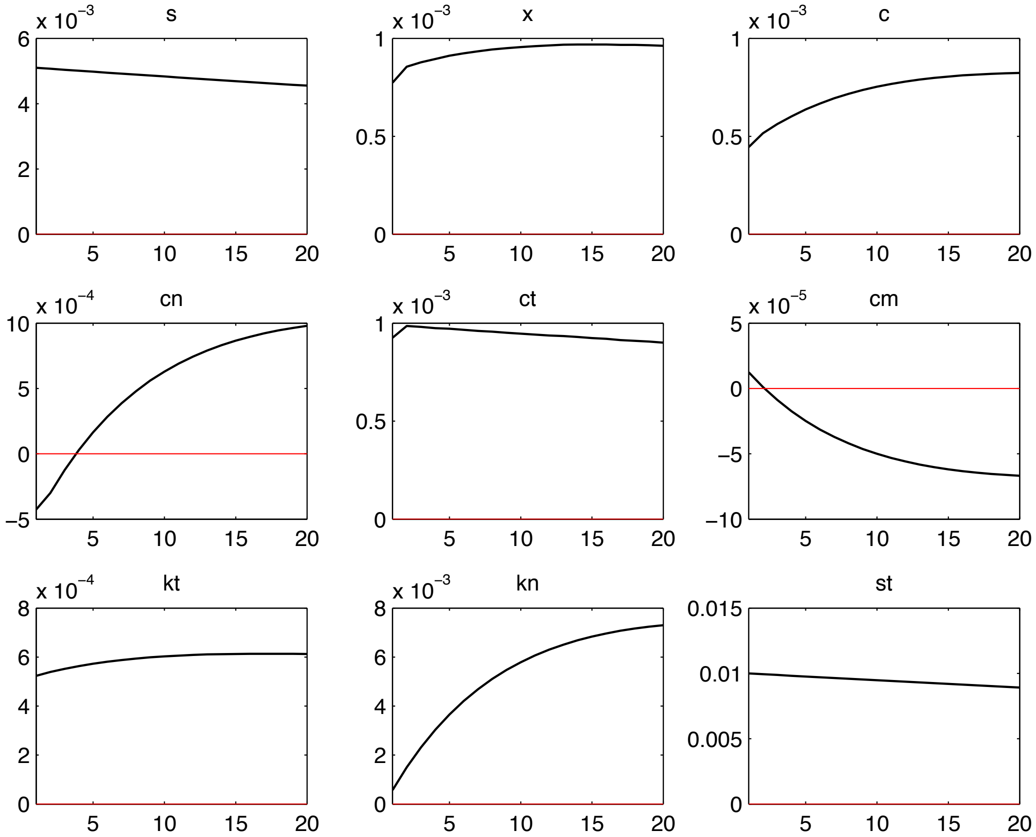

Figure 12: IRF, model with bonds and TFP shocks in the tradeable sector

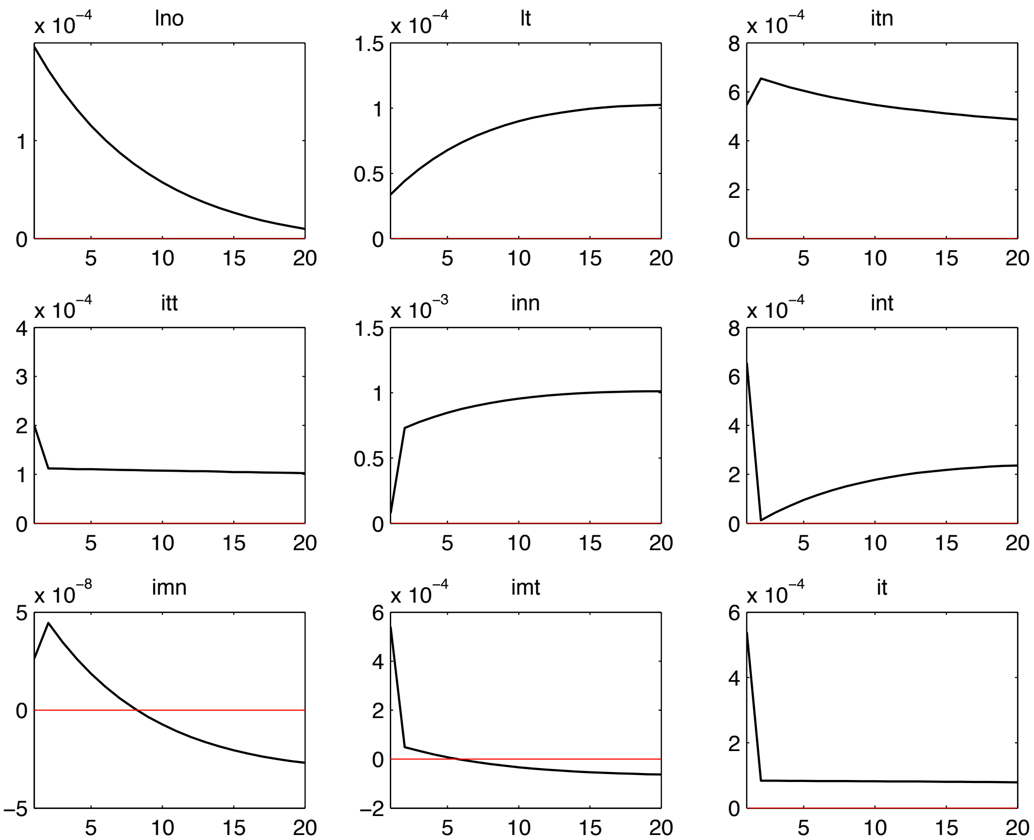

Figure 13: IRF, model with bonds