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Overvalued: Swedish Monetary Policy in the 1930s

Alexander Rathke, Tobias Straumann and Ulrich Woitek

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Alexander Rathke[†], Tobias Straumann,[‡] and Ulrich Woitek[§]
University of Zurich

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Abstract

This paper reconsiders the role of monetary policy in Sweden's strong recovery from the Great Depression. The Riksbank in the 1930s is sometimes seen as an example of a central bank that was relatively innovative in terms of the conduct of monetary policy. To consider this analytically, we estimate a small-scale, structural general equilibrium model of a small open economy using Bayesian methods. We find that the model captures the key dynamics of the period surprisingly well. Importantly, our findings suggest that Sweden avoided the worst excesses of the depression by conducting conservative rather than innovative monetary policy. We find that, by keeping the Swedish krona undervalued to replenish foreign reserves, Sweden's exchange rate policy unintentionally contributed to the Swedish growth miracle of the 1930s, avoiding a major slump in 1932 and enabling the country to benefit quickly from the eventual recovery of world demand.

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[†]Corresponding author: Department of Economics, Chair of International Trade and Finance, Zuerichbergstrasse 14, CH-8032 Zurich, Switzerland; alexander.rathke@econ.uzh.ch, phone: +41-(0)44-634-5261, fax +41-(0)44-634-2291.

[‡]Department of Economics, Chair of Economic History, Zuerichbergstrasse 14, CH-8032 Zurich, Switzerland; tobias.straumann@econ.uzh.ch.

[§]Department of Economics, Chair of Economic History, Zuerichbergstrasse 14, CH-8032 Zurich, Switzerland; ulrich.woitek@econ.uzh.ch; CESifo Munich.

1 Introduction

In the period of the Great Depression, Sweden was widely admired for its early and strong recovery from the deepest crisis of the 20th century (Fisher, 1935). In fact, the increase in Swedish industrial production from 1933 to 1939 was higher than elsewhere in Europe. However, despite the widely held admiration of the conduct of Swedish economic policy during this period, there has not since been any explicit econometric testing of the various hypotheses used to account for Sweden's apparently more benign depression experience. In particular, the crucial question Charles Kindleberger posed almost 40 years ago in his classic account of the Great Depression has not yet been formally addressed, namely "... to what extent the recovery represented simple exchange depreciation in excess of that of the pound, plus spillover from the British building and later armament boom" (Kindleberger, 1973, p. 182).

In this paper, we attempt to provide an empirical response to this question by estimating a dynamic stochastic general equilibrium (DSGE) model for a small open economy. Despite its relatively simple structure, this model adequately captures the key dynamics of the factors driving the Swedish economy in the period under analysis. We show that, by keeping the krona undervalued, Swedish exchange rate policy helped Sweden avoid a deep slump in 1932 and enabled it to benefit quickly from the recovery of world demand.

This finding has implications not only for Kindleberger's original question but also for the traditional view of Sweden's monetary policy in the 1930s. Monetary economists have long considered this as a precursor to modern inflation targeting (Svensson, 1995; Bernanke et al., 1999). Our econometric results, backed by narrative evidence, suggest that this assessment actually overvalues the purported ingenuity of the Swedish central bank (Sveriges Riksbank). Archival sources show that the Riksbank was not primarily concerned about price stability but rather about the stability of the exchange rate, believing that a floating exchange rate would actually hamper economic recovery. Therefore, the Riksbank simply adjusted the principles of the existing gold exchange standard to the new conditions following the fall of the

British pound in September 1931 without undertaking a true regime shift. Further, the board minutes reveal that the undervaluation resulted from the desire to replenish foreign exchange reserves in order to arrange the means to fix the currency to the British pound. Therefore, Sweden's exceptional recovery was not a consequence of an innovative monetary policy but rather a mere byproduct of orthodox reserve accumulation by the Riksbank.

The remainder of the paper is structured as follows. Section 2 provides a brief summary of the historical setting and outlines Sweden's exchange rate policy based on the available narrative and statistical evidence. Section 3 explains the model to be used, Section 4 outlines the estimation approach and the empirical findings, and Section 5 concludes.

