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Document de Travail n° 2021 – 21
(Version révisée du WP 2019-23)

Mai 2021

Bureau d'Économie Théorique et Appliquée BETA

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The Gold Standard and the International Dimension of the Great Depression*

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May 26, 2021

Abstract

Was the Gold Standard a major determinant of the onset and protracted character of the Great Depression of the 1930s in the United States and worldwide? In this paper, we model the 'Gold-Standard hypothesis' in an open-economy, dynamic general equilibrium framework. We show that encompassing the international and monetary dimensions of the Great Depression is important to understand the turmoil of the 1930s, especially outside the United States. Contrary to what is often maintained in the literature, our results suggest that the vague of successive nominal exchange rate devaluations coupled with the monetary policy implemented in the United States did not act as a relief. On the contrary, they made the Depression worse.

Keywords: Great Depression, Gold Standard, Open Macroeconomics, Dynamic General Equilibrium
JEL Classification: N10, E13, N01

*Paper presented at the EEA 2017 meeting in Lisbon, at the CEF 2017 conference in New York, at the ASSET 2016 conference in Thessaloniki, at the *Workshop in Macroeconomics* on the occasion of the Honorary Doctorate awarded to Olivier Blanchard in Ghent in 2017 and at the 2015 *Macro-Dynamics Workshop* in Bilbao. We thank participants at these meetings, as well as participants in seminars at the Universities of Louvain and Strasbourg for their feedback. Yao Chen, Eric Monnet, Charlotte de Montpellier, Robert Kollmann, Giulio Nicoletti, Henri Sneessens and Felix Ward made interesting remarks on an earlier version that circulated under the title "The Gold Standard and the Great Depression: a Dynamic General Equilibrium Model". The usual disclaimers apply. Restout thanks the Region of Lorraine for research support (Grant AAP-009-020).

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1 Introduction

In this article, we introduce a two-country, two-good dynamic general equilibrium model to study whether the Gold Standard was a major concomitant cause of the onset and long duration of the Great Depression of the 1930s in the United States and worldwide.

Since Keynes's *General Theory*, the Great Depression has been on the frontier of research in macroeconomics. Yet, the literature is still inconclusive as to the causes of the Depression, with macroeconomists and economic historians struggling to provide a consensual explanation of this exceptional event.

Traditional Keynesian explanations see the Great Depression as the epitome of market failures (Keynes (1936), Temin (1976)). Capitalist economies, the story goes, are chronically subject to depressions due to possible deficiencies in aggregate demand. This calls for systematic Government intervention in the form of public expenditure and expansionary monetary policy.

The alternative view flies the colors of Monetarism. It was proposed by Friedman and Schwartz (1963) and further elaborated by Mishkin (1978). According to the Monetarist explanation, the Great Depression was not a market failure, but actually a State failure, with the finger pointing at the Federal Reserve (Fed) for failing to act as lender of last resort. The consequent lack of liquidity in the market caused banking panics and debt-deflation, thereby prompting the worst Depression in American history.

Economic historians have blended the two theoretical approaches and widened the scope of the analysis from the United States to the rest of the world. The first remarkable analysis was that by Kindleberger (1973), who argued that the Depression was mostly induced by the malfunctioning of the monetary system of the time, the Gold Standard, due to a lack of lender of last resort at the international level, with the Bank of England not being capable of carrying out this role any more, and the Fed not yet ready to accept the handover. Taking the reasoning one step further, Eichengreen (1992) argued that not only did the Gold Standard not work well because of a lack of hegemonic power, but it was itself the heart of the problem. The Gold Standard hypothesis was most notably supported by the work of Bernanke (1995), Bernanke and Carey (1996), Eichengreen and Irwin (2010), Eichengreen and Sachs (1985), Eichengreen and Temin (2000) and Temin (1989), among others.[1]

[1] The Gold Standard hypothesis was somewhat anticipated by Gustav Cassel in the 1920s, as aptly argued by Irwin (2014).

At the end of the 1990s, a new strand of macroeconomic literature on the Great Depression saw the light of day.[2] Using dynamic general equilibrium (DGE) models, these authors collectively claimed that the Depression was a 'normal' business cycle worsened by bad policy decisions. Their models were equilibrium models of the business cycle, in the sense of Lucas (1980). They pointed to a State failure, but included Keynesian features in the form of frictions. Major contributions were Bordo et al. (2000), Cole and Ohanian (1999), Cole and Ohanian (2004), Weder (2006).

The emergence of DGE models of the Great Depression was a major breakthrough. In particular, it allowed a reformulation of the Keynesian and Monetarist views of the Depression in terms of formal economic models geared towards a quantitative assessment of their relevance. Still, this research agenda raises as many questions as it answers, as recalled by De Vroey and Pensieroso (2006), Pensieroso (2011b) and Temin (2008). One obvious concern is its main focus on closed-economy models and idiosyncratic, country-specific shocks.[3] As the Great Depression was clearly a worldwide phenomenon, explanations based on idiosyncratic shocks hitting different countries at the same time are hardly compelling. Moreover, none of the models produced so far in the literature can help us assess whether the Gold Standard hypothesis proposed by the historians holds good.

In this paper, we provide the first open-economy, DGE model of the Gold Standard and the Great Depression in the literature.[4] We built a two-country, two-good DGE model, in which the United States trade in goods with the rest of the world. The model is specified in monetary terms, with money supply linked to the gold reserves of the country, while gold flows ensure the equilibrium of the balance of payments. Monetary non-neutrality is introduced through nominal wage rigidity, while the presence of an exogenous money multiplier ensures the model can catch the financial dimension of the Depression, at least in reduced form. The

[2]See the articles in the collected volume by Kehoe and Prescott (2007), and Pensieroso (2007) for a critical survey.

[3]Closed-economy analyses include Beaudry and Portier (2002) for France, Cole and Ohanian (1999) for the United States, Cole and Ohanian (2002) for the United Kingdom, Fisher and Hornstein (2002) for Germany, Pensieroso (2011a) for Belgium.

[4]In an independent work, Chen and Ward (2019) estimated a New Keynesian model for the pre-1913 Gold Standard. They argued that price flexibility, due to the large predominance of agricultural products among tradeable goods, explains why adjustments of current account imbalances were typically not accompanied by significant output losses in the pre-WWI Gold Standard system. Fagan et al. (2013) estimated a closed-economy New-Keynesian model and argued that the Gold Standard was not the main determinant of the macroeconomic volatility in the United States between 1879 and 1914.

model is calibrated on historical data for the United States and a bunch of Western countries grouped together under the 'Rest of the World' label. It features several real and monetary shocks, also calibrated from the historical data. Results from numerical simulations show that the model has a good empirical fit, i.e. is capable of matching most of the statistical moments of the data. Furthermore, our results highlight how important it is to encompass a proper international dimension in the model, in order to better understand the behavior of the main aggregates during the 1930s. Monetary shocks linked to the Gold Standard help to account for the actual data, particularly in the Rest of the World.[5] Moreover, the Gold Standard did provide a powerful transmission mechanism of monetary shocks from the United States to the Rest of the World, as claimed by the historical literature. Contrary to what is often maintained in the literature, however, exiting the Gold Standard was hardly the way out of the Depression. Our counterfactual analysis shows that, had the world economy gone back to the 1929 Gold Standard by 1932, that is to say to the 1929 statutory gold parity and without sterilization policies, the Depression would have been less severe, especially in the Rest of the World. This is in accordance with Kindleberger (1973), who viewed the series of successive devaluations of the 1930s as essentially beggar-thy-neighbor, and with a recent contribution by Jacobson et al. (2019), who also contested the view that monetary and exchange rate policy were the key factors in driving the U.S. economy out of the Depression after 1933.

This research contributes to the macroeconomic literature on the Great Depression by assessing the qualitative adequacy and quantitative relevance of the Gold Standard hypothesis. The scope of our analysis, however, actually extends beyond the realm of history, and touches on recent events. In view of the instability experienced by the world economy in the aftermath of the 2008 financial crisis, discussions about the desirability of a Gold Standard have resurfaced. Diercks et al. (2020) introduced the Gold Standard into a New-Keynesian, closed-economy model. They estimated the model on U.S. data from 2000, and concluded that the price of gold volatility makes a fiat-money with a Taylor rule regime preferable to a Gold Standard regime. It has been argued that the Euro zone presents important analogies with the Gold Standard. Eichengreen and Temin (2010), in particular, maintain that the Europeans are chained by fetters of paper today, in the same way that the world was chained by fetters of gold during the Great Depression, suggesting implicitly that exiting the Euro might help the recovery. Assessing whether the Gold Standard was a likely culprit

[5]The VAR analysis developed by Karau (2020) confirms this conclusion.

for the Depression, and whether exiting the Gold Standard was the way out of the Depression, might therefore have important, if indirect, policy implications.

The paper is organized as follows. In Section 2, we review the historical narrative on the working of the Gold Standard and its possible role during the Great Depression. In Section 3, we present our model. We calibrate and simulate it in Section 4, where we also show the impulse response functions of the model and provide our counterfactual analysis. Section 5 concludes.

2 The Gold Standard

2.1 The working of the Gold Standard

The classical exposition of the working of the Gold Standard is to be found in Hume (1752).[6] Its mechanics are based on three pillars, money supply, the trade balance and gold flows. Money supply is linked to gold through the price of gold, the units of currency that must be given in exchange for a unit of gold. The price of gold in national currency is fixed by the monetary authority. When two countries both abide by the Gold Standard, the nominal exchange rate between their currencies is fixed and equal to the relative price of gold in the two countries. In other words, the Gold Standard is a fixed exchange rate regime, in which relative gold parity regulates the nominal exchange rate. In this context, when the trade balance in the domestic economy is in deficit, the domestic currency cannot devalue. Accordingly, the quantity of gold must adjust to restore equilibrium to the trade balance. The country in deficit will then experience a gold outflow, and consequently a deflation of monetary prices. By the same token, the country in surplus will experience an increase in gold reserves, which, given the gold content of the currency, implies an increase in money supply and therefore in monetary prices. Deflation in the domestic economy and inflation in the foreign economy will push the terms of trade in favor of the foreign economy. Hence, the latter will start importing more from, and exporting less to, the domestic economy, thereby correcting the initial disequilibrium in the trade balance. This mechanism will work until the trade balance is in equilibrium.

Although this is the backbone of the Gold Standard system, its actual working might be more complex, once we take into account the presence of

[6] Reprinted in Eichengreen, ed (1985).

banks and the financial system. As aptly noted by the Cunliffe Committee (1918),[7] capital movements (i.e. international lending and borrowing) add additional specific features to the system. If the trade balance is in deficit, the central bank of the deficit country can raise the discount rate to attract lending. In this way, the trade-balance deficit might be offset by capital inflows (i.e. debt), with no or less gold outflow. This possibility introduces an element of discretion in the working of an otherwise automatic mechanism. It follows that credible commitment to the Gold Standard and central bank cooperation become central features of the system. Notice that capital movements do not correct the disequilibrium in the trade balance, *per se*. Indeed, the inflows of capital, to be sustainable, cannot be perennial, while capital mobility will tend to equalize interest rates across countries. Therefore, the real exchange rate must adjust eventually to restore equilibrium. Again, in a fixed exchange rate context, it is the relative price index that must bear the brunt of adjustment. The higher interest rate in the deficit country will discourage investments, lower aggregate demand and therefore exert a deflationary pressure. The consequent depreciation of the real exchange rate will favor exports and depress imports, thereby contributing to restoring the equilibrium of the trade balance. Notice the possible trade-off between the long-run objective of balance-of-payments stabilization and the short-run objective of countercyclical monetary policy, a trait already highlighted by Keynes (1923), most notably.

