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Abstract

This paper studies the Great Depression in Belgium within the open-economy dynamic general equilibrium model. Results from the simulations show that productivity shocks, trade restrictions and nominal exchange rate shocks can account for 64% of the observed drop in output between 1929 and 1934. That value becomes 74% if we include a calibrated shock to the demand from the rest of the world. However, the lacklustre recovery after the 1935 devaluation of the Belgian franc remains largely unexplained, suggesting that additional shocks are needed to fully account for the data.

Keywords: Great Depression, Belgium, Dynamic General Equilibrium, Open Economy, Tradeables, Gold Standard, Tariffs, New Open Macroeconomics

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 looks particularly interesting in the case of 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]

There are two kinds of gain from international trade, the intertemporal

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

[2]See De Vroey and Pensieroso (2006), Pensieroso (2011b) 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 (2011a) with Belgium.

[5]Data taken from Buyst (1997). For comparison, the same ratios were about 4% in the United States (see Cole and Ohanian (1999)).

[6]See Vanthemsche (1987).

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

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 both the aspects. Accordingly, drawing inspiration from the works by Mendoza (1991), Perri and Quadrini (2002) and Stockman and Tesar (1995), the model economy considered here is a two-sector small open economy that can exchange bonds with the rest of the world.

As shown by Crucini and Kahn (1996) and Perri and Quadrini (2002), tariffs were an important source of disturbance for the world economy in the 1930s. Eichengreen and Irwin (2010) argue that countries sticking longer to the Gold Standard, like Belgium, resorted more to trade barriers than those who went off gold earlier. Moreover, the specific nature of Belgium, a small open economy well integrated to the world economy, suggests that trade distortions might have a significant role to play. Accordingly, I shall introduce measured tariffs variations as exogenous shocks to the model.

An additional innovative feature of this article is the fact that it considers explicitly the Gold Standard issue within the DGE framework. The fact that Belgium stuck to the Gold Standard until 1935, coupled with nominal wage rigidity is the staple of the traditional explication of the Great Depression in Belgium (Baudhuin (1946), Cassiers (1995), Eichengreen (1992)). To take that into account, the model is formulated in nominal terms and allows for exogenous nominal exchange rate shocks. It is assumed that the central bank sets money supply so as to keep the statutory parity between the Belgian franc and gold.

The rest of the paper is structured as follows. In Section 2, I shall briefly present selected data for the interwar Belgium. Section 3 discusses the benchmark two-sector, small-open-economy model. The two-sector framework was chosen so as to reproduce the asymmetric behaviour between the international and the domestic sector, a major element in the traditional explication of the Great Depression in Belgium (Cassiers (1989)). I simulated the response of the model economy to productivity, tariffs, external demand and exchange rate shocks. Results show that the combination of sectoral total factor productivity, tariffs and nominal exchange rate shocks, coupled with sticky nominal wages account for about 64% of the 1929-1934 drop in output. That value becomes 76% if we include a calibrated shock to the demand of Belgian goods from the rest of the world. A puzzling aspect of the model is that it shows a prompt recovery after the 1935 devaluation, a pattern clearly at variance with the data. In view of the similarity of this result with the slow-recovery puzzle highlighted by Cole and Ohanian (1999) and Prescott (1999) for the United States, I end the section by discussing whether some policy shock akin to those singled out by Cole and Ohanian (2004) is easily identified in the case of Belgium. Section 4 draws together the thread of the argument and concludes.

2 History and data

The traditional story about the Great Depression in Belgium focuses on the exchange rate system. 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. Although such a decision looked natural for a country so deeply connected with France and the Netherlands, it was nonetheless a problematic decision to take, especially because of what was contemporaneously happening in the United Kingdom. The United Kingdom, a major commercial partner for Belgium, exited the Gold Standard 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%. 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. The retail ('cpi'), cost-of-living and wholesale ('ppi') price indices all fell dramatically till 1934, to partially recover after the 1935 devaluation of the Belgian Franc. Notice that while all the price indices 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 the international sector more severely than the domestic one. This asymmetry between a sheltered domestic sector and an unsheltered international one is indeed a landmark in the traditional explanation of the Belgian Great Depression (Cassiers (1989)).

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 looks 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).[8]

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 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.[9] 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.

In the next section, I shall propose a suitable model of the Belgian economy to test how well the traditional account of the Great Depression in Belgium fit the detrended evidence.