2 Explaining the Swedish Recovery

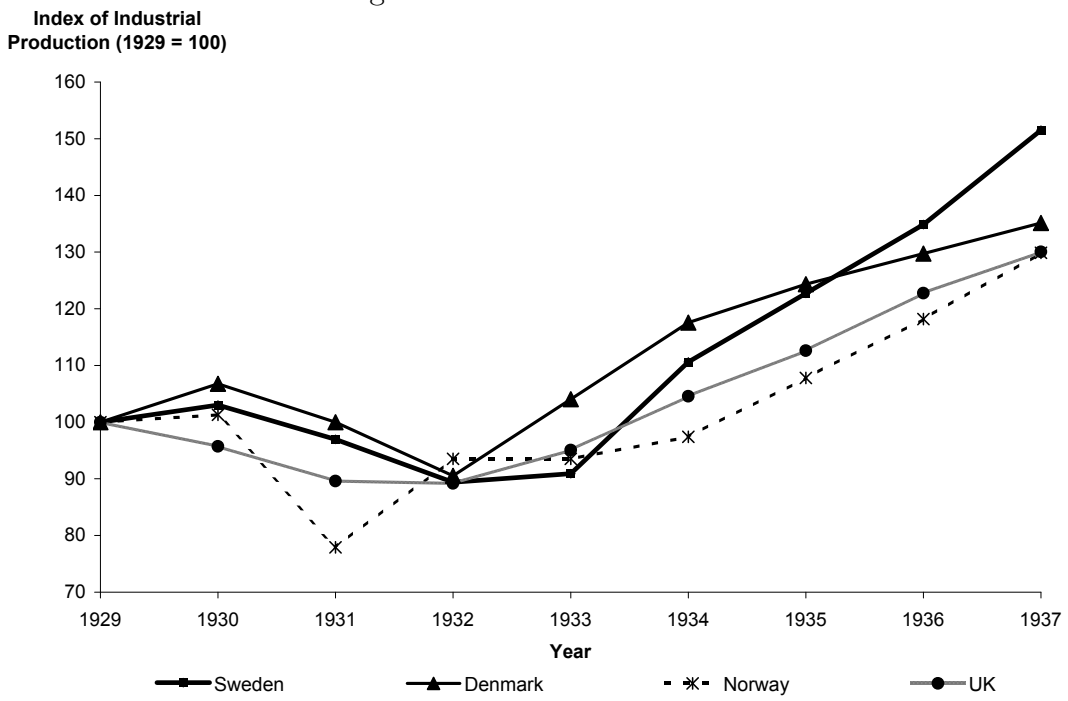
It is well established that economies that abandoned the gold standard at an early stage of the Great Depression enjoyed a faster recovery (Temin, 1996; Eichengreen, 1992). Sweden was among those lucky countries. In late September 1931, a week after the fall of the British pound, the Swedish authorities abandoned the gold standard and let the krona depreciate. Denmark and Norway took similar steps and likewise enjoyed a similarly rapid recovery. By contrast, the countries of the gold bloc (Belgium, France, Italy, Netherlands, Poland, and Switzerland), which maintained the gold standard until 1935–36, suffered from protracted economic depression.

Nonetheless, Sweden not only experienced a shorter crisis but also enjoyed a particularly strong industrial recovery after 1932. In 1937, Sweden's index of industrial production was 152 (1929 = 100) while the comparable indices in Denmark, Norway, and the UK were 135, 130, and 130, respectively (Figure 1). The question is to what extent this growth miracle was because of economic policy. In the following empirical analysis, we focus on the exchange rate policy and the effect of foreign demand, as suggested by Kindleberger. However, the literature has also suggested other explanations, for which Schön (2000) provides a useful survey of the Swedish work. During the postwar decades, the heyday of Keynesian economics, the most

popular explanation highlighted fiscal policy. Supposedly, the Swedish Social Democrats, who came to power in 1932, revived the depressed Swedish economy by pursuing a model countercyclical policy based on the teachings of the younger generation of the Stockholm school (including Gunnar Myrdal and Bertil Ohlin). Actual figures, however, show that the fiscal deficit was too small to account for the recovery. For instance, to achieve the actual increase in real GDP of 2,237 million Swedish krona (SEK) (in 1929 prices) from 1932 to 1936 with the changes in fiscal policy observed in the data (Mitchell, 2003, Tables G5, H2, G6, J1) would have required significantly higher fiscal multipliers (> 10) than can be found in the literature (e.g. Spilimbergo et al., 2009). In addition, as in the other sterling bloc countries, Sweden ran a more or less balanced budget during this period (Almunia et al., 2010, p. 235, Figure 13). Moreover, the size of the government sector was still small during the period under consideration (an average of 11% of GDP). Clearly, the Swedish Social Democrats did not implement a new fiscal regime during this period, and therefore the fiscal policy explanation for Swedish economic recovery is difficult to uphold.