and TFP shocks in the tradeable sector

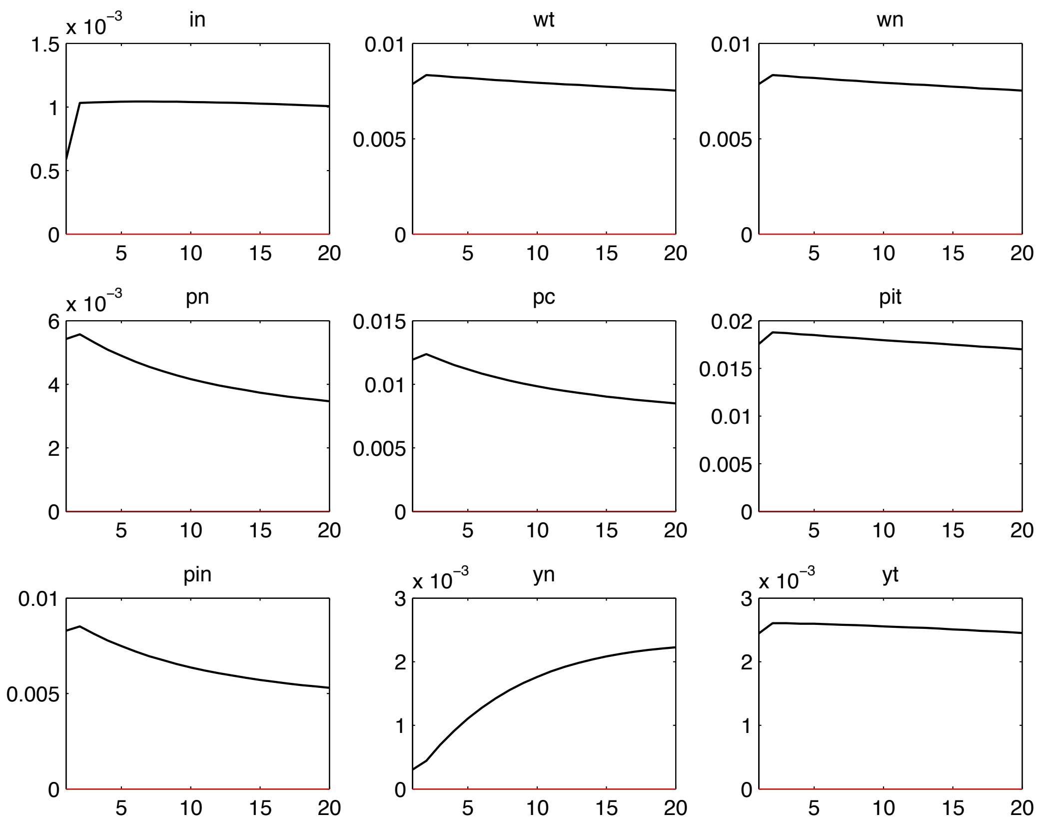

Figure 14: IRF, model with bonds and TFP shocks in the tradeable sector

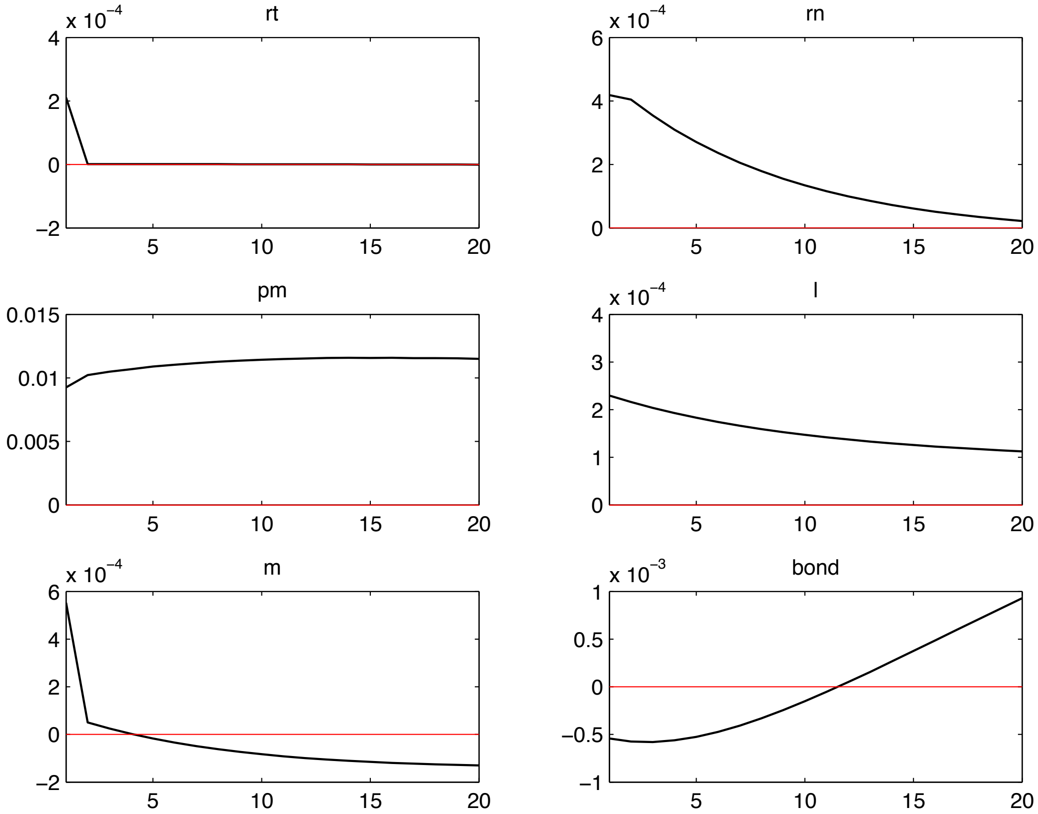