3 The model

I modelled the Belgian economy as a small open economy with two sectors, one producing a tradeable good, y^T, the other a non-tradeable one, y^N. Production functions in both sectors are Cobb-Douglas with constant return to scale:

$$y_t^N = A_t^N (k_t^N)^\iota (l_t^N)^{1-\iota}, \tag{1}$$

$$y_t^T = A_t^T (k_t^T)^\nu (l_t^T)^{1-\nu}. \tag{2}$$

[8]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 (2011a).

[9]Belgium's 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.

The variable $A_t^j = \exp(s_t^j)$ stands for total factor productivity in sector j, for $j = N, T$. Labour is assumed to be mobile across sectors, but not internationally.

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

The economy imports consumption and investment goods, c_t^M and i_t^M respectively. It is assumed that imports are taxed at the proportional rate τ. The revenue from the taxation is redistributed to households as lump-sum transfer.

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

$$c_t = (c_t^N)^{a_c}(c_t^T)^{b_c}(c_t^M)^{(1-a_c-b_c)}. \tag{3}$$

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

$$i_t^j = (i_t^{N,j})^{a_{i,j}}(i_t^{T,j})^{b_{i,j}}(i_t^{M,j})^{(1-a_{i,j}-b_{i,j})}. \tag{4}$$

All variables are per capita, and when suitable, detrended. Prices are expressed in terms of Belgian francs. I assumed perfect competition in the good market, and nominal wage rigidity in the tradeable sector.[10]

It is assumed that the economy can exchange assets with the rest of the world. These assets are expressed in Belgian francs and pay an interest rate $\bar{r}$ equal to the world interest rate corrected for variations in the nominal exchange rate:

$$\bar{r}_t = r^*\left(\frac{e_t}{e_{t-1}}\right). \tag{5}$$

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 BEF you need to have 1 unit of the bundle currency). The variable r^* is the world interest rate. It is constant and expressed in terms of the bundle currency. The small-open-economy assumption implies that the domestic economy cannot influence the value of r^*.

I assumed that the (non-modelled) National Bank of Belgium has a gold parity target, and implements monetary policy accordingly. This means that

[10]Wage formation will be specified later.

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 current account.

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

3.1 The static problem

3.1.1 Firms

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

$$\Pi^j = p^j y^j - w^j l^j - p^{i,j} r^j k^j, \tag{6}$$

given the constraints (1) and (2). In the profit equation (6), $p^{i,j}$ is the price index for aggregate investment in sector j, and will be defined later on. I omit the time subscript for the sake of notation.

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

$$w^N = \frac{p^N(1-\iota)y^N}{l^N}; \tag{7}$$

$$w^T = \frac{p^T(1-\nu)y^T}{l^T}; \tag{8}$$

$$r^N p^{i,N} = \frac{p^N \iota y^N}{k^N}; \tag{9}$$

$$r^T p^{i,T} = \frac{p^T \nu y^T}{k^T}. \tag{10}$$

3.1.2 Households

For any level of total consumption c, households choose to consume non-tradeable, tradeable and imported goods so as to minimize the expenditure associated to c,

$$p^N c^N + p^T c^T + (1+\tau)p^M c^M = p^c c,$$

subject to the constraint (3).

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:

$$c^N = \frac{a_c c p^c}{p^N}; \tag{11}$$

$$c^T = \frac{b_c c p^c}{p^T}; \tag{12}$$

$$c^M = \frac{(1-a_c-b_c) c p^c}{(1+\tau)p^M}. \tag{13}$$

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

$$p^c = \frac{(p^N)^{a_c}(p^T)^{b_c}\left((1+\tau)p^M\right)^{1-a_c-b_c}}{(a_c)^{a_c}(b_c)^{b_c}(1-a_c-b_c)^{1-a_c-b_c}}. \tag{14}$$

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.

$$i^{N,N} = \frac{a_{i,N}(i^N)(p^{i,N})}{p^N}; \tag{15}$$

$$i^{T,N} = \frac{b_{i,N}(i^N)(p^{i,N})}{p^T}; \tag{16}$$

$$i^{M,N} = \frac{(1-a_{i,N}-b_{i,N})(i^N)(p^{i,N})}{(1+\tau)p^M}; \tag{17}$$

$$p^{i,N} = \frac{(p^N)^{a_{i,N}}(p^T)^{b_{i,N}}\left((1+\tau)p^M\right)^{1-a_{i,N}-b_{i,N}}}{(a_{i,N})^{a_{i,N}}(b_{i,N})^{b_{i,N}}(1-a_{i,N}-b_{i,N})^{1-a_{i,N}-b_{i,N}}}; \tag{18}$$