This leaves us with just two other explanations discussed in the literature. The first, as advocated by Jonung (1984) and Fregert and Jonung (2004), focuses on monetary policy. By leaving the gold standard, the Riksbank was able to free itself from the deflationary train set in motion in 1930 and to implement a more expansionary monetary policy. In particular, this newly gained freedom enabled the Riksbank to act as lender of last resort in the aftermath of the Kreuger crash of March 1932 and to avert a major banking crisis. Moreover, the Riksbank adopted a new monetary policy framework, so-called price level targeting, based on the seminal work of the eminent Swedish economist Knut Wicksell.

Figure 1: Industrial Production



Source: Mitchell (2003, Table D1).

The second explanation is offered by Lundberg (1983). He highlights the importance of a weak krona throughout most of the 1930s and investigates why the undervaluation did not cause inflation at an earlier stage of the expansion. His answer is twofold. First, demand elasticity was rather high, i.e. foreign customers of Swedish products reacted strongly to the lowering of prices after the end of the gold standard in 1931. Second, the access to natural resources (wood, iron ore) was relatively cheap as domestic producers provided them.

The question is which was more important for Sweden's recovery, monetary or exchange rate policy. Jonung's claim that leaving the gold standard allowed the Riksbank to save the banking system from collapsing and to pursue a more expansionary policy can hardly be disputed (Bernanke and James, 1991). However, the Riksbank did not contribute to the Swedish growth miracle by adopting a modern monetary policy framework.

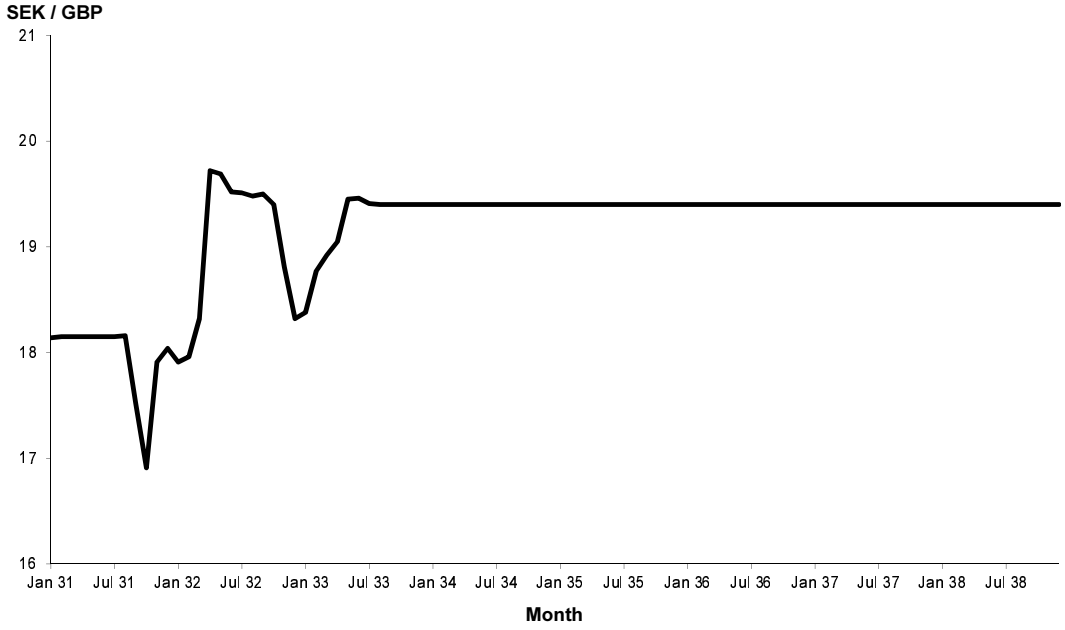
It is true that, after suspending the gold standard in 1931, the Swedish