2.2 The Gold Standard and the Great Depression

The most complete account of the Gold Standard hypothesis for the Great Depression is to be found in Eichengreen (1992). Like Friedman and Schwartz (1963), Eichengreen attributed the onset of the Great Depression to the restrictive monetary policy implemented by the Fed in 1927-1928, in the attempt to avoid the bursting of a speculative bubble. However, unlike Friedman and Schwartz (1963), Eichengreen looked at this factor from an international perspective. Higher interest rates in the United States implied less lending from the United States to the rest of the world. This was a problem for many countries, and in particular for the European countries, who were still recovering from World War I and witnessed heavy current account deficits. Absent American lending, the rest of the world was forced to turn to restrictive fiscal and monetary policies in order to keep gold parity and prevent gold outflows. If bad monetary policy in the United States was the impulse mechanism determining the onset of

[7] Reprinted in Eichengreen, ed (1985).

the Great Depression, the transmission mechanism from money to the real world was via wage and price rigidity in the United States and elsewhere, and through the lack of international cooperation. According to Eichengreen, the major economies of the time were all characterized by some degree of nominal stickiness in wages, as in rents and mortgages. This implies money non-neutrality, meaning that real variables (wages, profits etc. . .) will depend upon the monetary regime. In fact, the evidence suggests that real wages were increasing more for countries that belonged to the Gold Standard. Moreover, they started to decrease almost everywhere when the Gold Standard was abandoned (Bernanke (1995) and Eichengreen and Sachs (1985)). In the international context, monetary tensions were worsened by issues like war repayments and war debts, which led to a freeze of any coordinated action by the main central banks to provide liquidity to the economy without incurring losses of gold. The Depression was further worsened by the financial crises that hit the United States and other countries (Austria and Germany, most notably). Eichengreen points to the trade-off between financial stability and nominal exchange rate pegging. In case of liquidity problems in the banking system, liquidity provisions by central banks might increase the perceived risk of currency devaluation, thereby increasing deposit withdrawals and inducing capital (and gold) outflows. According to Eichengreen, far from acting as a stabilizer, the Gold Standard was actually fostering financial instability and banking crises.

These dramatic events unfolded in what was to become the worst economic crisis in the history of modern capitalism, until countries started exiting the Gold Standard one by one, or imposing strict capital controls. According to Eichengreen, this was the main policy decision that drove the world economy out of the Depression.[8] Indeed, the evidence shows that those countries that exited the Gold Standard earlier, recovered earlier and faster (Choudhri and Kochin (1980) and Eichengreen and Sachs (1985)). Absent the external constraint on the nominal exchange rate, fiscal and monetary expansion became possible. However, the Depression lingered for quite some time, and it was eventually swept away only by the outbreak of World War II.

[8]As will be clear later, in our model we reach a somewhat different conclusion. While the Gold Standard turns out to be an important transmission mechanism of monetary shocks from the United States to the Rest of the World, the series of competitive devaluations of the 1930s deepened the Depression. In this respect, our model rather conforms to the analysis by Kindleberger (1973).

3 The model

3.1 Key features and notation

The theoretical reasoning underpinning the literature on the Gold Standard and the Great Depression is based on many elements: exchange rate pegging, monetary and real shocks, money non-neutrality induced by nominal rigidities, financial instability and banking crises, trade and capital movements.

Our model features most of those elements. We have exchange rate pegging, monetary and real shocks, nominal wage rigidity and international trade. We do not model the use of reserve currency because the issue is irrelevant in a two-country model. Financial sector and banking crises are included in reduced form, as discussed at length in Section 3.6.

The model features two symmetric countries, the United States (US) and 'Rest of the World' (RW). Each country produces one country-specific good in perfect competition. It can be consumed and invested domestically, and traded internationally at no cost. Population is assumed to be constant in both countries. Agents have perfect foresight.[9]

We assume that both labor and capital are not mobile internationally. According to Eichengreen (1992), capital outflows from Europe to the United States at the end of the 1920s were the transmission mechanism of the monetary shock from the United States to the rest of the world, as they forced the European central banks to increase their policy rates, in order to avoid major outflows of gold. In our model, we do not include capital movements, as we want to isolate the role of gold flows as an adjustment mechanism of the balance of payments. Furthermore, capital movements were minor overall during the 1930s (see James (1992)). This modeling choice has implications for the interpretation of our results. In particular, in the model we treat monetary shocks in the Rest of the World as exogenous, but it must be understood that those shocks are linked to the Gold Standard.

A key ingredient of this model is the presence of money in the sense of cash balances whose quantity is linked to the quantity of gold and to

[9]While this is a common assumption in the literature, there is little consensus over the correct way of modeling expectations in analysis of the Great Depression. See Kehoe and Prescott (2008) for a discussion of rational expectations *vs* perfect foresight in the analysis of the Great Depression. Eggertsson (2008) provided a model highlighting the role of expectations in driving the American economy out of the Great Depression of the 1930s. Aguilar Garcìa and Pensieroso (2021) are currently further exploring the expectations hypothesis, by introducing adaptive learning into a DGE model of the U.S. Great Depression.

monetary policy.

Nominal wages are assumed to witness some degree of rigidity in both countries.

Before illustrating the model, some explanation about notation is in order. Variables referring to the Rest of the World are denoted by a 'star', X^*. Variables referring to the United States bear no superscript. A US or RW superscript denotes the origin of the good (i.e. where the good has been produced). Lower-case (upper-case) variable stand for per capita (aggregate). For the sake of exposition, the model is presented in undetrended terms. However, for the simulations we have detrended the model by dividing each growing per-capita variable by the deterministic component of TFP, x_t (see Equation (5) below). To detrend the data in a way that is compatible with the theoretical framework, we have divided each variable by $\gamma^{(t-t_0)}$, where $\gamma > 1$ is the growth factor and t_0 is the chosen initial value that corresponds to the steady state.

We will focus the exposition on the United States hereafter. Given the symmetry between the two countries, the model for the Rest of the World is analogous. We will spell out the equations for the Rest of the World only when there is some difference with respect to the U.S. economy.

3.2 The U.S. aggregate consumption

Real per-capita consumption in the United States, c, is made up of consumption of both the domestic and the foreign good. As is standard in the international trade literature, we shall use a CES aggregator, where $\phi > 0$ stands for the elasticity of substitution between the two goods, and $\omega \in (0, 1)$ indicates the relative preference for the U.S. good:

$$c_t = \left[\omega^{\frac{1}{\phi}} \left({c_t}^{US}\right)^{\frac{\phi-1}{\phi}} + (1-\omega)^{\frac{1}{\phi}} \left({c_t}^{RW}\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}. \tag{1}$$

In view of the importance attributed to the Hawley-Smoot Act of 1931 by the literature (see Crucini and Kahn (1996) and Crucini and Kahn (2003)), we allow for the presence of tariffs on U.S. imports. Tariffs on the dollar value of imports are denoted by τ. Calling p^* the price in foreign currency of U.S. imports from the Rest of the World, c^{RW}, and e the nominal exchange rate expressed as the amount of dollars for 1 unit of international currency, expenditure minimization by the representative household gives:

$$
\begin{aligned}
{c_t}^{US} &= \omega \left(\frac{p_t}{p_t^c}\right)^{-\phi} c_t, && (2a)\\
{c_t}^{RW} &= (1-\omega)\left(\frac{(1+\tau_t)e_t p_t^*}{p_t^c}\right)^{-\phi} c_t, && (2b)\\
p_t^c &= \left[\omega p_t^{1-\phi} + (1-\omega)\left((1+\tau_t)e_t p_t^*\right)^{1-\phi}\right]^{\frac{1}{1-\phi}}, && (2c)
\end{aligned}
$$

where p^c is the CPI implied by the model.

Two features are noteworthy. First, tariffs impact demand directly. Second, we ought to distinguish between two price indices, the GDP and the CPI deflator – p and p^c respectively.

3.3 The U.S. aggregate production

We assume that there is a representative firm producing via a constant return to scale technology:

$$
y_t = A_t k_t^{\alpha} l_t^{1-\alpha}, \tag{3}
$$

where, y, l and k stand for per-capita production, hours worked and capital, and $(1-\alpha)$ is the labor share in production. We assume that A, the total factor productivity (or TFP hereafter), can be broken down into two components, a stochastic one, given by $\exp(s)$, and a deterministic one, x:

$$
A_t \equiv \exp(s_t)\,(x_t)^{1-\alpha}. \tag{4}
$$

The stochastic component will give us the TFP shock, while x stands for the labor-augmenting technical progress that drives the economy along a balanced-growth path, with a growth factor equal to $\gamma > 1$:

$$
x_t = \gamma^t x_0. \tag{5}
$$

Calling w the nominal wage of labor, and r the nominal rental price of capital, profit maximization by the representative firm leads to labor and capital demand:

$$
\begin{aligned}
\frac{w_t}{p_t} &= (1-\alpha)A_t k_t^{\alpha} l_t^{-\alpha}, && (6a)\\
\frac{r_t}{p_t} &= \alpha A_t k_t^{\alpha-1} l_t^{1-\alpha}. && (6b)
\end{aligned}
$$

3.4 The U.S. household dynamic problem

The representative household draws utility from consumption, c_t, real cash balances, $m_t \equiv M_t/p_t^c$, and leisure. It has habit persistence, weighted by the parameter ξ. We normalize the total household time endowment to 1, so that leisure per capita can be expressed as $1 - l_t$. Assuming perfect foresight, the problem of the household reads:

$$\max_{\{c_t, l_t, i_t, k_{t+1}, m_{t+1}\}} \sum_{t=0}^{\infty} \beta^t \left[\ln\left(c_t - \xi c_{t-1}\right) + \zeta \ln(1 - l_t) + \chi \ln m_t\right], \tag{7}$$

subject to the following constraints:

$$m_t + \frac{w_t}{p_t^c} l_t + \frac{r_t}{p_t^c} k_t + t_t = c_t + \frac{p_t}{p_t^c} i_t + \frac{\psi}{2}\left(\frac{k_{t+1}}{k_t} - \gamma\right)^2 \frac{p_t}{p_t^c} k_t + m_{t+1}\left(1 + \pi_{t+1}^c\right), \tag{8}$$

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

where $\beta \in (0, 1)$ denotes the consumer's discount rate, ζ and χ are positive scaling parameters, t_t stands for transfers from the Government that are taken as given by the household, $(1 + \pi_{t+1}^c)$ is the CPI inflation factor (i.e. p_{t+1}^c/p_t^c), i stands for real per-capita investments, and $\delta \in (0, 1)$ is the depreciation rate of the capital stock. Equation (8) is the budget constraint of the household, equating income to expenditure. We assume quadratic capital adjustment costs, with the parameter $\psi > 0$ governing their magnitude. Equation (9) is the law of accumulation of physical capital, where, for the sake of simplicity, we assume that investments are made up of the domestic good only.[10]