Figure 15: IRF, model with bonds and TFP shocks in the tradeable sector

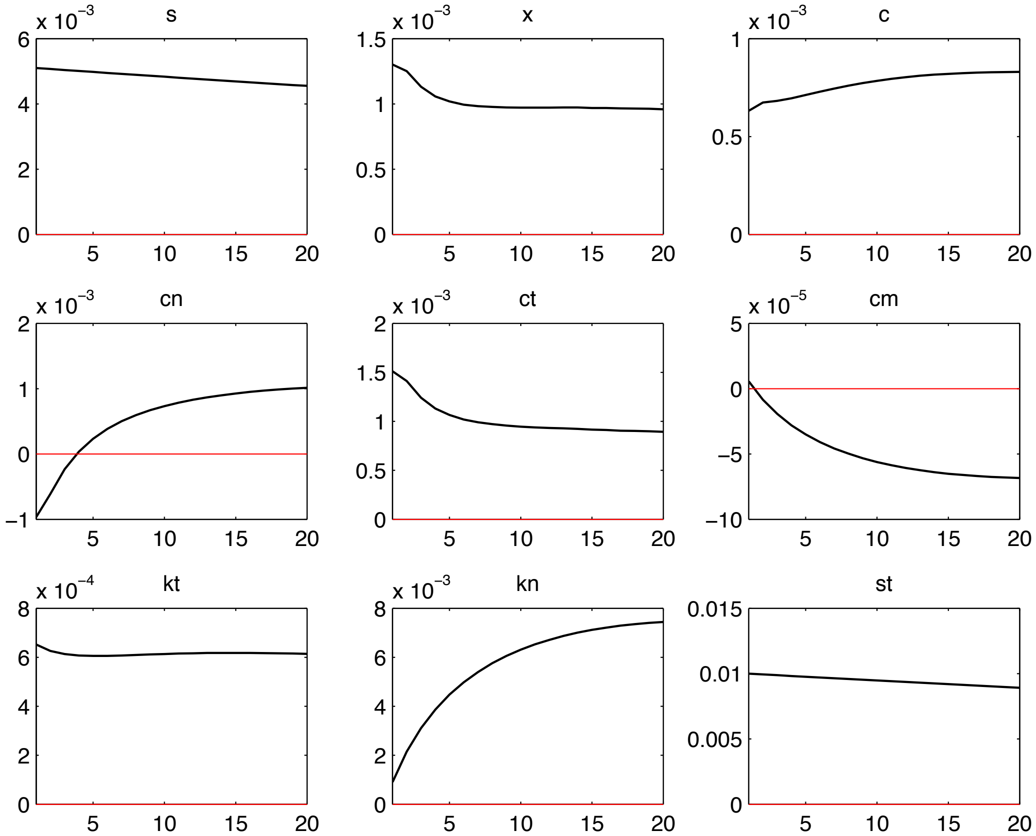

Figure 16: IRF, model with bonds, wage rigidity in the tradeable sector