finance minister made a remarkable official statement in which he announced that monetary policy would from then on be aimed at stabilizing the internal price level. Because of Sweden's subsequent excellent economic performance, the alleged adoption of price-level targeting has since been repeatedly invoked as a new model, with some monetary economists even acknowledging it as a precursor of today's inflation targeting (Svensson, 1995; Bernanke et al., 1999). However, Straumann and Woitek (2009) present evidence, both econometric and narrative, that this positive assessment in fact overestimates the ambitions of the Swedish central bank. Moreover, they argue that there was a huge gap between official declarations and the actual pursuit of policy in that the Riksbank was not primarily concerned about price stability but rather about the stability of the exchange rate, believing that the recovery would be hampered by a floating exchange rate. The Riksbank simply adjusted the principles of the gold exchange standard to the new conditions following the fall of the British pound without making a true regime shift.

At first impression, this conclusion appears to be inconsistent with the volatility of the krona rate vis-à-vis UK pound sterling (GBP), the currency of Sweden's most important trading and financial partner (Figure 2). In the period ranging from the suspension of the gold standard in late September 1931 to the official pegging to sterling in July 1933, the SEK/GBP rate appears to fluctuate relatively freely. A closer look, however, reveals that there were two major attempts to stabilize the krona at the previous parity rate of 18.16 SEK to the pound. In November 1931, shortly after the ending of the gold standard, the Riksbank unsuccessfully attempted to prevent the krona from rising above parity and the exchange rate fell to 19.40 SEK to the pound. In late 1932, the Riksbank again tried to return the krona rate to this level, and again the plan did not materialize. Thus, in the first phase of the depression, the Swedish central bank only seemingly embraced flexible exchange rates. It is then appropriate to assume the same policy orientation held for the entire period from September 1931 to the outbreak of the Second World War.

That the Riksbank gave priority to exchange rate stabilization over price level stabilization is revealed in a number of letters written by Ivar Rooth,

Figure 2: Nominal Exchange Rate SEK/GBP



Source: Sveriges Riksbank, Monthly Exchange Rates for Sweden, 1913–2006 (`www.riksbank.se/templates/Page.aspx?id=27403`)

central bank governor from 1929 to 1948. In late September 1933, he explained to O.M.W. Sprague, professor of economics at Harvard and temporary assistant to the United States Secretary of the Treasury:

> "My personal opinion is that it is of the utmost importance to the whole economic life of a nation which like Sweden for its standard of living is to such a great extent depending upon foreign trade, to have fairly stable quotations. I think that I dare say that also in order to get a rising price-level, stable foreign exchanges are better than the erratic movements of these rates which the world has suffered from ever since September 1931."[1]

Rooth also made it clear to Sprague that a depreciation of the krona resulted from the need to accumulate foreign exchange reserves after November 1931:

[1] Archives Bank of England, OV 29/26 (26 September 1933).

> "When we were driven off the Gold Standard in September 1931 we had less gold than usual and hardly any foreign exchange reserves. As there was then a stipulation in our law that we were allowed to issue notes to not more than double the amount of our gold reserve plus 250 million kronor, we could not reduce our gold holdings. In order to get some hold of the development of the Swedish exchange and the price level we had to try to build up a foreign exchange reserve. [...] A consequence of this policy of ours was that on the whole the foreign exchange quotations rose."[2]

In early 1936, Rooth argued that Sweden pegged the krona rate to sterling because most foreign business was invoiced in sterling:

> "It was particularly important for a small country like Sweden depending so strongly on its foreign trade to inspire trade and industry with trust in our currency."[3]

In a further statement in February 1938, Rooth wrote to Randolph Burgess, Vice-President of the Federal Reserve Bank of New York:

> "Some American professors, e.g. Professor Irving Fisher, believe that it is an achievement by us in the Riksbank that prices have been fairly steady up to the middle of 1936. I have told Professor Fisher before and I am sorry to have to tell you now that what we have done is merely that we have carried out a fairly conservative central banking policy. In fact we have never tried to do anything directly with regard to prices."[4]

As British prices were rising in 1936–37 and Sweden was concerned about importing inflation, the exchange rate policy was put to test. Swedish economists, including Gustav Cassel and Bertil Ohlin, were publicly suggesting a revaluation of the krona in order to contain the import of inflation, and