$$i^{N,T} = \frac{a_{i,T}(i^T)(p^{i,T})}{p^N}; \tag{19}$$

$$i^{T,T} = \frac{b_{i,T}(i^T)(p^{i,T})}{p^T}; \tag{20}$$

$$i^{M,T} = \frac{(1 - a_{i,T} - b_{i,T})(i^T)(p^{i,T})}{(1+\tau)p^M}; \tag{21}$$

$$p^{i,T} = \frac{(p^N)^{a_{i,T}}(p^T)^{b_{i,T}}\left((1+\tau)p^M\right)^{1-a_{i,T}-b_{i,T}}}{(a_{i,T})^{a_{i,T}}(b_{i,T})^{b_{i,T}}(1 - a_{i,T} - b_{i,T})^{1-a_{i,T}-b_{i,T}}}. \tag{22}$$

3.2 The dynamic problem

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

$$\max_{\{c_t, l_t^N, l_t^T, k_{t+1}^N, k_{t+1}^T, b_{t+1}\}_{t=0}^{\infty}} E_t \sum_{t=0}^{\infty} \beta^t \left[\ln(c_t) + \phi \ln(1 - l_t)\right], \tag{23}$$

subject to

$$\gamma k_{t+1}^N = (1-\delta)k_t^N + i_t^N; \tag{24}$$

$$\gamma k_{t+1}^T = (1-\delta)k_t^T + i_t^T; \tag{25}$$

$$\begin{aligned} w_t^N l_t^N + w_t^T l_t^T + r_t^N(p^{i,N})k_t^N + r_t^T(p^{i,T})k_t^T + (1+\bar{r}_t)b_t + Tr_t = \\ (p_t^c)c_t + (p_t^{i,N})i_t^N + (p_t^{i,T})i_t^T + \gamma b_{t+1}; \end{aligned} \tag{26}$$

$$l_t = l_t^N + l_t^T. \tag{27}$$

Here, I have assumed a log-log utility function in total consumption, c, and leisure - that is 1, the time endowment of the household in each period, minus l, the amount of time devoted to work. The variable b_t stands for the value of per-capita net foreign assets held by the representative household at the end of period $t-1$. The parameter γ is the growth factor of the labour-augmenting technological progress, which was subtracted to the data when linear filtering them. The variable Tr is a lump sum transfer, equal in equilibrium to $\tau p_t^M(c_t^M + i_t^{M,N} + i_t^{M,T})$.

The solution to problem (23) gives the rules for the intertemporal allocation of consumption, e.g. the Euler equations for k^N, k^T and b, and the labour supply schedules if the labour market were competitive.

$$\frac{\gamma}{c_t}\frac{p_t^{i,N}}{p_t^c} = \beta E_t\left((1 + r_{t+1}^N - \delta)\frac{1}{c_{t+1}}\frac{p_{t+1}^{i,N}}{p_{t+1}^c}\right); \tag{28}$$

$$\frac{\gamma}{c_t}\frac{p_t^{i,T}}{p_t^c} = \beta E_t\left((1 + r_{t+1}^T - \delta)\frac{1}{c_{t+1}}\frac{p_{t+1}^{i,T}}{p_{t+1}^c}\right); \tag{29}$$

$$\frac{\gamma}{c_t p_t^c} = \beta E_t\left((1 + \bar{r}_{t+1})\frac{1}{c_{t+1}p_{t+1}^c}\right); \tag{30}$$

$$\frac{\phi}{1 - l_t} = \frac{1}{c_t p_t^c} w_t^N; \tag{31}$$

$$\frac{\phi}{1 - l_t} = \frac{1}{c_t p_t^c} w_t^T. \tag{32}$$

However, in this article I have assumed that the labour market in the tradeable sector is not perfectly competitive. This is justified on the ground of the historical evidence. According to Cassiers (1989), the specificity of Belgium was 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. Two general strikes broke out in 1932 and 1934 (Chlepner (1972)). Eventually, nominal wages in the whole economy did decline, but not enough to prevent real wages from increasing.

Accordingly, I have replaced Equation (32) with

$$w_t^T = \kappa w_{t-1}^T + (1 - \kappa)\frac{c_t p_t^c \phi}{1 - l_t}. \tag{33}$$

Equation (33) makes nominal wages in the tradeable sector a weighted average of the previous period sectoral wage and the equilibrium sectoral wage, with κ being the proportion of the households that sticks to the previous period wage.[11] 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. On the contrary, if κ were zero, nominal wages would be perfectly flexible. In this case, nominal shocks would have no direct effect on hours worked.

As labour is mobile, nominal wages must be equal across sectors, implying $w_t^T = w_t^N$. This implies that the nominal wage rigidity extends *de facto* also to the nontradeable sector, enhancing the response of the model to nominal shocks.