and TFP shocks in the tradeable sector

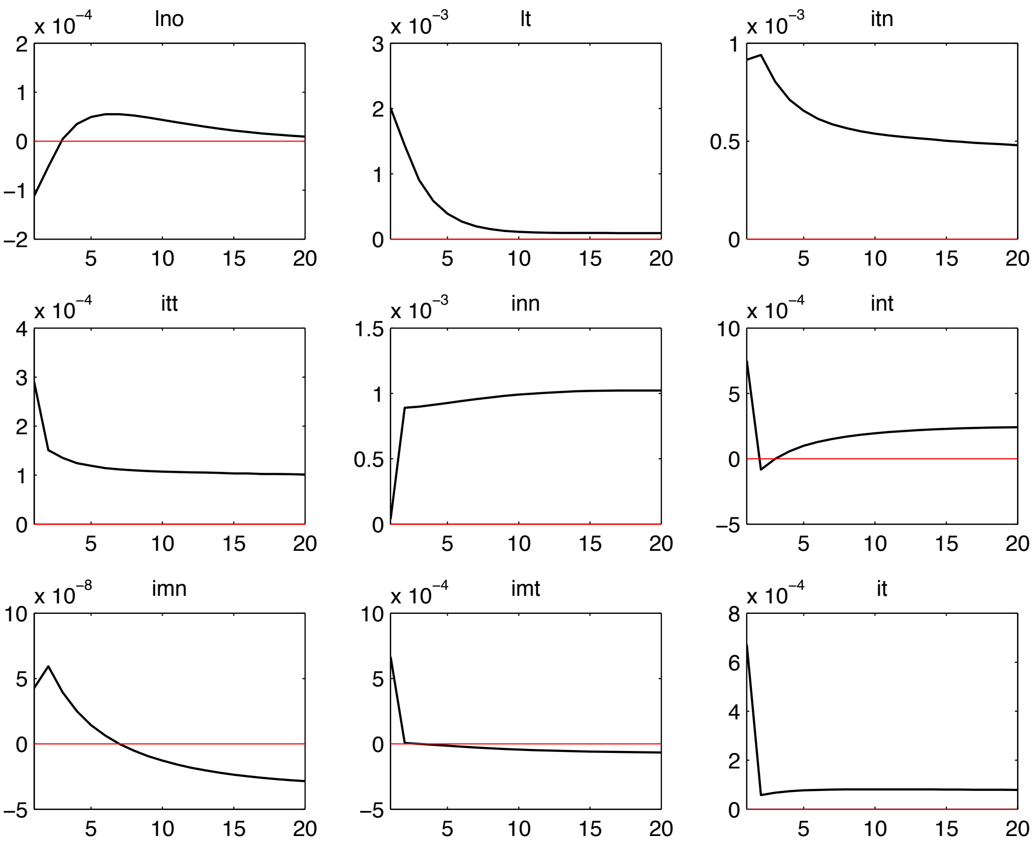

Figure 17: IRF, model with bonds, wage rigidity in the tradeable sector and TFP shocks in the tradeable sector