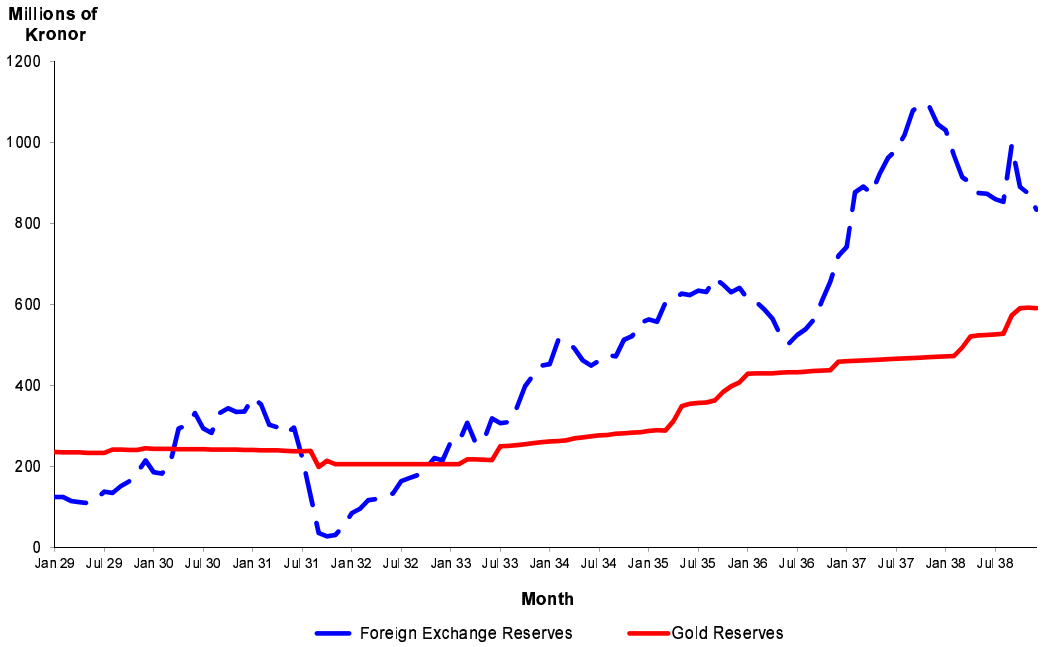
[2] Archives Bank of England, OV 29/26 (26 September 1933).

[3] Archives Bank of England, OV 29/4 (January 1936). The original text is in German; unfortunately, the English summary attached to the document is not very accurate.

[4] Archives Sveriges Riksbank, Rooth papers, Box 129 (10 February 1938).

investors began exchanging their pounds and dollars for kronor. As a result, the foreign exchange reserves of the Riksbank dramatically increased, starting in the summer of 1936. The Swedish authorities, however, maintained parity in order to retain the competitive advantage of Sweden's exporting sectors. However, when British prices began to fall in the second half of 1937, investors began selling their krona assets.

Figure 3: Gold and Foreign Exchange Reserves of the Riksbank



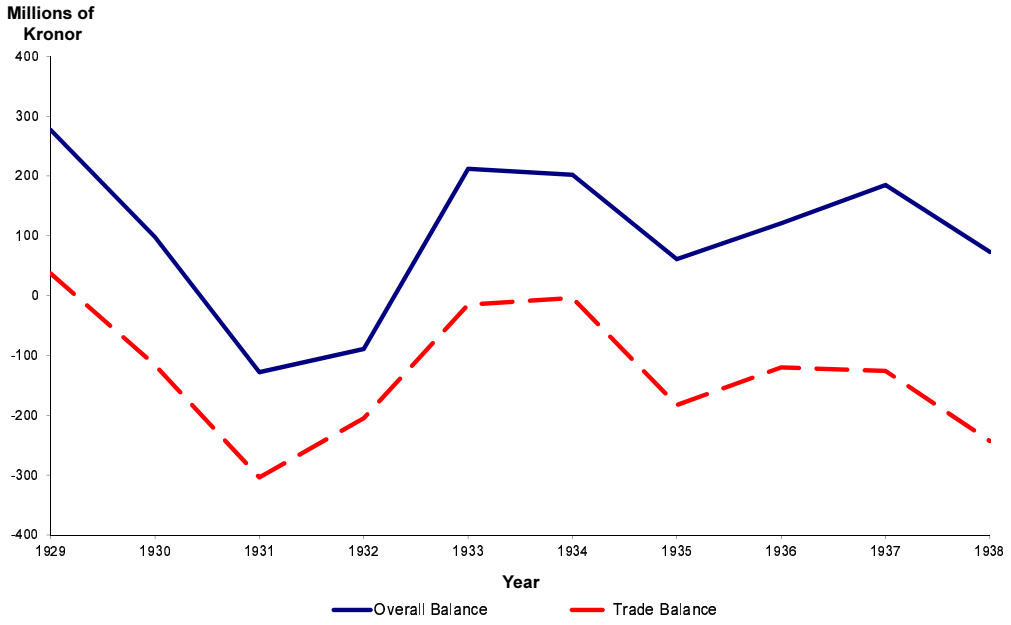
Source: Sveriges Riksbank, Årsbok, various years.