The first order conditions of the problem are:

$$\frac{\bar{c}_{t+1}}{\bar{c}_t} = \beta\left(\frac{1 - \beta\xi\frac{\bar{c}_{t+1}}{\bar{c}_{t+2}}}{1 - \beta\xi\frac{\bar{c}_t}{\bar{c}_{t+1}}}\right)\left(\frac{1 + \iota_{t+1}}{1 + \pi_{t+1}^c}\right), \tag{10a}$$

$$m_t = \frac{\chi}{\iota_t}\bar{c}_t\left(1 - \beta\xi\frac{\bar{c}_t}{\bar{c}_{t+1}}\right)^{-1}, \tag{10b}$$

$$\zeta\frac{\bar{c}_t}{(1 - l_t)} = \left(1 - \beta\xi\frac{\bar{c}_t}{\bar{c}_{t+1}}\right)\frac{w_t}{p_t^c}, \tag{10c}$$

$$(1 + \iota_t) \equiv (1 + \pi_t)\left[(1 + \frac{r_t}{p_t} - \delta) + \frac{\psi}{2}\left(\left(\frac{k_{t+1}}{k_t}\right)^2 - \gamma^2\right)\right]\left[\psi\left(\frac{k_t}{k_{t-1}} - \gamma\right) + 1\right]^{-1}, \tag{10d}$$

[10] The share of capital equipment in total imports in 1935 was 1% in the United States, 2.5% in the United Kingdom, 4.9% in France and 12.5 % in Canada (League of Nations (1941), no data for Germany and Italy).

plus the appropriate transversality conditions. π_{t+1} is the GDP-deflator inflation and, for the sake of notation, we denote $\bar{c}_t \equiv c_t - \xi c_{t-1}$. Equation (10a) is the Euler equation. Equation (10b) is the standard money demand as a function of consumption and the nominal interest rate. Identity (10d) is the definition of the nominal interest rate, ι, in terms of the Fisher equation. Finally, Equation (10c) is the labor supply.

3.5 The Gold Standard

We model the Gold Standard as an automatic rule linking the aggregate monetary base, M^B, to the price and aggregate quantity of gold, p^g and G, respectively, through the statutory gold-backing ratio of the currency, i.e. the minimum percentage of the monetary base that must be covered by the value of gold reserves, according to the law. A similar rule was first proposed by Barro (1979). In an independent work, Chen and Ward (2019) modeled the Gold Standard in a different way, through a Taylor-type rule on the discount factor, in a New Keynesian model with many frictions. Ours is more of a real business cycle model in the sense of Kehoe et al. (2018). Furthermore, we have chosen to model the Gold Standard in a way that makes policy shocks directly measurable from the data.

Calling $\eta \in (0,1)$ the gold-backing ratio, the expressions for the monetary base M^B in both countries will be

$$M_t^B = \left(\frac{1}{\eta(1+\lambda_t)}\right) p_t^g G_t, \tag{11a}$$

$$M_t^{B*} = \left(\frac{1}{\eta^*}\right) p_t^{g*} G_t^*. \tag{11b}$$

Notice the asymmetry between the two countries. While we assume that the Rest of the World sticks mechanically to the Gold Standard, like in Barro (1979), so that, absent changes in the price of gold, any inflow or outflow of gold will affect the stock of the monetary base, we allow the Gold-Standard constraint to be non-binding for the United States. The implication of this assumption is that the U.S. monetary authorities can sterilize gold inflows and outflows by acting on the parameter $\lambda > -1$. This is in accordance with the historical evidence from Bordo et al. (2002) and Hsieh and Romer (2006), who maintained that the U.S. Federal Reserve was actually not constrained by the amount of gold, and could have undertaken a more expansionary monetary policy in the 1930s, if only it had wished to. Similarly to the United States, France had huge reserves of gold at the beginning of the 1930s (Irwin (2012)). This makes France somewhat special with respect to the other countries bundled under the Rest-of-the-World label, as noticed by Kindleberger (1973) and Eichengreen (1992) among others. We obviously cannot consider this feature in a two-country model. Notice however that in the data the equivalent of λ for the Rest of the World, λ^*, was approximately zero on average between 1929 and 1936. In the same period, instead, the average value of λ in the United States was 0.6.

We assume that gold can move freely between countries. To the extent that shipping costs were constant, they are not relevant for our purpose. Any volatility in shipping costs should be captured by shocks on the price of gold.

In this context, the nominal exchange rate is simply the ratio between the statutory price of gold in both countries, that is the ratio between the gold content of the two currencies:

$$e_t = \frac{p_t^g}{p_t^{g*}}. \tag{12}$$

The values of p_t^g and p_t^{g*} are decided by the monetary authority of each country.

We assume that all existing gold is used for monetary purposes. This assumption is made for the sake of simplicity. Notice that theoretically, the commodity-nature of monetary gold is important to rule out hyperinflation, but it plays no obvious key role in the deflationary context of the Depression.

3.6 Inside money

As explained above, the historical literature on the Gold Standard and the Great Depression focuses on the link between the Gold Standard and the financial system in order to account for the depth of the Great Depression. Unfortunately, modern DGE macroeconomics have long overlooked the issue of financial stability, meaning that we lack tools to model this claim properly about the Great Depression. Much research effort is currently devoted to understanding the link between the banking system and real recessions, like in Boissay et al. (2018), while a model of financial accelerator has been developed by Bernanke et al. (1996). Adapting these models to the international context of the Great Depression is an interesting question that we leave to future research.[11] In this article, we shall content ourselves with having a kind of 'reduced form' formulation for the banking sector. In particular, we shall assume that in the aggregate, cash balances, M, are a multiple of the monetary base by an exogenous money multiplier, μ:

$$M_t = \mu_t M_t^B, \tag{13a}$$

$$M_t^* = \mu_t^* M_t^{B*}. \tag{13b}$$

This formulation allows us to interpret variations in the money multiplier as exogenous banking shocks. While this is admittedly an oversimplified representation of the banking system, it has the advantage of being simple and tractable. Moreover, we can measure the shock directly from the data, which makes us confident that, although we are not modeling them explicitly, we are still considering the quantitative relevance of banking shocks in our Gold Standard model.

3.7 Equilibrium conditions

In a Gold-Standard system, the equilibrium of the balance of payments ensures that any surplus or deficit of the trade balance is compensated by a flow of gold from the deficit to the surplus country. Accordingly, we shall have

$$\underbrace{p_{t+1}^g G_{t+1} - p_t^g G_t}_{\Delta\text{ gold}} = \underbrace{p_t C_t^{US*} - e_t p_t^* C_t^{RW}}_{\text{trade balance}}, \tag{14}$$

or, in real, per-capita terms,

$$(1+\pi_{t+1}^c)\left(\frac{p_{t+1}^g}{p_{t+1}^c}\right) g_{t+1} - \left(\frac{p_t^g}{p_t^c}\right) g_t = \left(\frac{p_t}{p_t^c}\right) n c_t^{US*} - \left(\frac{e_t p_t^*}{p_t^c}\right) c_t^{RW}, \tag{15}$$

where $n = N^*/N$ denotes the ratio of the RW to the US population.

In our model, the Government collects revenue from three sources: seignorage, the flow of gold due to the surplus of the current account (if any) and tariffs. We assume that the Government rebates these resources to the household via lump-sum transfers:

$$t_t = \left[(1+\pi_{t+1}^c) m_{t+1} - m_t\right] - \left[(1+\pi_{t+1}^c)\left(\frac{p_{t+1}^g}{p_{t+1}^c}\right) g_{t+1} - \left(\frac{p_t^g}{p_t^c}\right) g_t\right] + \tau_t \frac{e_t p_t^*}{p_t^c} c_t^{RW}. \tag{16}$$

[11] Some effort in this direction has been made by Christiano et al. (2003) and Karau (2020) in the context of closed-economy models. The importance of financial shocks in the Great Recession of 2008 has been stressed by Kollmann et al. (2016), among others.

Finally, market clearing requires:

$$p_t Y_t = p_t^c C_t + p_t I_t + (p_t C_t^{US*} - (1+\tau_t) e_t p_t^* C_t^{RW}), \tag{17a}$$
$$G^W = G_t + G_t^*. \tag{17b}$$

Equation (17a) states that the value of aggregate demand must be equal to the value of aggregate supply. Equation (17b) clears the market for gold and guarantees that the sum of the stock of gold in the two countries is equal to the (exogenously given) worldwide gold reserves G^W.

3.8 Frictions

From a methodological point of view, our standpoint favors parsimony over perfect data mimicking, in the spirit of Kehoe et al. (2018). Accordingly, we have refrained from introducing too many frictions, and have tried to minimize the number of free parameters. We have limited ourselves to capital adjustment costs and habit persistence, two standard features in international macroeconomics, aimed at avoiding excess volatility in the state variables. This notwithstanding, we cannot ignore that in the literature on the Great Depression, two main frictions linked to the Gold Standard have been emphasized, namely tariffs and nominal wage rigidity. We shall consider them in the model as well.

The case for tariffs as a major determinant of the Great Depression was originally advanced by Meltzer (1976), and more recently by Crucini and Kahn (1996) and Crucini and Kahn (2003). Interestingly, Eichengreen and Irwin (2010) argued that countries sticking to the Gold Standard longer were also experiencing deeper slides toward protectionism.

A glance at Figure 1 suggests that the case for tariffs is compelling and uncontroversial. Measured tariffs were indeed increasing at the onset of the Great Depression, both for the United States and, to different degrees, for the group of countries we will include in our definition of the Rest of the World. We shall use variations in measured average tariffs for the United States and the Rest of the World as shocks.

The case for nominal wage rigidity is less immediate. Convincing direct evidence (surveys) for the United States is provided by Bordo et al. (2000). Indirect evidence for the United States and a bunch of other countries is discussed by Eichengreen and Sachs (1985), Bernanke (1995) and Bernanke and Carey (1996). Their empirical strategy consists in estimating the shape of the short-run aggregate supply curve (AS). In the short run, real wages make up the bulk of marginal costs. A positively shaped AS is interpreted as evidence of nominal wage stickiness. The argument

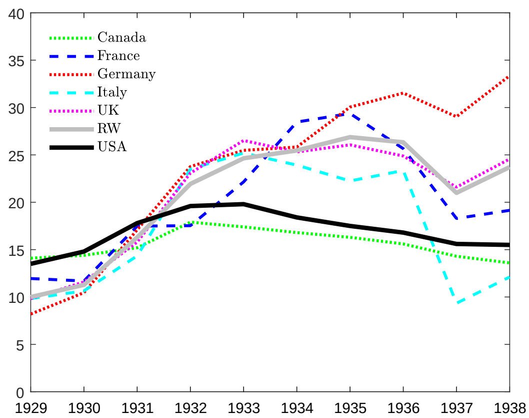

Figure 1: Tariffs. Source: Crucini and Kahn (2003). Customs revenue over total imports

is that if supply increases with prices, it must be that nominal wages are not keeping up with prices. Otherwise, the real wage would be constant and the AS vertical. Bernanke and Carey (1996) go one step further, and also estimate the degree of nominal wage stickiness directly, by using one-period lagged nominal wages in the supply equation. They conclude that the data suggest a sizeable degree of nominal wage stickiness.