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 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 $\bar{r}$, with

$$r_t \equiv \bar{r}_t + \psi\{[\exp(-b_t)] - 1\}. \tag{34}$$

3.3 Equilibrium conditions

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

Concerning the current account, I assumed

$$p_t^X x_t = p_t^M (c_t^M + i_t^{M,N} + i_t^{M,T}) + \gamma b_{t+1} - (1 + r_t) b_t. \tag{35}$$

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

$$x_t = a m_t \left(\frac{p_t^X}{p_t^M} \right)^{\zeta}, \tag{36}$$

[11] This simple formulation was first proposed by Blanchard and Galì (2007).

where $\zeta < 0$ is the elasticity of export demand from the rest of the world to the terms of trade. The variable am_t stands for the "autonomous" components of the export demand.

In equilibrium, the productions of tradeable and non-tradeable goods are equal to their respective demands:

$$y_t^N = c_t^N + i_t^{N,N} + i_t^{N,T}, \tag{37}$$

$$y_t^T = c_t^T + i_t^{T,N} + i_t^{T,T} + x_t. \tag{38}$$

Finally, the law of one price must hold. Accordingly,

$$p_t^X = p_t^T, \tag{39}$$

$$p_t^M = p^{*T} e_t. \tag{40}$$

The first equation states that 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.[12] The second equation applies the law of one price the foreign good: its price in Belgian francs must be the same both in Belgium and abroad. 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.

3.4 Calibration

The model's structural parameters are calibrated as shown in Table 1. The unit period is the year. The parameter δ, the depreciation rate of capital, is 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.

[12] This implies that the neither the Belgian nor the foreign firms are price taker abroad. Such a feature stems from the fact that in the model Belgium and the rest of the world produce each its own specific good, with the two goods being only imperfect substitute in the investment and consumption aggregators. This assumption makes the terms of trade sensible to variations in the nominal exchange rate.

Parameter	*Value*
β	0.975
r^*	0.0567
γ	1.03
δ	0.1
ν	0.34
ι	0.73
ζ	-1
ϕ	1.60
ψ	0.001
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
κ	0.8
p^{*T}	1

Table 1: Calibration of parameters.

The preference for leisure, ϕ, is calibrated so that in equilibrium hours worked are 1/3 of the household's time endowment, which is normalized to 1.

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).[13]

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

[13] Schmitt-Grohé and Uribe (2003) assign this parameter a value of 0.000742, for a small open-economy model calibrated on contemporary Canadian data. Robustness analysis shows 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.

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 0.34 and 0.73 respectively. [14]

The steady state value of the autonomous component of export demand, am, is calibrated so that $p^M = 1$ in steady state. The series $\{am\}_{1930}^{1939}$ is calibrated so that real exports, $(\frac{p^X x}{p^c})$, behave in the model as they do in the data. In other words, I have assumed that there is an exogenous shock to the demand for Belgian exports by the rest of the world, and calibrated the shock so that the simulated real export series matches the data.

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 $b_{i,j}$.[15]

I calibrated the value of κ by approximating it with 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 survey by Blanchflower (2007) fixes this value to 42% in 1970 and 55% at the end of the 1990s. 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

[14] 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.

[15] The use of modern data to single out the sectoral 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).

period wage (remember that I have assumed that $\frac{l^T}{l}$ is 0.56 in steady state).[16]

I have assumed that the sectoral TFPs are subject to zero-mean i.i.d shocks of the AR(1) kind.

$$s_t^N = \rho^N s_{t-1}^N + v_t^N, \tag{41}$$

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

We do not have a clear-cut empirical counterpart for s^N and s^T. In their stead, I used the aggregate productivity shock estimated in Pensieroso (2011a).[17]

$$s_t = \rho s_{t-1} + v_t, \tag{43}$$

I also assumed that the sectoral autoregressive coefficient for TFP is the same as the one estimated there for the whole economy, that is $\rho^N = \rho^T = \rho$. I assumed the following relationship between sectoral and aggregate TFP:

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

with $\lambda = 0.49$ being the weight of the non tradeable sector in the 1965 input-output matrix.

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.[18] 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.

The tariff on imports, τ, is computed as the ratio of customs revenue to total imports, both expressed in millions of Belgian francs.[19].

[16]The benchmark value of the parameter κ in Blanchard and Galì (2007) is 0.9.