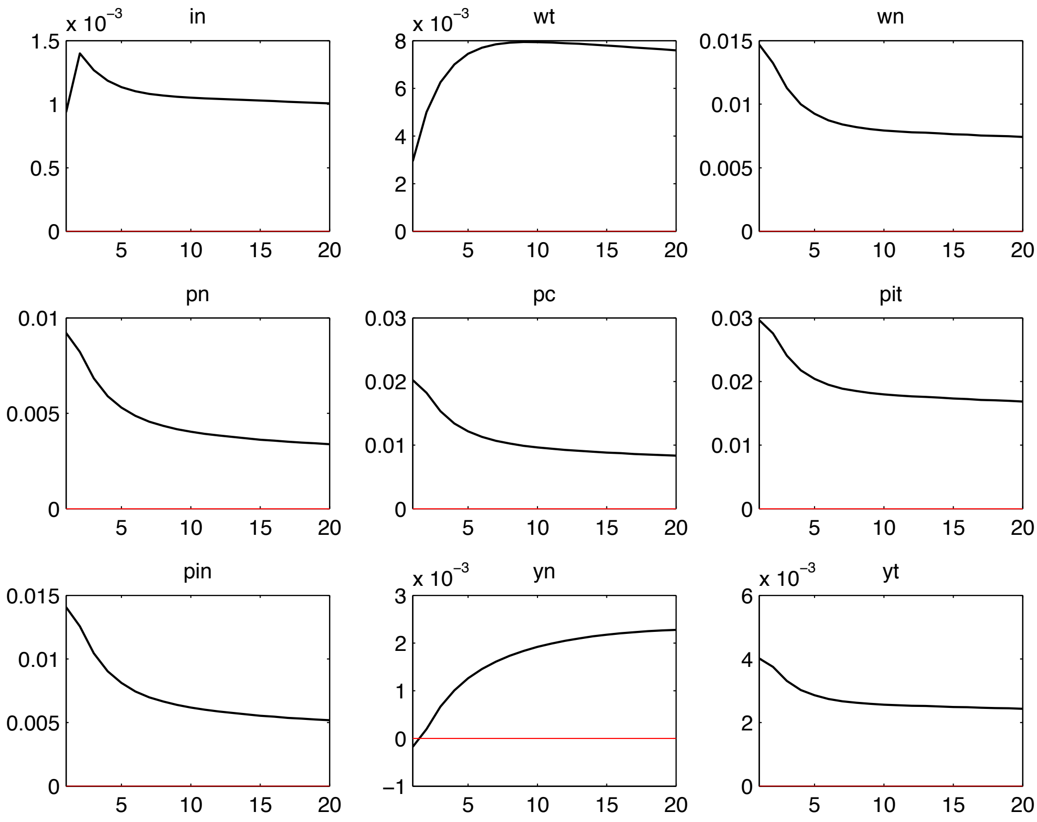

Figure 18: IRF, model with bonds, wage rigidity in the tradeable sector and TFP shocks in the tradeable sector