In line with this literature, we shall assume that nominal wages are sticky and model such stickiness as in Blanchard and Galì (2007). In our terms, this implies

$$w_t = \kappa w_{t-1} + (1-\kappa)\zeta \frac{p_t^c \bar{c}_t}{(1-l_t)} \left(1 - \beta\xi \frac{\bar{c}_t}{\bar{c}_{t+1}}\right)^{-1}. \tag{18}$$

This formulation states that absent nominal rigidities (i.e. for $\kappa = 0$), nominal wages should be equal to the value of the marginal rate of substitution between consumption and leisure, as from Equation (10c). In this way, we can calibrate the extent of nominal wage rigidity (i.e. κ) directly from the data.

To check to what extent this formulation is compatible with the data, we run the following regression on a panel composed by annual observations from the United States, Canada, France, Germany, Italy and the United Kingdom - the countries we consider in this study - between 1929 and 1939 (59 observations):

$$\ln(\tilde{w}_{it}) = b_i + b \ln(\tilde{w}_{it-1}) + u_{it}. \tag{19}$$

In this regression, $\tilde{w}$ stands for detrended nominal wages, i and t index country and time, and u_{it} are i.i.d. error terms. Country fixed effects b_i are included to capture the detrended value of the marginal rate of substitution between consumption and leisure in Equation (18) which is assumed to be country specific. The parameter we are interested in, the degree of nominal wage rigidity, is given by $\kappa = \gamma b$ (where γ is the calibrated deterministic trend equal to 1.02). The estimated value of κ is 0.816 (significant at the 1% level), suggesting that the degree of overall wage stickiness was relatively high and can be modeled as in Equation (18).[12]

3.9 Shocks

There are five shocks in our model, two real shocks and three monetary shocks.

Real shocks are TFP and tariff shock. Detrended TFP in both countries is assumed to follow an AR(1) process:

$$s_t = \rho s_{t-1} + \nu_t, \tag{20a}$$
$$s_t^* = \rho^* s_{t-1}^* + \nu_t^*. \tag{20b}$$

Tariff shocks are measured directly from the data. We normalize tariffs in 1929 to zero in both countries and assume this corresponds to the steady state.

$$\tau_{29} = \tau_{ss} = 0, \tag{21a}$$
$$\tau_{29}^* = \tau_{ss}^* = 0. \tag{21b}$$

Monetary shocks concern the U.S. gold-backing ratio, the U.S. and RW money multiplier and the price of gold in both countries, which implies the nominal exchange rate. The U.S. gold-backing ratio shock is measured from the data:

$$\lambda_t = \frac{p_t^g G_t}{M_t^B}\frac{1}{\eta} - 1. \tag{22}$$

It is a measure of the sterilization policy implemented by the Fed. As discussed previously in Section 3.5, we impose $\lambda_t^* = 0$ for any t.

The U.S. and RW money multipliers are also taken from the data:

$$\mu_t = \frac{M1_t}{M_t^B}, \tag{23a}$$
$$\mu_t^* = \frac{M1_t^*}{M_t^{B*}}, \tag{23b}$$

[12]Estimations are robust to the inclusion of more years. If anything, the degree of wage stickiness increases when we extend the chronological window. Results are available upon request.

where we assume that $M1$ is a good empirical proxy for M. This formulation is a reduced form representation for banking shocks.

Concerning the price of gold in the United States (Rest of the World), we assume that it follows an AR(1) process converging to its statutory price $\bar{p}^g$ ($\bar{p}^{g*}$):

$$\begin{aligned} p_t^g &= (1-\rho_g)\bar{p}^g + \rho_g p_{t-1}^g + \vartheta_t, && \text{(24a)} \\ p_t^{g*} &= (1-\rho_{g*})\bar{p}^{g*} + \rho_{g*} p_{t-1}^{g*} + \vartheta_t^*. && \text{(24b)} \end{aligned}$$

In our model, all shocks are temporary. That is, we assume that deviations from the Gold Standard (devaluations, capital controls, sterilizations . . .) were by and large perceived as temporary by contemporary observers. Although this may look odd to modern eyes, the historical evidence seems to suggest that this was actually the case. When the United States suspended gold parity in 1933, the suspension was presumably regarded as part of the banking emergency and hence expected to be temporary (Friedman and Schwartz (1963), p. 463). Soon after the World Economic Conference (London, June 1933), the United Kingdom formalized the constitution of the Sterling bloc. In the monetary declaration of the British Empire it was stated that the United Kingdom aimed to pursue exchange rate stability over a wider area than the British Empire, ideally through the re-establishment of the international Gold Standard (Eichengreen (1992)). Similarly, on the eve of the devaluation of the French franc (1936), the original French proposal to the United States and the United Kingdom foresaw a return to the Gold Standard after the crisis. Devaluation (coordinated so as to avoid retaliations) was therefore deemed to be temporary. Furthermore, even after devaluation, many currencies kept a nominal anchoring to Gold, the dollar most notably. Finally, it is worth noticing that after World War II, countries did not immediately opt for floating exchange rates. On the contrary, they established the Bretton Woods system, which is a gold-exchange-standard system centering on the convertibility of the U.S. dollar into gold. One may infer from this development that the monetary shocks on the 1930s were largely perceived as temporary and overall harmful.

4 Numerical Analysis

4.1 The Rest of the World

Before getting to the numerical analysis, we need to specify the empirical counterpart to the country labelled the 'Rest of the World' in our model. For

Country	Weight
Canada	0.052
France	0.205
Germany	0.301
Italy	0.145
United Kingdom	0.297

Table 1: Average on 1920-1939. Source: Maddison (2011)

consistency, we restrict ourselves to the countries that had already returned to the Gold Standard by 1929. This includes all the major trading partners of the United States, excluding Japan. We have chosen a GDP-weighted average of Canada, France, Italy, Germany and the United Kingdom, the countries considered also by Crucini and Kahn (2003). The weights are reported in Table 1. Together, those countries amounted to 56% of U.S. exports and to 31% of U.S. imports (Crucini and Kahn (2003)).[13] Together, they were quite similar to the United States: they amounted to 116% of U.S. GDP (in PPP) and to 166% of the U.S. population (Maddison (2011)). On top of that, they are made up of representatives of both the 'Gold Bloc' and the 'Sterling Bloc', so we can be sure not to have introduced any arbitrary bias linked to monetary regimes.

4.2 Calibration

The model is calibrated on yearly data, assuming that the economy was in steady state in 1929. The value of some parameters can be measured directly from the data, but for others, like ζ, ζ^*, χ, χ^* together with ω and ω^* we need to calibrate them to fit a set of aggregate ratios in both countries. Table 2 shows the chosen value for each parameter and the target variable for calibrating it.

Let us start our description by the calibration of the household-side parameters. The discount factor is set to 0.979 in both countries to ensure that annual real interest rates r and r^* are equal to 4% in the deterministic steady state, the value suggested by Prescott (1986) for the United States.

The preferences in Equation (7) are characterized by scaling parameters ζ and χ for the United States (and ζ^* and χ^* for the Rest of the World) that indicate households' relative preference for leisure and liquidity, respec-

[13]Notice that the chosen countries together represented 77% of U.S. imports from the subsample of the countries that were back to the Gold Standard by 1929.

tively. We choose ζ and ζ^* so that hours worked are one third of total available time in the steady state. The resulting values are $\zeta = 1.973$ and $\zeta^* = 2.036$. The parameters χ and χ^* are set to 0.015 and 0.026 in order to target the 1929 money-over-GDP ratio (M/pY and M^*/p^*Y^* respectively). This was 0.253 in the United States and 0.435 in the Rest of the World.[14] The elasticity of substitution between domestic and foreign goods, ϕ and ϕ^*, is set to 1 in each economy, in line with standard macroeconomic estimates of ϕ (see for instance Backus et al. (1994) and Corsetti et al. (2008)).[15] The weight of consumption in domestic goods ω (ω^*) in the United States (Rest of the World) is computed so that the home goods share in consumption, α_C (α_C^*), targets the value found in the data, 93.8% (75.1%).[16] Given the calibrated value for ϕ and ϕ^*, ω and ω^* are fixed to 0.938 and 0.249 respectively.

The weight of habit persistence for the United States, ξ, is fixed to 0.63, as in Christiano et al. (2003). We assume the same value for ξ^*.

We now turn to the calibration of production-side parameters. For the United States, the δ, α and γ parameters are fixed as in Cole and Ohanian (1999): the labor share in production, $1 - \alpha$, has a standard value of 2/3, the depreciation rate, δ, is chosen to be 0.10 and the deterministic growth rate is 0.02 implying that $\gamma = 1.02$. This value is used to detrend all U.S. macroeconomic variables, excluding hours worked. In the RW economy, we assume that physical capital depreciates at the same rate of $\delta^* = 0.10$ and we let per capita variables grow by the factor $\gamma^* = 1.02$, which again is used to detrend the data for the Rest of the World. The RW share of labor income in output, $1 - \alpha^*$, is the GDP weighted average of labor share in Canada (0.70), France (0.66), Germany (0.75), Italy (0.55) and the United

[14]The money stock M refers to M1, which is defined as currency and notes in circulation plus commercial bank deposits. The sources are Friedman and Schwartz (1963) for the United States, Amaral and MacGee (2002) for Canada, Beaudry and Portier (2002) for France, Ritschl (2002) for Germany, Fratianni and Spinelli (2005) for Italy and Cole and Ohanian (2002) for the UK.

[15]Results are robust to values of $\phi = \phi^* \in (0.5, 1.3)$.

[16]To obtain $\alpha_C = 0.938$ and $\alpha_C^* = 0.751$, we proceed as follows. For each country α_C is computed as the ratio of the share of imports in GDP to the share of consumption in GDP (both evaluated in 1929). Notice that this calculation implicitly assumes that, in the model as in the data, all imports are made up of consumption goods only. According to the League of Nations international trade database, the share of imports of capital goods in total imports in 1935 (no data were available for 1929) amounts to only 1% in the United States (for France and the United Kingdom the respective values are 4.9% and 2.5%). Given these numbers, our assumption is unlikely to affect our results in a quantitatively important way. Once all individual α_C are obtained, α_C^* is computed as the GDP weighted average of home goods share in consumption across Canada, France, Germany, Italy and UK.