[17]The aggregate TFP shock in Pensieroso (2011a) is obtained by running the AR(1) process in Equation (43) on the logarithm of detrended TFP. The latter is computed from aggregate detrended data as the Solow residual, under the assumption that the production structure of the Belgian economy is well represented by an aggregate Cobb-Douglas production function, with labour and capital as inputs, and constant returns to scale.

[18]These countries together received about 62% of the total Belgian exports in 1929. Data from Banque Nationale de Belgique (1943).

[19]The same indicator was used by Crucini and Kahn (1996). Data from Banque Nationale de Belgique (1943)

3.5 Simulation

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 productivity, tariffs, external demand and exchange rate shocks into the model developed above.

I assume that the economy was in steady state in 1929. 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 attribute all the measured variations in productivity to the tradeable sector. That is, I assume that the $\{v^N\}_{1929}^{1938}$ series is made of zeros. This is done in order to emphasize the asymmetry between the two sectors advocated by the historians.

I fed in the computed $\{v^T\}_{1929}^{1938}$, $\{\tau\}_{1929}^{1939}$, $\{e\}_{1929}^{1939}$ and $\{am\}_{1929}^{1939}$ series and run the simulation.[20] I assume perfect foresight of the shock.

There are four impulse mechanisms in this model, the productivity shock in the tradeable sector, the nominal exchange rate shock, the tariffs shock, and the rest-of-the world's demand shock. Measured productivity shocks are positive until 1931. This has a positive direct effect on the model economy, as it shifts capital and labour demand upwards. On the other hand, a productivity increase has deflationary effects, which, coupled with nominal wage rigidity causes real wages to increase and employment and production to decrease. To further complicate the matter, price deflation in the domestic economy translates into an increase in the terms of trade, which should in turn improve the trade balance, by increasing exports and decreasing imports. When, after 1931, productivity shocks turn negative, the same mechanisms are operative, only with the opposite sign.

Concerning the exchange rate shock, notice that the Belgian franc was overvalued with respect to the pre-Depression gold parity during the whole decade. Such overvaluation reached its peak in 1933, when the Belgian franc was more than 30% above its 1929 parity with the bundle currency. An overvalued currency means lower price for imports and higher price for exports. Therefore, its effects on the economy pass through two channels, the trade balance and the induced price deflation. In the context of nominal wage rigidity, the deflationary pressure translates into an increase in real wages, and therefore, again, into a decrease in employment and output.

Tariffs's increase started in 1930 and accelerated after the devaluation of the British pound in 1931. Tariffs reached a peak in 1934, and then decreased till 1937, though they were never back to the initial 1929 level

[20] We do not have data for TFP in 1939.

(here normalized to 0). Notice that there is a strong negative correlation between τ and e, a testimony to the robustness of the hypothesis advanced by Eichengreen and Irwin (2010): countries with overvalued currencies tended to resort more to trade barriers. The increase in tariffs affects directly the price of imports, thereby having general equilibrium effects. The substitution effect implies that consumers and investors should shift to the home production, as imports have become costlier. On the other hand, the income effect implies that households and firms will want more goods in general. As we have assumed a Cobb-Douglas aggregator for both aggregate consumption and investment, complementarity among different goods implies that the quantity of each of them should increase. Additionally, tariffs's variations have a direct effect on the terms of trade, and therefore on the current account.

The latter effect is reinforced by the external demand shock. The shock on am is calibrated so that the real export series in the model matches that of the data, conditional to the measured productivity, tariff and exchange rate shocks. Therefore, the external demand shock influences production and prices directly through the quantity of exports.

Results from the simulation are shown in Figure 3, 4 and 5.

The model reproduces fairly well the peak-to-trough overall pattern of aggregate variables between 1929 and 1934, and in particular in the early years of the Depression. The model account for 74% of the drop in real aggregate output, for 45% of the drop in real aggregate consumption, for 65% of the drop in real aggregate investment (in 1933) and for 122% of the drop in hours worked. The terms of trade is reasonably well matched for all the decade, and the consumption price index between 1929 and 1934 is also fully matched. Hours worked fully recover by 1937 in the model, while still being far below the trend in the data. The model overestimates the real wage dynamics in both sectors, and it fails to reproduce the CPI/PPI pattern. The model does a poor job in accounting for imports and shows somewhat excessive volatility in investment.

If we exclude the external demand shock, and limit the analysis to the shocks we can measure from the data, the model shows the same qualitative behaviour, and is still quantitatively relevant. For instance, the model account for 64% of the drop in real aggregate output, for 41% of the drop in real aggregate consumption, for 64% of the drop in real aggregate investment (in 1933), for 45% of the drop in exports and for 108% of the drop in hours worked.