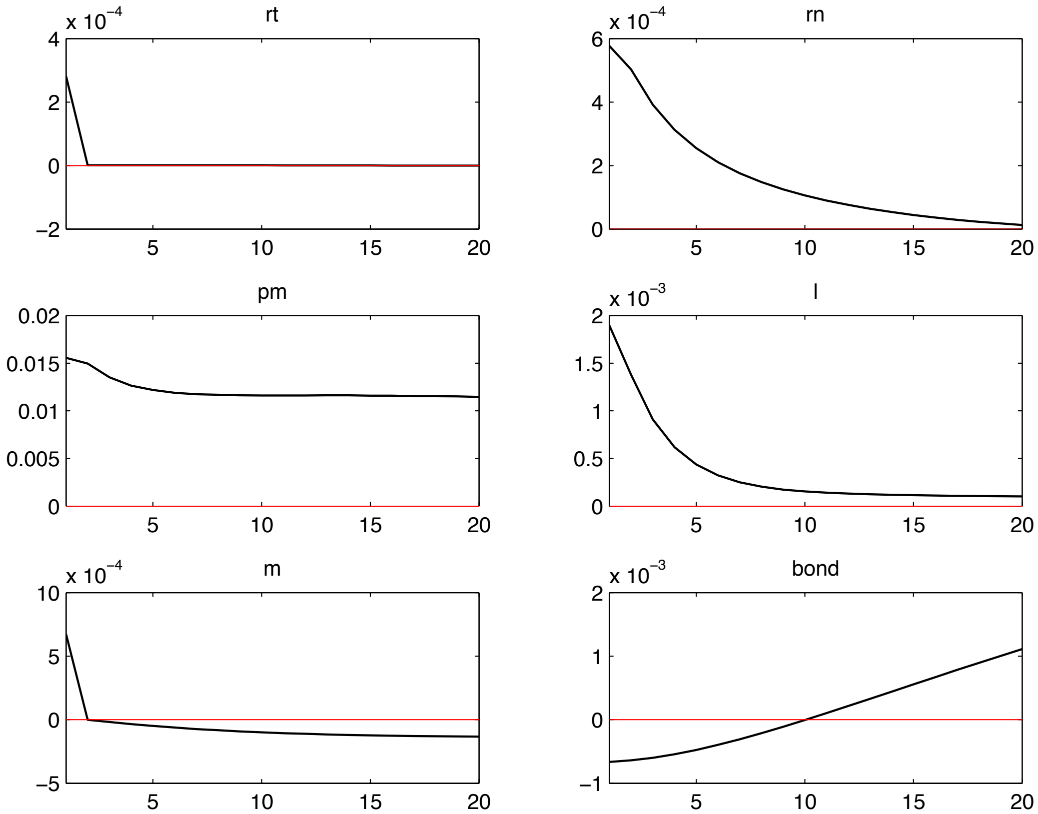

Figure 19: IRF, model with bonds, wage rigidity in the tradeable sector and TFP shocks in the tradeable sector

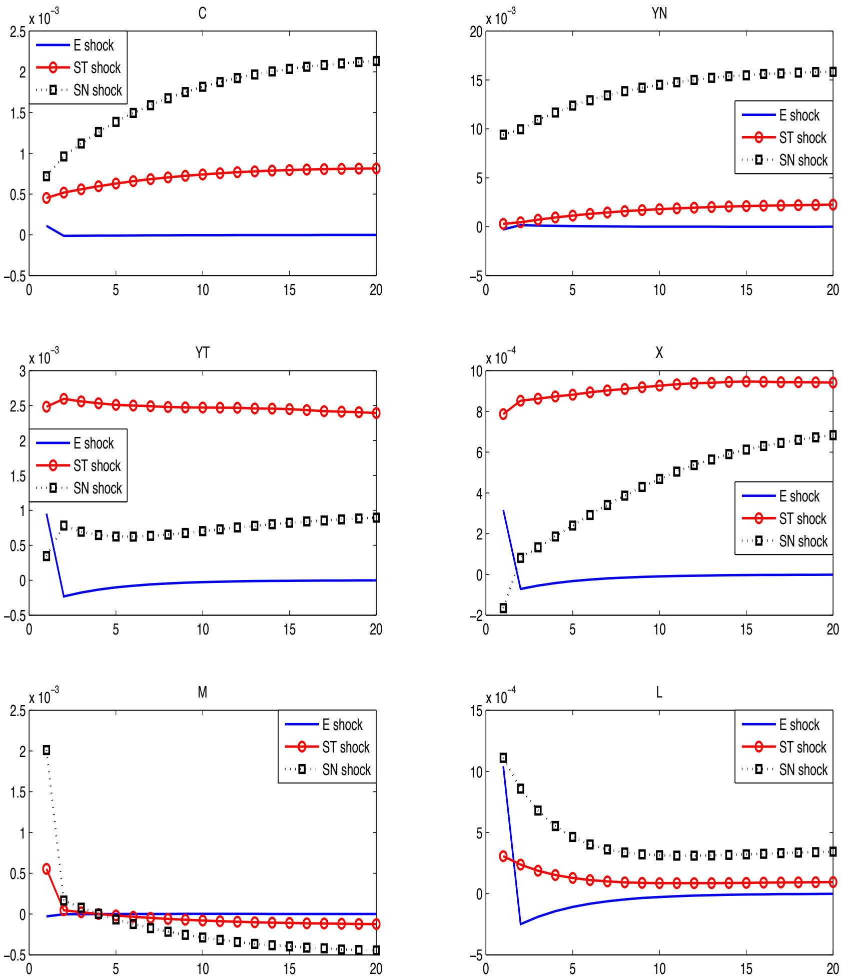

Figure 20: IRF, model with bonds, nominal wage rigidity in the tradeable sector, nominal exchange rate shocks and aggregate TFP shocks. Blue line: IRF to a 1% standard deviation positive shock to the nominal exchange rate. Red line: IRF to a 1% standard deviation positive shock to the tradeable sector productivity. Black line: is the IRF to a 1% standard deviation positive shock to the non-tradeable sector productivity.