In short, the Riksbank wanted to replenish reserves after leaving the gold standard and was determined to serve the interests of the Swedish exporting sector by keeping the exchange rate as stable as possible. However, did the Riksbank, as Lundberg argues, also maintain the krona rate at an undervalued level? The Riksbank was very successful in building up reserves immediately after the suspension of the gold standard (Figure 3). This steep rise in reserves suggests that it indeed may have been the case that the krona was undervalued. In the first six months of 1929 (that is, before the beginning of the world economic crisis), Swedish gold and foreign exchange reserves

amounted to 350 million SEK; by the end of 1935 they reached 1,000 million SEK. This increase of reserves was so sudden that the Bank of England observed in a memo in January 1936 that "...the Riksbank is still holding an abnormally large share of Sweden's abnormally large foreign reserves".[5]

The dramatic improvement in the trade balance after 1931 is another sign that the Swedish currency was most probably undervalued. In 1931–32, the trade balance was extremely negative, as Sweden, as a small open economy, was suffering immensely from the collapse of world trade (Figure 4). By 1933–34, the trade deficit had disappeared, partly because of the recovery in exports. In 1932, the worst year of the depression, they amounted to 947 million SEK and two years later in 1934 to 1,302 million SEK. During the same period, imports increased just 150 million SEK, from 1,155 to 1,305 million SEK.

Figure 4: Current Account Visibles and Invisibles, Sweden



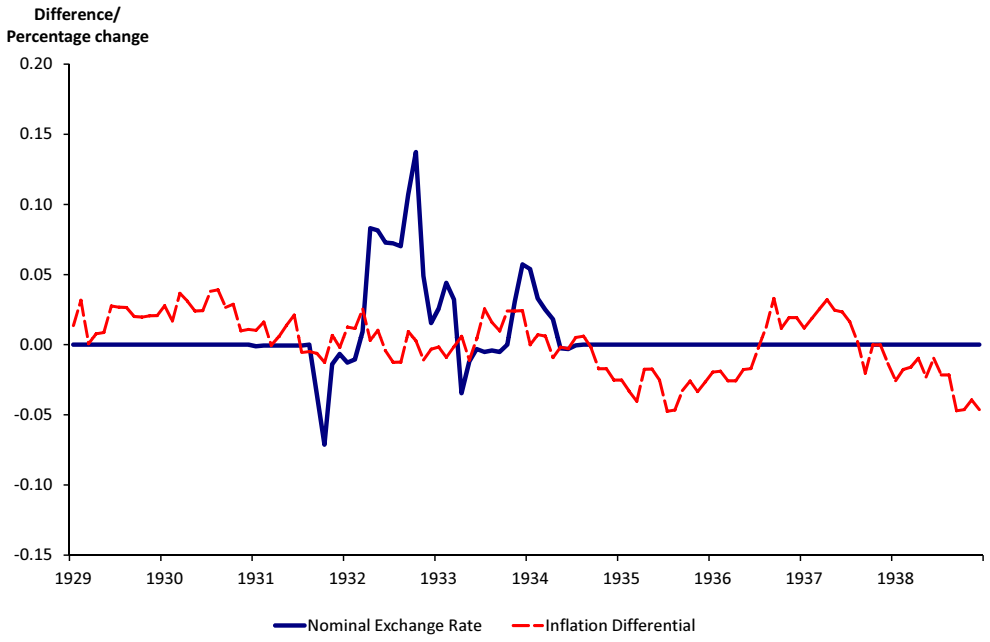
Source: Mitchell (2003, Table J3).