Parameter	Value	Target
n	1.656	RW population / U.S. population
α	1/3	U.S. labor income share 2/3
α^*	0.315	RW labor income share 0.685
β	0.979	U.S. real interest rate $r = 4\%$
β^*	0.979	RW real interest rate $r^* = 4\%$
ϕ	1	Chari et al. (2002)
ϕ^*	1	Chari et al. (2002)
ω	0.938	Share of the domestic good in U.S. consumption $\alpha_c = 0.938$
ω^*	0.249	Share of the domestic good in RW consumption $\alpha_c^* = 0.751$
ζ	1.973	Share of U.S. hours worked is 1/3 of time endowment
ζ^*	2.036	Share of RW hours worked is 1/3 of time endowment
χ	0.015	$M/pY = 0.253$
χ^*	0.026	$M^*/p^*Y^* = 0.435$
$\gamma = \gamma^*$	1.020	U.S. secular growth
$\delta = \delta^*$	0.1	Cole and Ohanian (1999)
ρ	0.848	AR(1) on detrended TFP
ρ^*	0.892	AR(1) on detrended TFP
κ	0.583	AR(1) on detrended nominal wage
κ^*	0.734	AR(1) on detrended nominal wage
η	0.4	U.S. gold backing ratio
η^*	0.511	RW gold backing ratio
ρ_g	0.536	AR(1) on data on p_t^g
ρ_{g^*}	0.612	AR(1) on data on p_t^{g*}
$\xi = \xi^*$	0.63	Christiano et. al (2003)
ψ	2.95	$\sigma_I/\sigma_Y = 2.27$
ψ^*	0.70	$\sigma_{I^*}/\sigma_{Y^*} = 2.86$

Table 2: Calibration of the Baseline Model

Kingdom (0.70). Such values give an aggregate labor income share of $1 - \alpha^* = 0.685$.[17]

As is standard in the literature (Uribe and Schmitt-Grohé (2017)), the capital adjustment costs are calibrated so that the model matches the standard deviation of investment relative to output in the 1929-1939 period for both countries.

The persistence of the process of U.S. technology, ρ, is estimated by regressing the logarithm of the detrended TFP s_t as an AR(1) process over the period 1929-1938. Undetrended TFP A_t is extracted from the empirical Solow residual defined as output over inputs, where the different inputs are weighted by their factor shares. Then detrended TFP s_t is obtained by using the formula $s_t = A_t/(\gamma^{t-t_0})$ where $t_0 = 1929$. The resulting point estimate is $\rho = 0.848$ in the United States. The same procedure was followed for obtaining the technology persistence in the RW, this gives $\rho^* = 0.892$.

[17] The sources for these countries' labor share are Amaral and MacGee (2002) for Canada, Beaudry and Portier (2002) for France, Perri and Quadrini (2002) for Italy, Fisher and Hornstein (2002) for Germany and Cole and Ohanian (2002) for the UK.

Turning to the labor market, the degrees of nominal wage rigidity κ and κ^* are obtained by running AR(1) processes with a drift on detrended nominal wages over the period 1929-1939 for the United States and 1929-1938 for the Rest of the World. This corresponds to Equation (18), and yields the following estimates: $\kappa = 0.583$ and $\kappa^* = 0.734$. Concerning the monetary variables, the backing ratio in the United States is set to 0.40, a value consistent with the legal reserve requirement (i.e. liabilities against which gold must be held) in 1929, see Bernanke (1995). For the RW, the cross-country average of backing ratios in Canada, France, Germany, Italy and UK gives $\eta^* = 0.511$.[18]

For the U.S. price of gold, p^g, the autoregressive coefficient $\rho_g = 0.536$ is obtained by running an AR(1) process with a drift and a trend on the actual data from Bernanke (1995) over the period 1929-1939. The constant term in the regression is restricted to be compatible with equation (24a).

In order to retrieve an empirical value for the RW price of gold, p^{g*}, we proceed as follows. First, we construct a series for the nominal effective exchange rate between the U.S. dollar and the RW currency, e_t. This is obtained as the GDP-weighted average of the nominal bilateral exchange rate of the United States vis-a-vis Canada, France, Germany, Italy and the UK using data from League of Nations (1939). Then, we use this series together with data on p^g to get a data-based series for p^{g*} in accordance with Equation (12). The autoregressive coefficient $\rho_{g^*} = 0.612$ is obtained by running an AR(1) process with a drift and a trend on this data-based series over the period 1929-1939. The constant term in the regression is restricted to be compatible with equation (24b).

4.3 Impulse response functions

Before assessing the quantitative performance of the model during the Great Depression, we first illustrate its working by computing the impulse response functions (IRF hereafter) for the main variables after real and monetary shocks. For the sake of brevity, we focus on the IRF after two

[18]The backing ratios in France, Italy and Germany correspond to the official legal reserve requirements and are 0.35, 0.40 and 0.40 in 1929 respectively (source: Federal Reserve Board (1930)). No information for Canada is provided by Federal Reserve Board (1930), we thus assign this country the value of 0.383 which corresponds to the mean value of η in France, Italy and Germany. In the UK, only issues in excess of £ 260 million had to be fully backed by gold. In order to obtain a value of the backing ratio that applies to the entire monetary base, η in the UK is computed according to: $\eta = 0.383 \times 260 + 1.00 \times$ (Monetary base in excess of £ 260 million) where we apply again the mean value of η in France, Italy and Germany to the monetary base below the official threshold of £ 260 million.

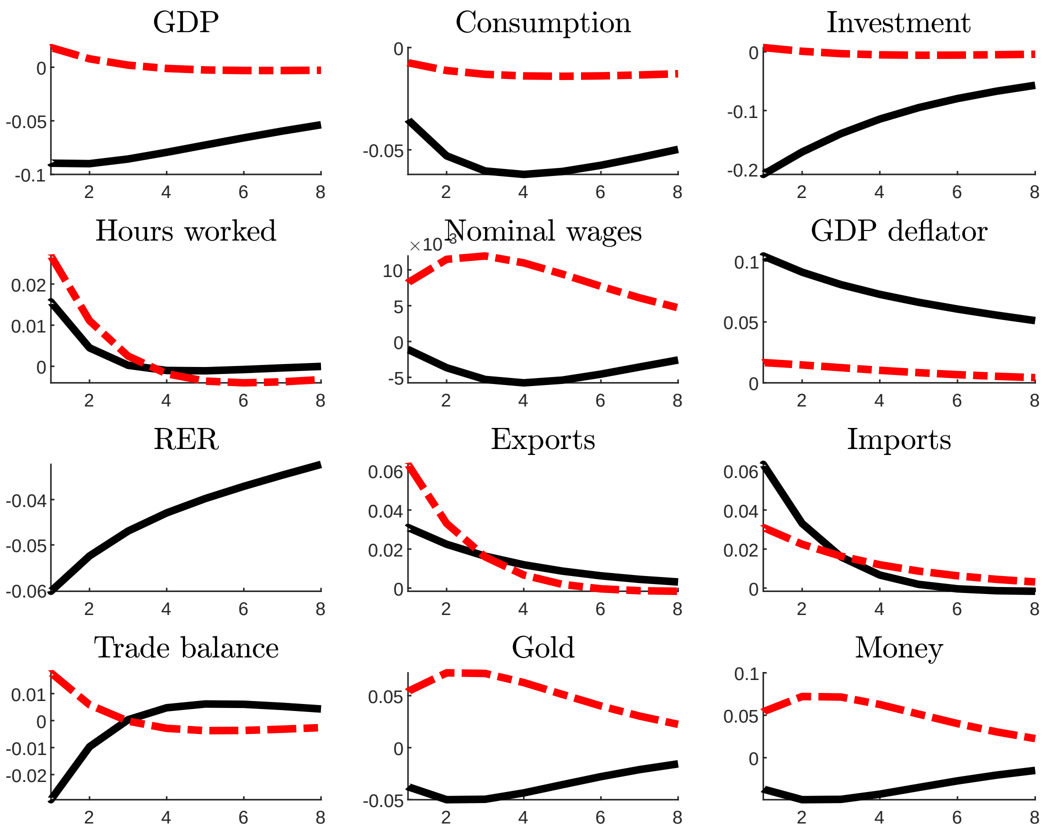

Figure 2: Impulse Response Function to a negative U.S. TFP shock. United States: solid black line. Rest of the World: dashed red line. All variables are in real, per capita terms, except Money, Trade balance, Exports, Imports and Gold that are in nominal per capita terms.

negative shocks in the United States: a decrease in the U.S. TFP, (i.e. a decrease in ν_t), and a rise in the U.S. gold-backing ratio (i.e. an increase in λ_t).[19]

Figure 2 and Figure 3 show the IRF conditional on the shock on ν and λ, respectively. In each panel, the solid black line displays the response in the U.S. economy whilst the dashed red line shows the IRF in the Rest of the World.

The size of the (temporary) shock on ν_t is calibrated so that the U.S. TFP decreases by 1% from its steady state level. The fall of productivity in the United States produces a negative wealth effect which encourages U.S. agents to decrease consumption expenditure and supply more labor.

[19]The same logic underpins the behavior of the model when hit by the other shocks considered in this article. IRF are available upon request.

At the same time, the lower TFP reduces labor demand. The combined effect of a higher labor supply and a lower labor demand leads to a fall in the real wage (also due to the presence of nominal wage rigidity). The labor-supply effect dominates, so that hours worked rise on impact. The negative TFP shock reduces the marginal productivity of capital and hence investment. This, coupled with the decrease in consumption entails an output drop. In turn, the fall in productivity and output implies higher prices in the United States, causing the U.S. real exchange rate ($e(p^c)^*/p^c$) to decrease (appreciation of the real exchange rate). The higher relative price, p/p^*, induces households to substitute away from the domestic to the foreign good. The rise in nominal imports outweighs that in the value of exports, turning the trade balance into a deficit along the adjustment path. Accordingly, through the Gold Standard rule (11a), the U.S. economy experiences a gold outflow, which in turn reduces the monetary base.[20] By the same token, the surplus of trade balance in the Rest of the World implies an inflow of gold. The subsequent increase in money supply raises the price level in the Rest of the World. However, this increase is smaller on impact than the increase of p in the United States, which explains the overall appreciation of the U.S. real exchange rate. The surplus of the trade balance boosts aggregate demand in the Rest of the World, thereby slightly increasing real GDP and hours worked.

Concerning the shock on the U.S. gold-backing ratio, λ_t, this is calibrated so as to induce a 1% increase from its steady state level. This reduces money supply on impact, for it increases the gold content of the U.S. dollar. This in turn triggers an increase in the value of money and hence a fall in the price level p. Due to the presence of nominal wage rigidities, the real wage goes up, while hours worked fall. As a result, output declines. As GDP falls below trend, imports decline as well. This, coupled with the depreciation (increase) of the real exchange rate, results in a surplus of the trade balance. An inflow of gold ensues. The corresponding gold outflow from the Rest of the World implies a decrease in money supply there and, consequently, a fall in the price level p^*. Turning now to the real effects, the deterioration of the trade balance in the Rest of the World depresses aggregate demand so that real output and hours worked decline. Notice that while the effects of a shock on λ look overall quantitatively tiny, this is mostly due to the i.i.d. nature of shocks on λ in our model, and on the small value of the shock chosen for this exer-

[20] In our model, a negative TFP shock implies an increase in the U.S. price level. However, this is moderated by the deflationary pressures due to the reduction in the U.S. money supply induced by the outflow of gold. Therefore, when the Gold Standard mechanism is operational, the price level does increase, but by a smaller amount.