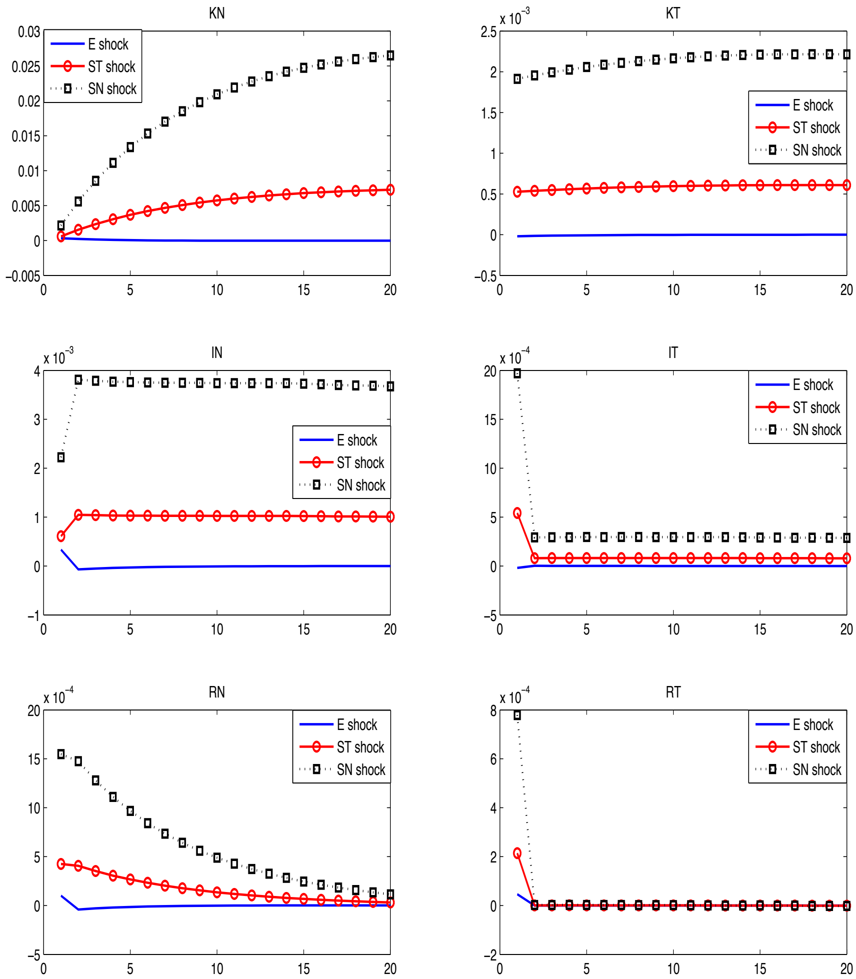

Figure 21: IRF, model with bonds, nominal wage rigidity in the tradeable sector, nominal exchange rate shocks and aggregate TFP shocks. Blue line: IRF to a 1% standard deviation positive shock to the nominal exchange rate. Red line: IRF to a 1% standard deviation positive shock to the tradeable sector productivity. Black line: is the IRF to a 1% standard deviation positive shock to the non-tradeable sector productivity.