Looking at the trade changes in more detail, we can see that from 1932,

[5]Archives Bank of England, OV 29/26: 'Purchases of gold by Sveriges Riksbank'.

the nadir of the depression, to 1937, the peak of the recovery, Swedish exports to the UK increased from 242 to 479 million SEK (+98%), to Germany from 90 to 315 million SEK (+250%), and to the USA from 100 to 221 million SEK (+121%).[6] In other words, Great Britain remained Sweden's most important trading partner on the eve of World War II, but the German market had gained in importance from 1932 to 1937. As for the most important economic sectors, exports of paper pulp, paperboard, and paper increased from 290 to 588 million SEK (+103%), wood and cork from 153 to 262 million SEK (+71%), base metals from 140 to 322 million SEK (+130%), and mineral and fossil products from 43 to 240 million SEK (+458%).[7] Overall, Sweden strongly profited from the rising exports of its raw materials (mainly wood and iron ore) associated with the recovery of world demand.

Figure 5: Change in Real Exchange Rate



Source: Sveriges Riksbank, Årsbok, various years.

[6]Statistika Centralbyrån (1972).
[7]Statistika Centralbyrån (1972).

A straightforward approach to test the Lundberg hypothesis would be to calculate the real exchange rate of the krona against sterling based on foreign and domestic prices and the nominal exchange rate. As an initial approximation, we consider only the percentage changes in the real exchange rate. The results in Figure 5 of this simple exercise are quite clear. Already in 1930, when the nominal exchange rate was fixed, the Swedish inflation rate was lower than in Britain, implying a real depreciation of the Swedish currency. The nominal devaluation in September 1931 then reinforced the real depreciation. The question remains as to the effects of this depreciation.

3 The Basic New Open Economy Model

In order to support the evidence from Section 2, we estimate a small-scale, structural general equilibrium model of a small open economy. Our theoretical framework is based on New Open Economy Macroeconomics (NOEM). This strand of the literature can be regarded as an extension of the New Keynesian paradigm, which has been used extensively in recent theoretical and applied work exemplified, for instance, by Clarida et al. (2000) or Woodford (2003).[8] The basis of these models is the optimizing behavior of representative agents with all featuring monopolistic competition and nominal rigidities. The basic New Keynesian DSGE model has been adapted to the small open economy setting by Galí and Monacelli (2005) and Monacelli (2005).

Openness and nominal stickiness were among the defining characteristics of the Swedish economy in the interwar period. The ratio of imports and exports in GDP of about 50% in 1929 provides some indication of the great importance of international trade for the Swedish economy at this time. There is also strong evidence of sticky prices in Sweden during the 1930s. For example, from 1928 to 1933, wholesale prices decreased by roughly 30%, while consumer prices fell by a little more than 10%. From 1933 to 1937, wholesale prices increased by almost 40%, while consumer prices crept up by roughly

[8] An overview of the NOEM literature starting with Obstfeld and Rogoff (1995, 1996) can be found in Lane (2001) or Corsetti (2008).

8% (Edvinsson and Söderberg, 2010).

In the following section, we briefly introduce the basic New Keynesian model that we use in the empirical analysis. More detailed descriptions can be found in Galí and Monacelli (2005), Galí (2008, Chapter 7) or Walsh (2003, Chapter 6).

3.1 Households

We consider a small open economy populated by an infinitely lived representative household. The household seeks to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t), \tag{1}$$

where β is the discount factor and $U(.)$ denotes the period utility function, which is defined over a composite consumption index C_t and working hours N_t. The composite consumption index consists of a Dixit–Stiglitz aggregate of domestic goods C_t^h and foreign goods C_t^f,

$$C_t = \left[(1-\gamma)^{\frac{1}{a}} \left(C_t^h\right)^{\frac{a-1}{a}} + \gamma^{\frac{1}{a}} \left(C_t^f\right)^{\frac{a-1}{a}} \right]^{\frac{a}{a-1}} \tag{2}$$

and

$$C_t^h = \left(\int_0^1 C_t^h(j)^{\frac{\theta-1}{\theta}} dj \right)^{\frac{\theta}{\theta-1}}, \quad j \in [0,1]. \tag{3}$$