On the whole, these results confirms the main findings for Belgium by Pensieroso (2011a): the onset and depth of the Great Depression seem linked to the monetary turbulence originating in the exchange rate market and to productivity shocks. However, contrary to the analysis presented there, in our open-economy scenario the protracted character of the Great Depression remains partially unexplained. The model shows sign of recovery by 1937, while the data do not.

The presence of a similar slow-recovery puzzle for the United States has led Cole and Ohanian (2004) to argue that additional policy shocks, such as the National Industrial Recovery Act, that promoted collusive price settings among firms and high wages are to be held as responsible for the long duration of the crisis. This State-failure explanation has been endorsed by many authors (Bordo, Erceg, and Evans (2000), Christiano, Motto, and Rostagno (2004)), and extended to other countries as well (Beaudry and Portier (2002), Fisher and Hornstein (2002)). The natural question then arises, whether the same explanatory facts were present in Belgium as well.

The answer is mixed. In effects, a 1935 Royal Decree introduced changes in the competition rules. The new law stated that if the majority of the firms operating in a sector reached an agreement about prices, the concerned Ministry could make the agreement compulsory for the other firms in that sector. Such a decree basically gave the Government the authority to oblige all the firms in a specific sector to join an existing cartel, thereby limiting competition and entry in a specific market (Chlepner (1972)). This looks akin to the National Industrial Recovery Act.

However, there are also significant differences. Contrary to its American homologue, the Belgian act was not aimed at enhancing a general price reflation. Its genesis was more modestly related to providing help to the mining sector (Mommen (1994)). It is unclear from the historical accounts whether the discretionary powers given to the Ministries by the decree were followed by effects in the rest of the economy. A second difference concerns the link between cartelization and wage policy. This was important for the United States, but had little equivalent in Belgium. Within the National Industrial Recovery Act, the codes of "fair competition" needed a Presidential approval before coming into effect. Such an approval was typically granted only to those codes including collective bargaining and minimum wages. This link between cartelization and wage policy, resulting in an appreciable increase of real wages, is a crucial factor for the results of Cole and Ohanian (2004), meaning that cartelization alone does not account for the observed evidence. To further compound the matter, the presence of strong cartels in the domestic market was already an established feature of the Belgian economy well before the decree was passed. As a result, there was not a "cartelization shock", a policy reversal comparable to that of the United States. These facts makes the parallel with the National Industrial Recovery Act in the United States less compelling.

As for a possible parallel with the French situation analyzed by Beaudry and Portier (2002), the emergence of the *Front Populaire* in France (1936) and the Matignon agreement had obvious echoes in Belgium (Baudhuin (1946), Chlepner (1972)). A call for higher wages and the reduction of working time to 40 hours per week resulted in 1936 in a general strike that led the country on the edge of a revolution. A Government of national unity, formed in 1935 under the presidency of Van Zeeland, did concede wage increases, plus 6 days of paid holidays. A non-binding law on minimum wage was also passed. The working time was reduced to 40 hours per week, but only for those workers facing "difficult" or "arduous" working condition. In practice the measure was limited to mining and chemical industries. All in all, the policies envisaged under the Van Zeeland Governments can be considered as an edulcorated version of the French ones (Cassiers (1995)). Noticeably, the effects of those policies on real wages were different in the two countries. If we make 100 the 1929 value of real wages in both France and Belgium in 1938, this value reached 139.9 in France and 119.8 in Belgium. Moreover, if we repeat the exercise for detrended data, real wages in France were 7.4% above the trend in 1938, while, at the same date, real wages in Belgium were 9.4% below the trend.[21] These numbers fail to support an explanation of the slow recovery from the Great Depression in Belgium solely based on labour market distortions.

4 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 (2011a)) to a full-fledged open-economy dimension.

In Pensieroso (2011a), it was argued that TFP and monetary shocks could account for the Depression, in a closed-economy DGE model with sticky nominal wages. Monetary shocks were intended as a shortcut for exchange-rate-related disturbances. The analysis presented here delves deeper into the issue, by modelling the Gold-Standard-related nominal exchange rate shocks, in a two-good DGE model with sticky nominal wages in the tradeable sector, productivity shocks to the tradeable sector and tariffs shocks too.

Results show that, in response to the drop in external demand, and the exchange rate and tariffs variations of the early 1930s, the perverse combina-

[21] Data for France are from Beaudry and Portier (2002).

tion of flexible product prices and sticky production costs has played a major role in precipitating Belgium into the Depression. This result gives credit to the analysis by historians of the period, like Cassiers (1989).