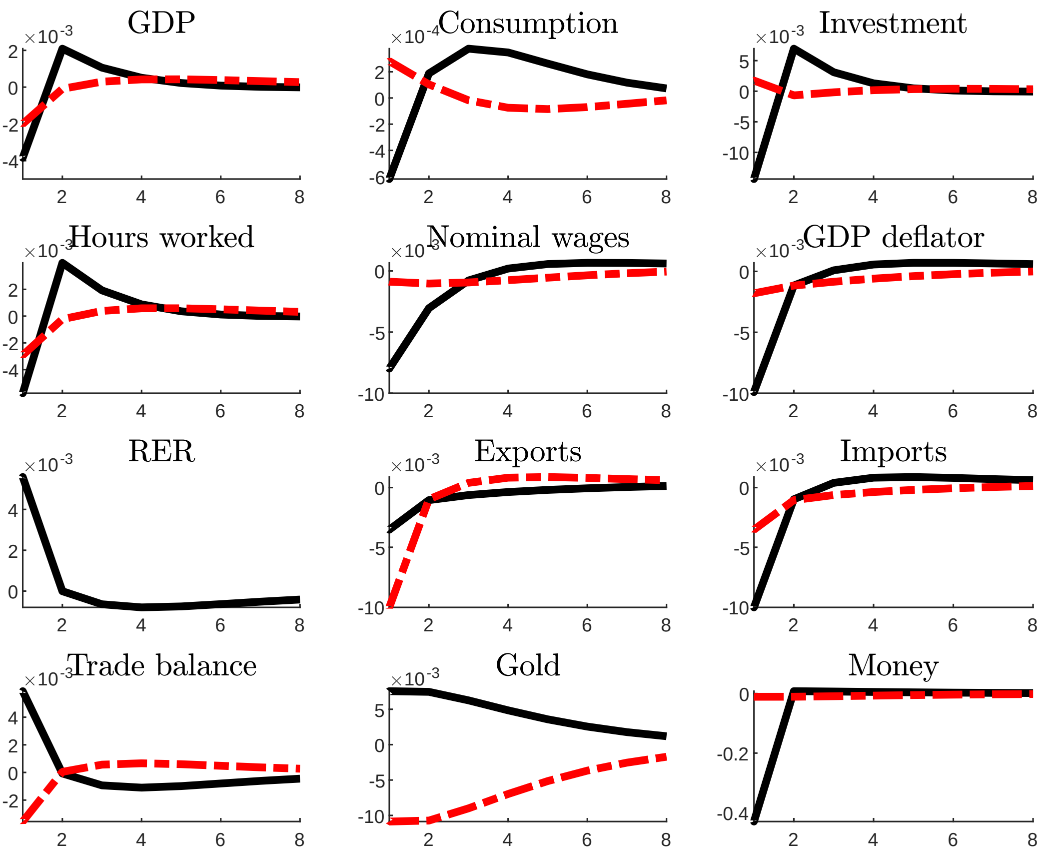

Figure 3: Impulse Response Function to a positive U.S. gold-backing ratio shock. United States: solid black line. Rest of the World: dashed red line. All variables are in real, per capita terms, except Money, Trade balance, Exports, Imports and Gold that are in nominal per capita terms.

cise. Actually, as we shall see in the next section, the measured value of λ for the United States has changed significantly, making it an important contributor to the Great Depression.

With the knowledge of the mechanisms underpinning the working of the model, we now turn to its quantitative relevance in the context of the Great Depression. To do so, in the next sections we shall simulate the calibrated model and compare its behavior with the actual data.

4.4 Simulations

The model period is one year. All variables are assumed to be at their steady state level in 1929. All shocks are temporary, i.e., we assume that the economy will eventually fall back to the initial steady state. Consistently

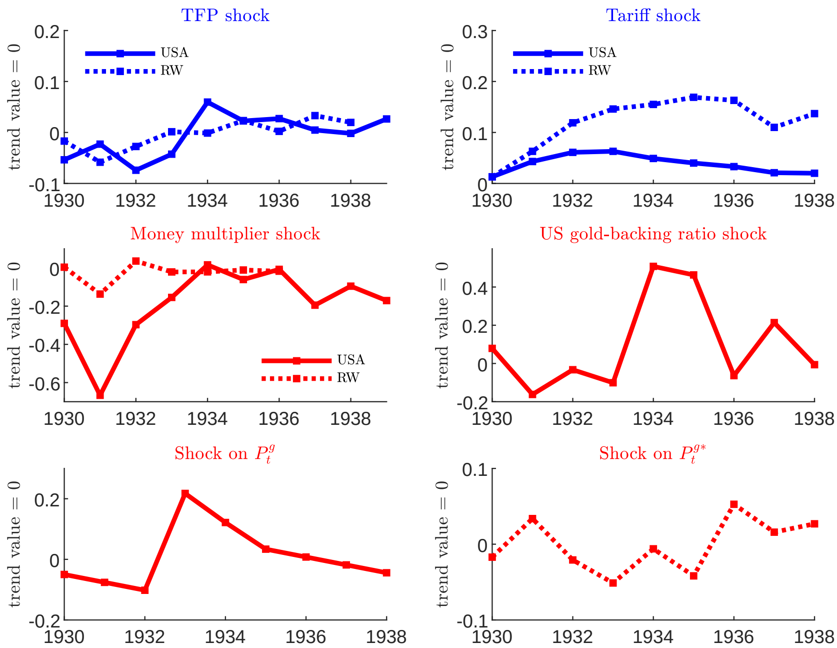

Figure 4: Shocks used in the simulations

with the model, we assume perfect foresight of the shock starting at 1929.[21]

Figure 4 shows the pattern of the shocks. TFP shocks (ν and ν^*) were negative in both countries until 1932, becoming positive after 1934. Tariffs increased in both countries, more markedly so in the Rest of the World. In accordance with the thesis of Eichengreen and Irwin (2010), tariffs in the United States started to decline after 1933, the year of the devaluation of the dollar.

Shocks to the U.S. money multiplier were negative throughout the decade, particularly from 1930 to 1932, and from 1936 to 1938. This suggests that banking problems were important, a finding consistent with Friedman and Schwartz (1963). On the other hand, the Fed acted in an expansionary way from 1930 to 1933 on the exchange market, accepting lower backing ratios than normal. This pattern reverted after the dollar devaluation, with the Fed seemingly engaging in some form of sterilization policy. Shocks to the money multiplier in the Rest of the World were only slightly negative between 1930 and 1931, staying roughly constant thereafter.[22]

The shocks on the price of gold in the United States induce a slight

[21] See Footnote 9 for a discussion of this assumption.

[22] The shock ends in 1936, due to the lack of reliable data for France and the United Kingdom.

appreciation of the dollar with respect to gold in the early 1930s, a sudden depreciation in 1933, followed by a return to the initial value by the end of the decade. The RW currency depreciates against gold in 1931 and from 1936 onwards, whereas it appreciates slightly in the other years. Overall, the calibrated shocks on the price of gold are compatible with the actual changes in the exchange rate policy implemented by the countries considered in our sample, which are reported in Table 3. In particular, the shocks are good at capturing the 1931 devaluations of sterling and the Canadian dollar, the 1933 devaluation of the American dollar and the 1936 devaluations of the French franc and Italian lira.

Country	Suspension of GS	Exchange controls	Devaluation
Canada	Oct. 1931	–	Sept. 1931
France	–	–	Oct. 1936
Germany	–	Jul. 1931	–
Italy	–	May 1934	Oct. 1936
United Kingdom	Sep. 1931	–	Sep. 1931
United States	March 1933	March 1933	April 1933

Table 3: Exchange rate policy. Source: Bernanke and James (1991) reprinted in Bernanke (2000)

We have run three different simulations, one with real shocks only (shocks on ν, ν^*, τ, τ^*), one with monetary shocks only (shocks on λ, μ, μ^*, p^g, p^{g*}), and one with all shocks confounded.

Main ratios (% of GDP), Data vs Model, 1929

	United States		Rest of the World	
	Data	Model	Data	Model
Consumption	0.685	0.718	0.776	0.734
Investment	0.178	0.282	0.156	0.266
Trade balance	0.007	0.000	−0.013	0.000
Exports	0.050	0.045	0.180	0.183
Imports	0.043	0.045	0.193	0.183
Gold	0.038	0.038	0.048	0.109

Table 4: Model fit: steady state compared with actual data in 1929.

We judge the data mimicking ability of the model along several dimensions. First, in Table 4, we compare the steady state of the model with the data in 1929. We find that the model fit is relatively good, with the exception of the Gold-to-GDP ratio in the Rest of the World.[23]

[23]Notice that the model overestimates the ratio of investment to GDP, most likely

(a) Correlation with real GDP, United States

Variable	Data	Real shocks	Nominal shocks	All shocks
Consumption	+0.98***	+0.93***	+0.49	+0.86***
Investment	+0.97***	+0.97***	+0.88***	+0.96***
Hours worked	+0.98***	+0.22	+0.99***	+0.43
Real wages	−0.40	+1.00***	−0.89***	+0.71**
GDP deflator	+0.95***	−0.96***	+0.25	−0.13

(b) Correlation with real GDP, Rest of the World

Variable	Data	Real shocks	Nominal shocks	All shocks
Consumption	+0.66**	+0.87***	+0.27	+0.75***
Investment	+0.86***	+0.96***	+0.51	+0.77***
Hours worked	+0.96***	+0.94***	+0.98***	+0.91***
Real wages	+0.22	+0.95***	−0.77***	+0.14
GDP deflator	+0.83***	−0.91***	+0.28	−0.02

Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 5: Correlation of selected aggregate variables with real GDP: 1929-1938, (a) the United States, (b) the Rest of the World. Comparison between the data, the model with real shocks only, the model with nominal shocks only and the model with all shocks confounded.

Second, in Table 5 - panel (a), we report the contemporaneous cross-correlation with GDP of several aggregate variables in the United States, for the period 1929-1938. We do the same for the Rest of the World in Table 5 - panel (b). For both the United States and the Rest of the World, results show that the model economy simulated with the whole set of shocks matches the data reasonably well. In both countries, the presence of nominal shocks linked to the Gold Standard improves on the model with only real shocks on several dimensions. Nominal shocks i) mitigate the negative correlation between the price level and GDP, ii) reduce the excessive co-movement in real wages and iii) increase the co-movement in hours worked.

As a third quantitative test, in Table 6 we study the synchronization of the Great Depression between the United States and the Rest of the World, by looking at the co-movement of variables across the two countries. Results from the model with all shocks show a high degree of synchronization, in accordance with both the historical narrative and the data. In this case, nominal shocks linked to the Gold Standard tend instead to reduce

because of the absence of public expenditures. Also, we have imposed equilibrium of the trade balance in the steady state, where in the data there was a small surplus (deficit) in the United States (Rest of the World) in 1929.

the cross-country correlation, that is they induce some asymmetry in the behavior of United States and the Rest of the World, except for inflation, whose cross-country correlation is instead fostered by the nominal shocks.

Correlations United States - Rest of the World

Variable	Data	Real shocks	Nominal shocks	All shocks
GDP	$+0.94^{***}$	$+0.83^{***}$	$+0.46$	$+0.84^{***}$
Consumption	$+0.92^{***}$	$+0.94^{***}$	$+0.45$	$+0.90^{***}$
Investment	$+0.80^{***}$	$+0.82^{***}$	$+0.74^{***}$	$+0.81^{***}$
Hours worked	$+0.85^{***}$	$+0.63^{**}$	$+0.56^{*}$	$+0.45$
Real wages	$+0.31$	$+0.91^{***}$	-0.44	$+0.32$
GDP deflator	$+0.84^{***}$	$+0.61^{*}$	$+0.80^{***}$	$+0.74^{***}$

Significance levels: *** p<0.01, ** p<0.05, * p<0.1

Table 6: Correlation of selected aggregate variables between the United States and the Rest of the World, 1929-1938. Comparison between the data, the model with real shocks only, the model with nominal shocks only and the model with all shocks confounded.