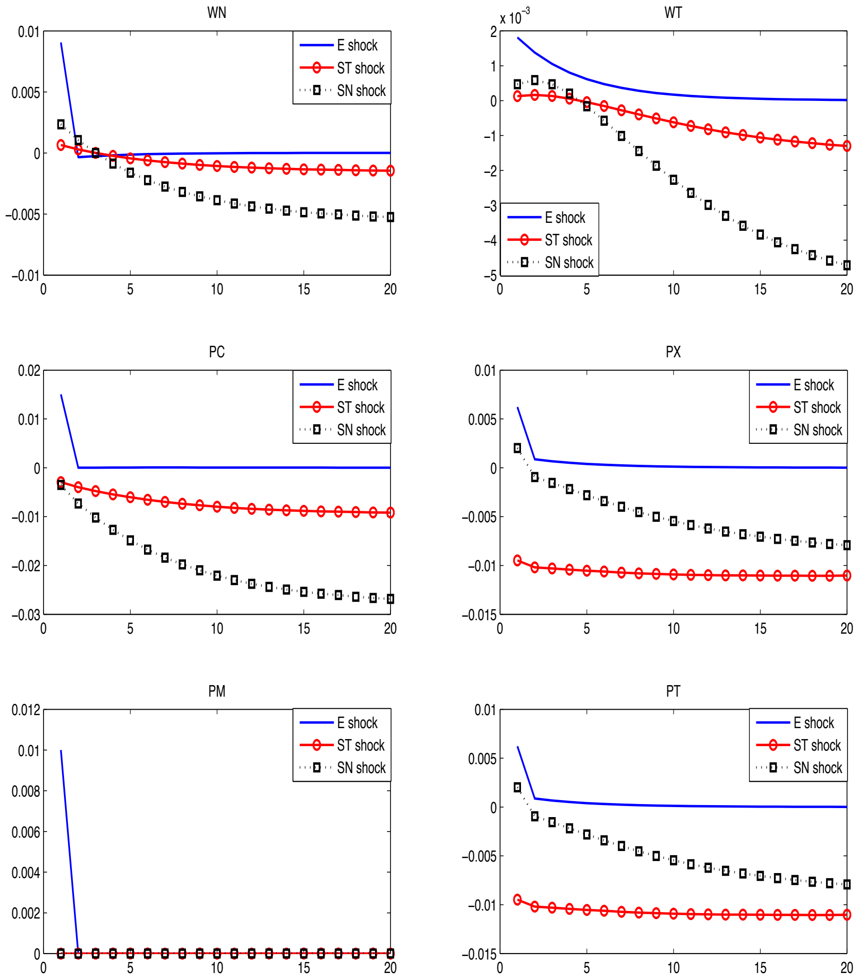

Figure 22: IRF, model with bonds, nominal wage rigidity in the tradeable sector, nominal exchange rate shocks and aggregate TFP shocks. Blue line: IRF to a 1% standard deviation positive shock to the nominal exchange rate. Red line: IRF to a 1% standard deviation positive shock to the tradeable sector productivity. Black line: is the IRF to a 1% standard deviation positive shock to the non-tradeable sector productivity.

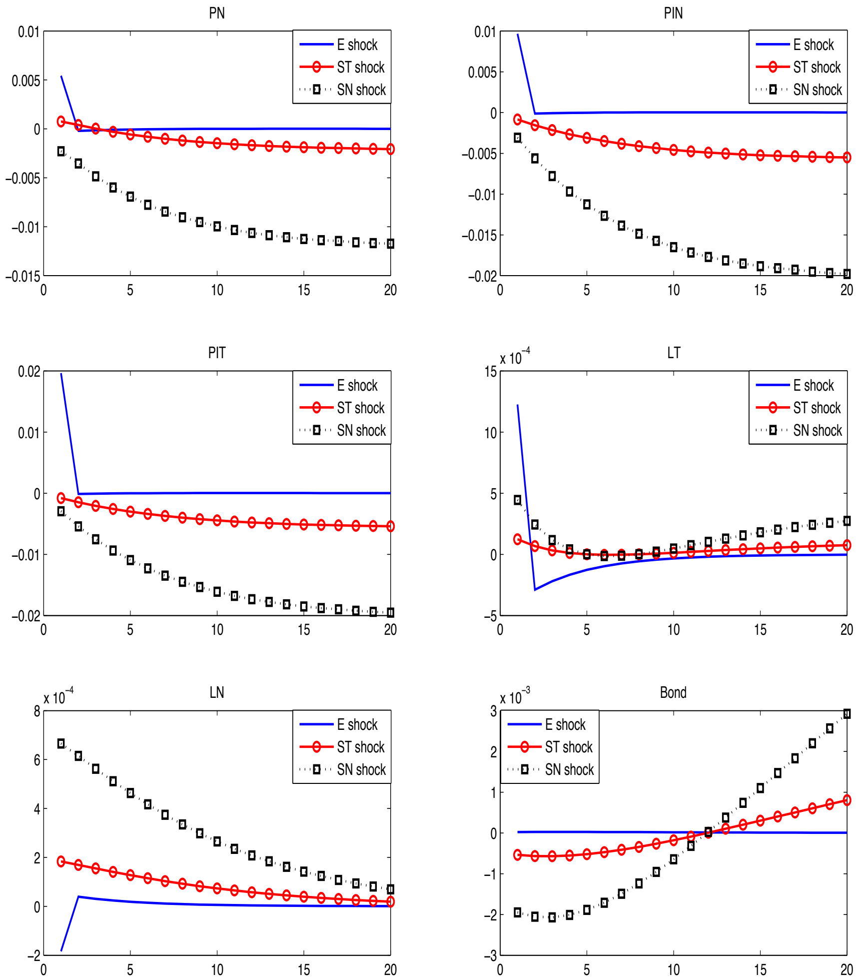

Figure 23: IRF, model with bonds, nominal wage rigidity in the tradeable sector, nominal exchange rate shocks and aggregate TFP shocks. Blue line: IRF to a 1% standard deviation positive shock to the nominal exchange rate. Red line: IRF to a 1% standard deviation positive shock to the tradeable sector productivity. Black line: is the IRF to a 1% standard deviation positive shock to the non-tradeable sector productivity.

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