However, the fact that Belgium did not recover from the Depression after the 1935 devaluation is not well accounted for by the model. Nor, the historical analysis briefly discussed in Section 3.5 allows for the easy identification of pro-labour policies as a likely culprit, as claimed most notably by Cole and Ohanian (2004) for the United States.

An extension of the present work that could help solving the puzzle and lead to intriguing results should provide a sound modelization of the rest of the world, one going beyond the *ad hoc* specification of the export-demand in Equation (36). Further suitable refinements include the addition of capital adjustment costs, and, most challenging, a throughout consideration of the financial sector, so deeply connected to the Gold Standard monetary regime.

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Figures

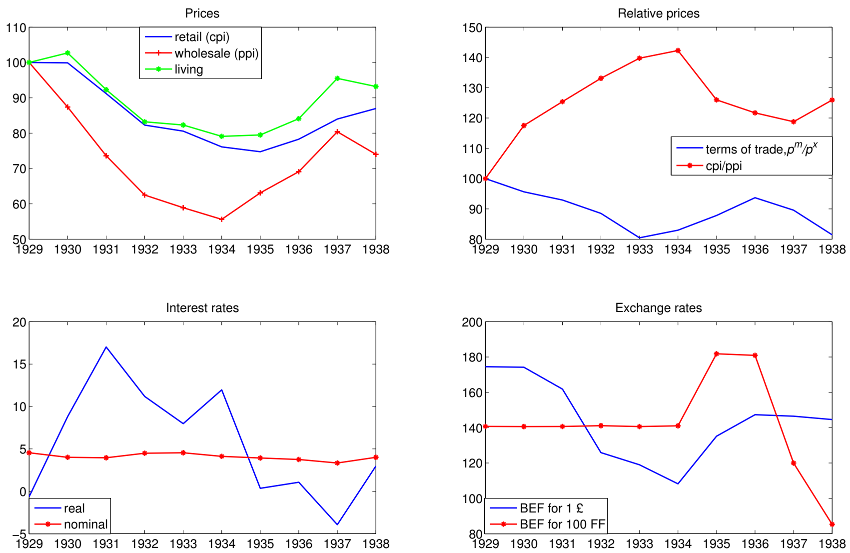

Figure 1: Data on prices, interest rates and selected exchange rates in Belgium, 1929-1938. Indices, 1929=100. Source: Pensieroso (2011a)

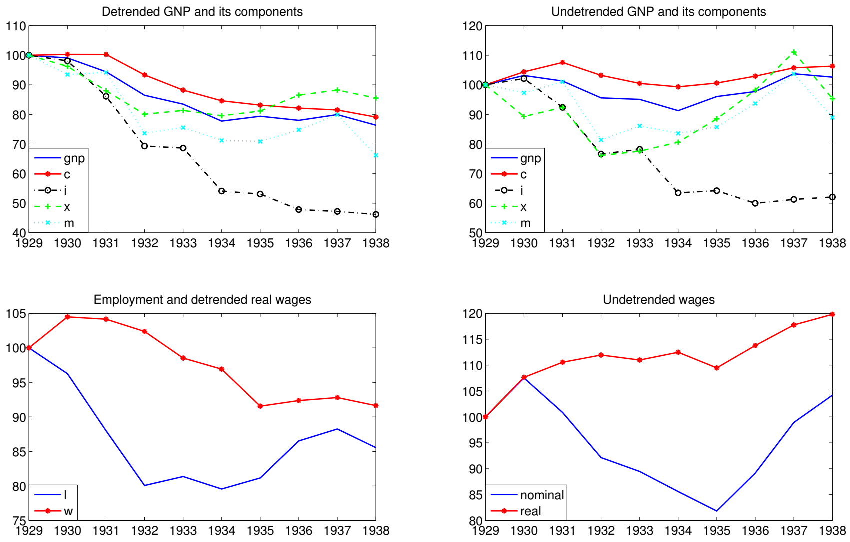

Figure 2: Data on detrended and undetrended output, its components, and the labour market in Belgium, 1929-1938. Indices, 1929 = 100. Source: Pensieroso (2011a)