As a fourth metric to evaluate the quantitative fit of the model, we study the standard deviation of several aggregate variables relative to GDP in both countries. Results are reported in Table 7, panel (a) and (b) for the United States and the Rest of the World, respectively. In the data, consumption, hours worked, real wages are less volatile than output, investment more. Monetary prices are less volatile than output in the United States and as volatile as output in the Rest of the World. The model with all shocks reproduces these key features of the data, with the exception of real wages in United States, whose standard deviation relative to GDP is too high, and prices in the Rest of the World, whose standard deviation with respect to GDP is instead too low.

Finally, we may want to be more demanding, check the pattern of the model on a year-by-year basis, and compare it with the data. In Figure 5, we report the results of our simulations for output, consumption, investment and hours worked, in both the United States and the Rest of the World. In Figure 6, we do the same for nominal wages, price indices and the nominal exchange rate. The solid black line depicts the behavior of the model economy when hit by all the shocks, whereas the dotted black line depicts the behavior of the detrended data. The blue and the red line depict the behavior of the model economy when hit by the real-only or the monetary-only shocks, respectively. Figures 5 and 6 show that the model does a pretty good job of reproducing the qualitative and quantitative behavior of the data, particularly for the Rest of World.

(a) Standard deviation relative to real GDP, United States

Variable	Data	Real shocks	Nominal shocks	All shocks
Consumption	0.85	0.59	0.44	0.67
Investment	2.27	2.23	2.35	2.27
Hours worked	0.87	0.08	1.58	0.68
Real wages	0.46	0.98	0.91	1.02
GDP deflator	0.62	1.12	2.03	0.80

(b) Standard deviation relative to real GDP, Rest of the World

Variable	Data	Real shocks	Nominal shocks	All shocks
Consumption	0.89	0.44	0.29	0.28
Investment	2.85	2.95	3.33	2.85
Hours worked	0.74	0.43	1.40	0.89
Real wages	0.28	0.83	1.03	0.58
GDP deflator	1.08	0.76	1.07	0.35

Table 7: Standard deviation of 'Variable' relative to GDP: 1929-1938, the United States (a), the Rest of the World (b). Comparison between the data, the model with real shocks only, the model with nominal shocks only and the model with all shocks confounded.

In the United States, the model with all the shocks can reproduce 45% of the drop in output between 1929 and 1932, and 15% of the drop in output between 1929 and 1936. The numbers are 79% and 67% for the Rest of the World. The simulated pattern of GDP and its components is qualitatively in line with the data, with the possible exception of employment in the United States. A striking observation is that the model reproduces the dynamics of the real variables in the Rest of the World quite well over the entire 1929-1938 period. Looking at the results from the simulations with different subsets of shocks, it turns out that in the United States, monetary shocks linked to the Gold Standard contribute to explaining the onset of the Great Depression and allow the model to account well qualitatively for the behavior of nominal variables. However, monetary shocks seem to have contributed little to the long duration of the Great Depression. Given the explanatory power of real shocks, which is in line with the DGE literature on the Depression,[24] this suggests that additional shocks or stronger propagation mechanisms are needed to account for the protracted character of the Great Depression in the United States, as argued for instance by Cole and Ohanian (1999), Cole and Ohanian (2004)

[24]In our model, real shocks can account for about 38% of the drop in output between 1929 and 1933 in United States. In Cole and Ohanian (1999), TFP shocks can account for about 40% of the drop in output between 1929 and 1933.

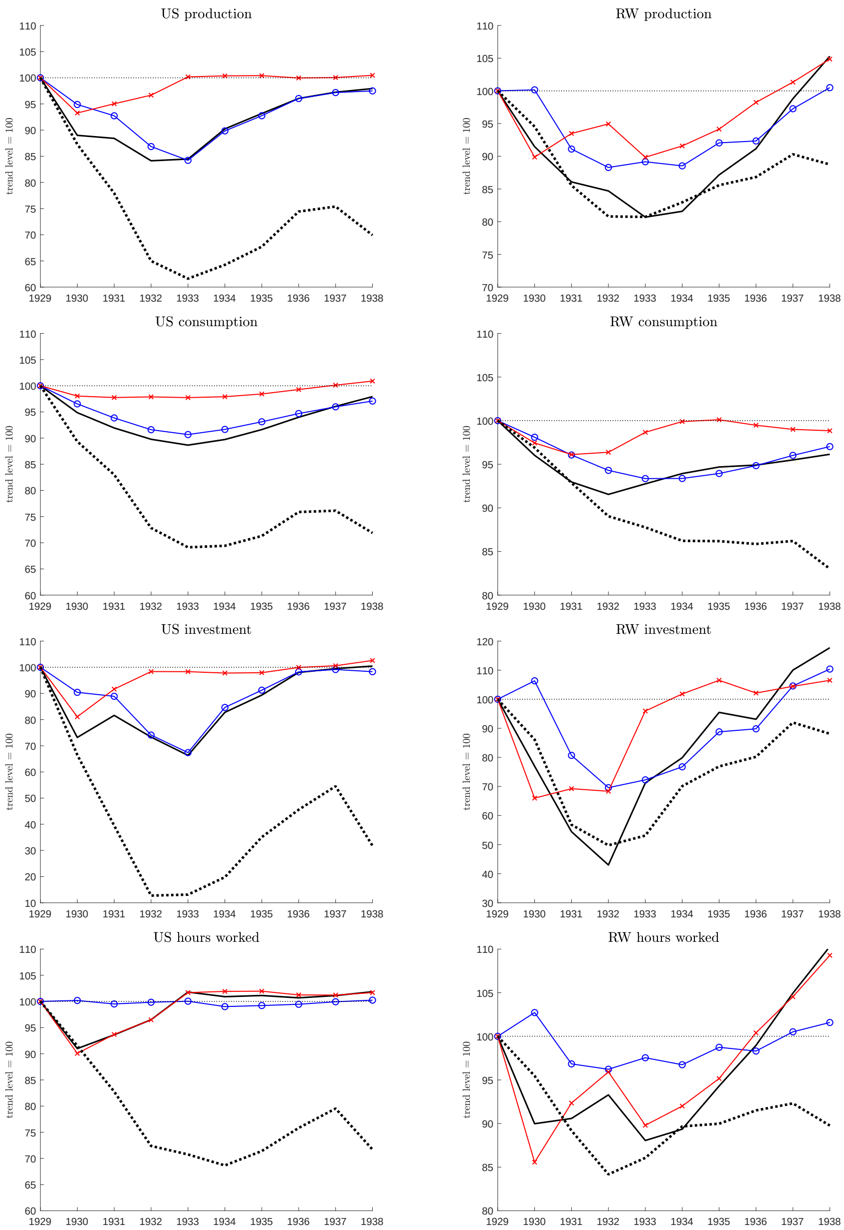

Figure 5: Simulations, real variables. Black-dotted line: data. Blue line (o): real shocks. Red line (x): monetary shocks. Black line: all shocks.

and Prescott (1999). For the Rest of the World, the role of monetary shocks linked to the Gold Standard is significantly more important than in the United States. Monetary shocks linked to the Gold Standard explain much of the onset of the Great Depression in the Rest of the World, and also have a significant impact on its long duration. Moreover, like for the United

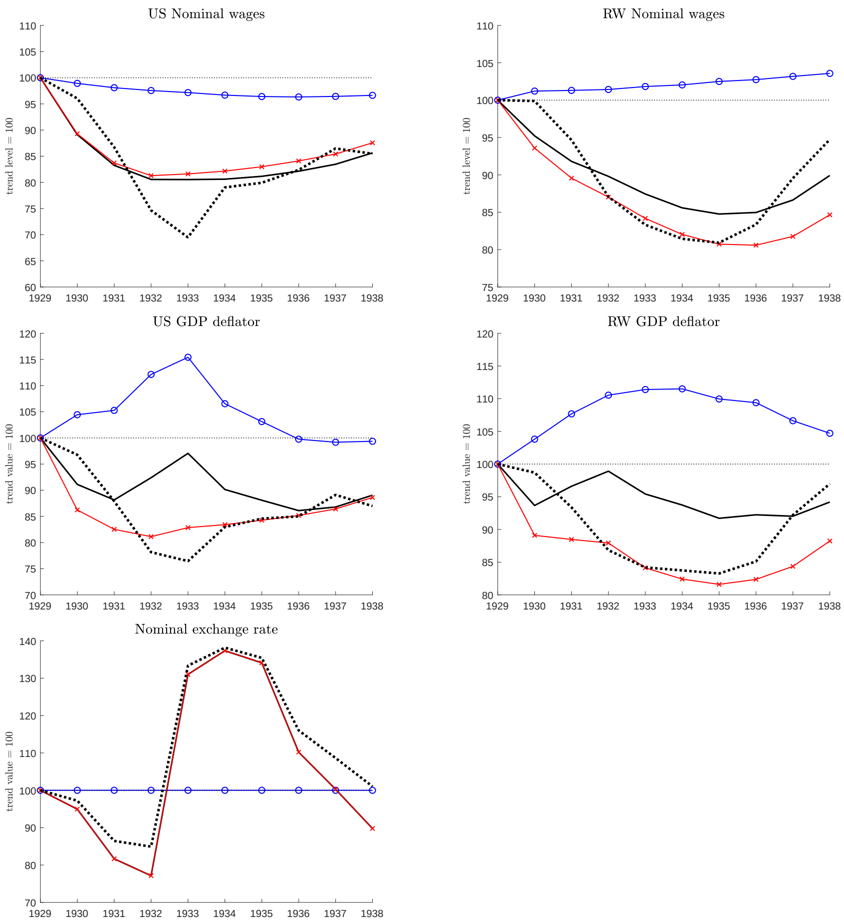

Figure 6: Simulations, nominal variables. Black-dotted line: data. Blue line (o): real shocks. Red line (x): monetary shocks. Black line: all shocks.

States, the presence of monetary shocks allows the model to account well in qualitative terms for the behavior of nominal variables. Contrary to what happens in the simulations for the United States, real shocks tend to increase output and employment in the Rest of the World in 1930. Their contribution turns negative from 1931 onwards, however. Finally, the model captures the dynamics of the nominal exchange rate fairly well throughout the considered period.

In conclusion, the simulations show that our two-country DGE model with a Gold Standard monetary regime has the right qualitative behavior and can account for a significant portion of the observed pattern of several aggregate variables during the Great Depression of the 1930s. Notice that these results have been obtained with a model that is still quite parsimonious with respect to the medium scale DSGE model à la

Smets and Wouters (2003). In particular, we have introduced only those shocks that are deemed to be relevant by the historical analysis and can be disciplined by the theory and the data.

4.5 Counterfactual analysis

In the Sections above, we have studied the qualitative and quantitative behavior of the model, both *per se* and in the context of the Great Depression. We have seen that our two-country model with a Gold Standard monetary regime behaves in accordance with the available evidence along most dimensions. Moreover, its data mimicking ability is relatively good, especially for the Rest of the World, and comparable to the existing literature on DSGE models of the Great Depression in the case of the United States.