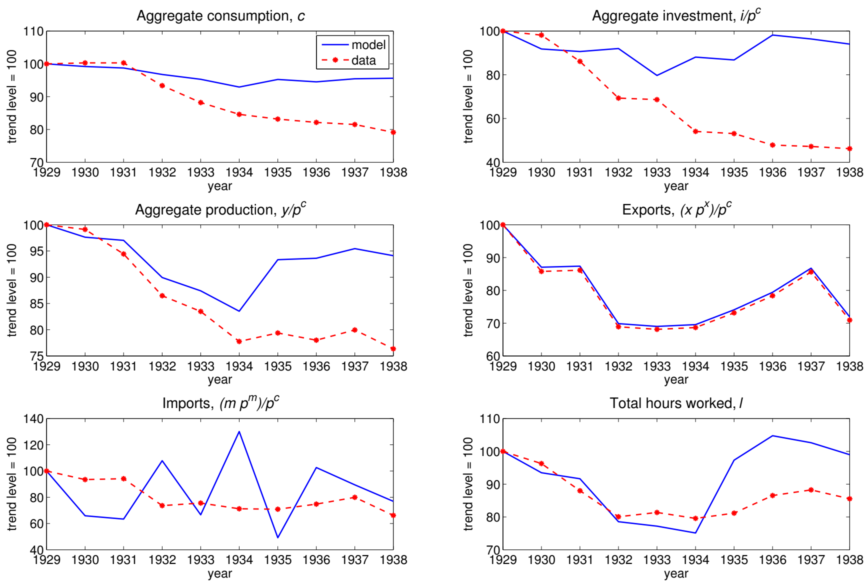

Figure 3: Simulation

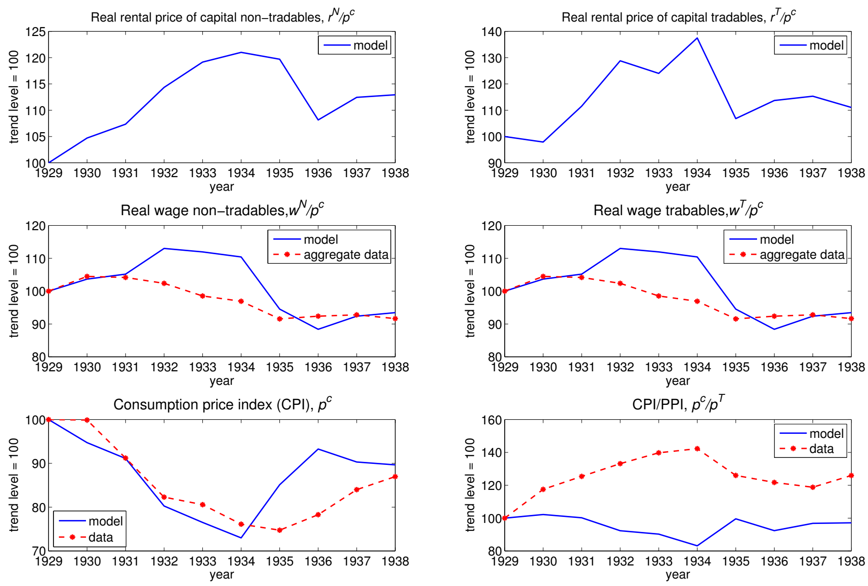

Figure 4: Simulation

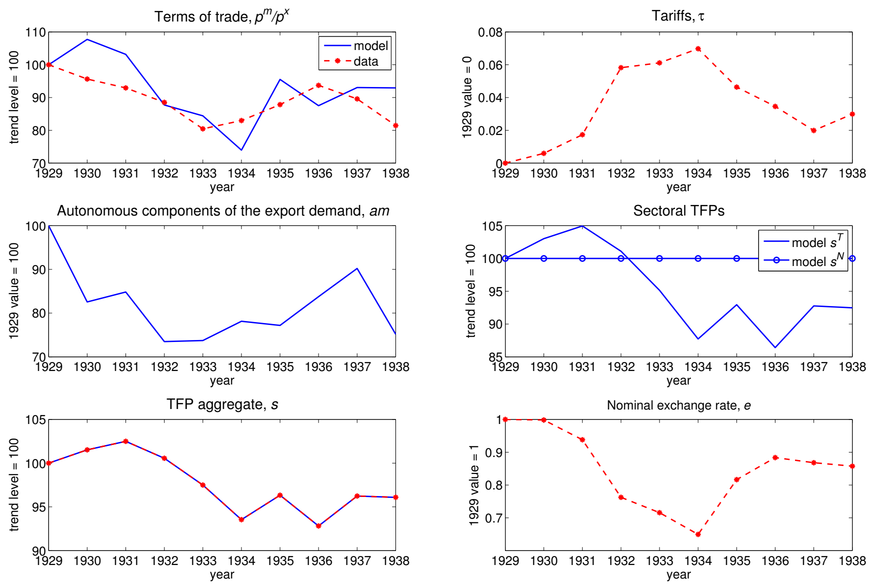

Figure 5: Simulation

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