We are now going to use the model to answer two additional research questions:

1. Was the Gold Standard a powerful transmission mechanism of the Great Depression from the United States to the Rest of the World, as claimed by a significant part of the literature?

2. Was the series of uncoordinated devaluations through the 1930s the proxy cause of the way out of the Depression?

4.5.1 The Gold Standard as transmission mechanism

In order to assess the quantitative relevance of the Gold Standard as a transmission mechanism, we start by running a counterfactual experiment in which the model economy is hit only by shocks to the TFP in the United States. The counterfactual hypothesis is that the Great Depression was a real phenomenon, originated in the United States and transmitted to the Rest of the World via the Gold Standard.

Results for both the United States (left panel) and the Rest of the World (right panel) are shown in Figure 7. The dotted blue line represents the evolution of GDP in the simulation with the counterfactual model, whereas the continuous black line represents GDP in the simulation with the benchmark model with all shocks. Overall, the counterfactual and benchmark models have similar patterns as far as the United States are concerned. In particular, the two simulations almost overlap for the 1933-1938 period. For the 1929-1933 drop, they are qualitatively similar, though output drops faster in the benchmark model. These results are broadly in line with the

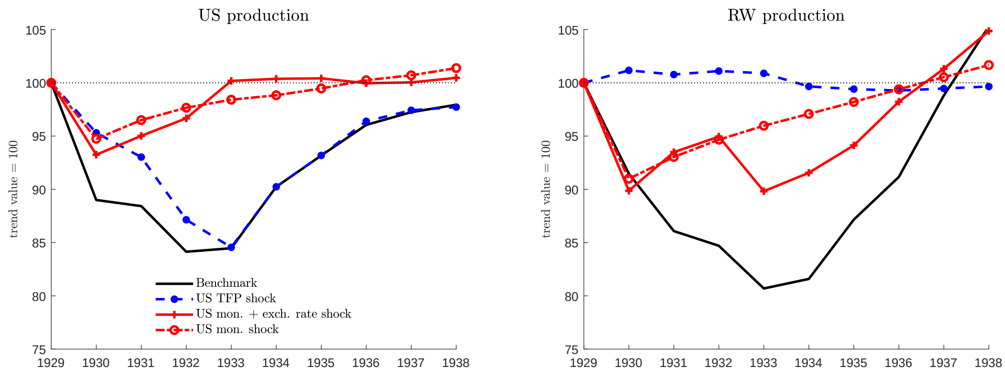

Figure 7: The Gold Standard as transmission mechanism. Black line: benchmark (all shocks). Blue dotted line: U.S. TFP shocks. Red line: U.S. monetary and exchange rate shocks. Red dotted line: U.S. monetary shocks.

closed-economy analysis by Cole and Ohanian (1999), which confirms the importance of TFP shocks in order to account for the Great Depression in the United States. On the contrary, transmission to the Rest of the World is comparatively minor and mostly goes in the opposite direction with respect to the benchmark. Feedback from the Rest of the World to the United States is also quite small. Overall, these results suggest that 1) the Gold Standard was not a powerful transmission mechanism of TFP shocks from the United States to the Rest of the World; and 2) the monetary shocks linked to the Gold Standard must be important to account for the onset of the Great Depression both in the United States and, especially, in the Rest of the World.[25]

To verify this hypothesis, we run a second counterfactual. In this exercise, we shut down all real shocks: the model economy is hit only by monetary shocks in the United States plus shocks to the price of gold in both countries (i.e. active shocks are those on λ, μ, ϑ and ϑ^*). In this case, the counterfactual hypothesis is that the Great Depression was a monetary phenomenon linked to U.S. monetary policy and the Gold Standard. Results from this counterfactual are represented by the continuous red line in Figure 7. The negative effect of monetary shocks on GDP in the United States is important only at beginning of the Depression, and becomes negligible after 1933, the year of the devaluation of the dollar. Henceforth, if

[25]We also run an additional counterfactual with only shocks to tariffs in both the United States and the Rest of the World in order to assess the role of tariffs independently on other shocks. The results of this analysis (available upon request) show that tariffs play only a very minor role in the onset and the long duration of the Great Depression.

anything, monetary shocks actually turn out to have a positive effect on U.S. GDP. On the contrary, the monetary dimension is crucial to account for both the onset, depth and long duration of the Great Depression in the Rest of the World. These results suggest that monetary shocks linked to the Gold Standard were an important factor contributing to the Great Depression, especially outside the United States.

To further disentangle the role of the Gold Standard as a transmission mechanism of the Great Depression from the United States to the Rest of the World, we run a third counterfactual, in which we exclude shocks on the price of gold (i.e. we keep the nominal exchange rate constant – active shocks are those on λ and μ). In this case, the counterfactual hypothesis is that the Great Depression originated from the domestic monetary policy of the United States and was transmitted to the Rest of the World via the Gold Standard.

Results are represented by the dotted red line in Figure 7. For the United States, the pattern is quite similar to the previous counterfactual. For the Rest of the World, instead, there is an important quantitative difference. Without shocks to the exchange rate, the Rest of the World would have still suffered from U.S. domestic monetary policy, but the Depression would have been less severe. This counterfactual suggests that i) domestic U.S. monetary shocks were transmitted to the Rest of the World via the Gold Standard, regardless of shocks to the nominal exchange rate, but ii) the latter were still an important contributing factor to the depth and duration of the Great Depression. Overall, the results discussed above suggest that the Gold Standard was a powerful transmission mechanism of the Depression from the epicenter of the crisis, the United States, to the Rest of the World, thus giving credit to the analysis by Eichengreen (1992), Romer (1993) and Temin (1993), most notably.

4.5.2 Back to gold

So far, we have shown that the monetary shocks linked to the Gold Standard worsened the Depression and favored its transmission from the United States to the Rest of the World.

We now study what would have happened to our model economy if the world had already returned to the 1929 Gold Standard (in terms of both nominal exchange rates and actual gold-backing ratios) in 1933. This allows us to test the narrative by Eichengreen (1992) and Eichengreen and Sachs (1985), who maintained that exiting the Gold Standard was the way out of the Depression, and a possible alternative take, advanced most notably by Kindleberger (1973), according to whom the successive waves of com-

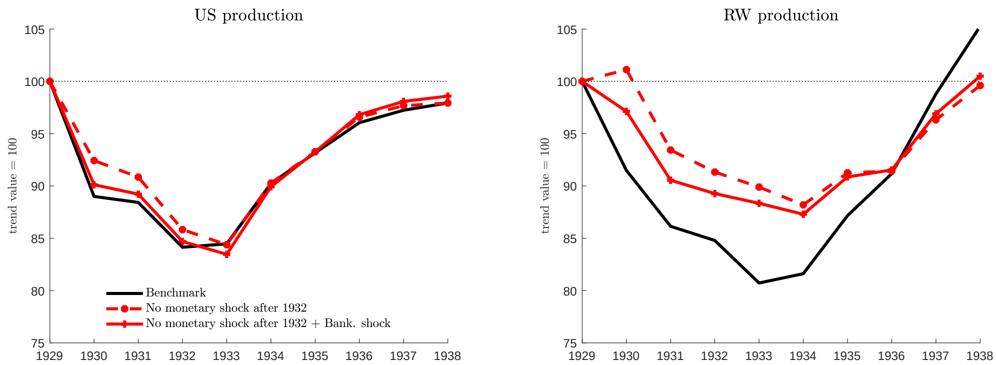

Figure 8: Counterfactual analysis. Black line: benchmark (all shocks). Red dotted line: no monetary shock after 1932. Red continuous line: no monetary shock after 1932 but banking shocks.

petitive devaluations were essentially beggar-thy-neighbor policies that disrupted global stability. In our counterfactual, we shock the model with the full set of real shocks for the whole decade, but with monetary shocks limited to 1930-1932.

Results for both the United States (left panel) and the Rest of the World (right panel) are shown in Figure 8. The dotted red line represents the change in GDP in the simulation with the counterfactual model, whereas the continuous black line represents GDP in the simulation with the benchmark model with all shocks. Results from our counterfactual show that in the model economy, a gradual return to the 1929 Gold Standard with no monetary shock after 1932 would have had only a slight positive effect on GDP in the United States, limited to the early 1930s. On the contrary, it would have had strong expansionary effects with respect to the benchmark (i.e. with respect to the actual monetary shocks) in the case of the Rest of the World, well into 1936. In particular, GDP in the Rest of the World would have been 6.2 points higher each year on average, if both countries had returned to the 1929 Gold Standard by 1933. The continuous red line in Figure 8 shows the results from the same counterfactual exercise, to which we have added the money multiplier shocks after 1932. This means assuming that banking shocks were present throughout the decade, somewhat independently of the monetary regime, which is unlikely. Be that as it may, the results are qualitatively the same as in our first counterfactual, though obviously banking shocks do affect the model negatively both - slightly - in the United States, and - more appreciably - in the Rest of the World.

This counterfactual analysis suggests that exiting the Gold Standard in the way the monetary and exchange rate policies were actually implemented in the 1930s, far from being a key recovery factor from the Depression, actually worsened it. Particularly so for the Rest of the World.

The rationale for this result is twofold. First, the United States did not expand the monetary base as they could have, as suggested also by Bordo et al. (2002). This shows up in our model in high positive values for the gold-backing ratio shock, λ. In other words, the Fed was sterilizing gold inflows throughout the 1930s, and this acted as a contractionary force on both the United States and the Rest of the World. Second, shocks on the price of gold act in the model as a beggar-thy-neighbor policy. A unilateral devaluation in the United States had a positive impact on GDP and other real variables there, but a stronger negative impact on the Rest of the World through the Gold Standard mechanism.

5 Conclusions

In this paper, we have built a two-country, two-good dynamic general equilibrium model to assess whether the Gold Standard was the main contributing factor explaining the Great Depression of the 1930s, as claimed most notably by Eichengreen (1992).

Our analysis suggests that encompassing the international and monetary dimensions of the Great Depression is important to understand what happened in the 1930s, especially outside the United States.

More specifically, we have shown that monetary shocks linked to the Gold Standard do matter to account for the onset of the Great Depression in both the United States and the Rest of the World, particularly for the latter. Furthermore, while they have little to say about the long duration of the Great Depression in the United States, monetary shocks linked to the Gold Standard did contribute significantly to stagnating output in the Rest of the World.

In our simulations, the Gold Standard turns out to be a powerful transmission mechanism of monetary shocks from the United States to the Rest of the World, giving credit to what is known in the literature as the "Gold Standard hypothesis". However, contrary to what is often maintained in part of the literature, our results suggest that the wave of successive nominal exchange rate devaluations coupled with the monetary policy implemented in the United States did not act as a relief. On the contrary, they made the Depression worse, in line with the argument by Kindleberger (1973).

The model we have presented in this article encompasses several dimensions deemed crucial by economic historians, such as international trade, tariffs, exchange rate pegging, nominal wage stickiness and monetary disturbances. However, there are other dimensions that we have overlooked for the sake of tractability. In particular, financial factors and banking crises are modeled in reduced form, through exogenous measured variations in the money multipliers. The story of the interaction between financial factors and monetary policy in a Gold Standard regime is one that still awaits proper modeling in an open-economy DGE framework. Future research on this topic can be expected to shed additional light on the Great Depression.

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