The elasticity of substitution between domestic and foreign goods is determined by the parameter a, and γ is the degree of home bias in consumption and therefore is a natural indicator of the openness of the economy. Moreover, θ is the elasticity of substitution between domestic varieties. The optimal allocation of expenditures across domestic and foreign goods implies the demand functions:

$$C_t^h = (1-\gamma) \left(\frac{P_t^h}{P_t} \right)^{-a} C_t, \quad \text{and} \quad C_t^f = \gamma \left(\frac{P_t^f}{P_t} \right)^{-a} C_t, \tag{4}$$

where $P_t = \left((1-\gamma)P^{h^{1-a}} + \gamma P^{f^{1-a}}\right)^{\frac{1}{1-a}}$ denotes an appropriately defined consumer price index. In addition, the demand function for any domestic variety j is:

$$C_t^h(j) = \left(\frac{P_t^h(j)}{P_t^h}\right)^{-\theta} C_t^h, \tag{5}$$

where $P_t^h = \left(\int_0^1 P_t^h(j)^{1-\theta} dj\right)^{\frac{1}{1-\theta}}$ is the appropriate domestic price index. The period budget constraint can be written as:

$$P_t C_t + E_t(Q_{t,t+1} B_{t+1}) = W_t N_t + B_t + T_t. \tag{6}$$

Note that $P_t C_t = \int_0^1 P_t^h(j) C_t^h(j) dj + P_t^f C_t^f$. We assume the household has access to a full set of state-contingent securities traded internationally denominated in the domestic currency. B_t is the nominal payment in period t from a portfolio of assets held at the end of period $t-1$ and $E_t Q_{t,t+1} B_{t+1}$ corresponds to the price of portfolio purchases at time t. The nominal wage is given by W_t, and T_t is a lump-sum transfer. The remaining optimality conditions can be rewritten in the convenient form:

$$\begin{aligned} -\frac{U_N(C_t, N_t)}{U_C(C_t, N_t)} &= \frac{W_t}{P_t}, \\ Q_{t,t+1} &= \beta \frac{U_C(C_{t+1}, N_{t+1})}{U_C(C_t, N_t)} \frac{P_t}{P_{t+1}}. \end{aligned} \tag{7}$$

The first equation describes the optimal intratemporal labor/leisure choice, whereas the second can be rewritten as a conventional stochastic Euler relation by taking conditional expectations on both sides and rearranging:

$$1 = \beta R_t E_t \frac{U_C(C_{t+1}, N_{t+1})}{U_C(C_t, N_t)} \frac{P_t}{P_{t+1}}, \tag{8}$$

where $R_t = \frac{1}{E_t Q_{t,t+1}}$ is equal to the riskless nominal return of a one-period bond paying one unit of the domestic currency in period $t+1$.

3.2 Domestic and CPI Inflation, Terms of Trade, and Real Exchange Rate

We assume that the law of one price holds at all times:

$$P_t^f = \Xi_t P_t^\star,$$

where $P_t^\star$ is the foreign currency price of the foreign-produced good and Ξ_t is the exchange rate expressed as foreign currency in terms of domestic currency. The terms of trade (the price of foreign goods in terms of domestic goods) is defined as:

$$S_t \equiv \frac{P_t^f}{P_t^h} = \frac{\Xi_t P_t^\star}{P_t^h}.$$

Note that S is equal to one in the steady state; that is, purchasing power parity (PPP) holds. To consider the effect of an undervalued currency, we treat $\log S_t$ as an unobservable exogenous stable AR(1) process, which allows us to estimate the time path of the terms of trade,

$$\log S_t = \rho_s \log S_{t-1} + \epsilon_t^s, \quad \epsilon_t^s \sim N(0, \sigma_s^2). \tag{9}$$

3.3 Domestic Firms

We assume the existence of a continuum of monopolistically competitive firms that produce differentiated domestic goods. All firms employ identical constant returns to scale production functions:

$$Y_t(j) = ZN_t(j), \quad j \in [0, 1], \tag{10}$$

where we assume $Z = 1$ for all firms. Total factor productivity shocks can be interpreted as reduced-form shocks that can have very heterogenous causes. In our empirical methodology, we allow for a more general reduced-from shock as the conventional autoregressive one, hence inclusion into the production function is unnecessary. We analyze the optimal behavior of the firms in two steps. First, note that minimizing the cost of production $\frac{W_t}{P_t^h} N_t(j)$ subject

to producing $Y_t(j) = N_t(j)$ implies:

$$MC_t = \frac{W_t}{P_t^h}, \tag{11}$$

where MC is the real marginal cost of production and W_t/P_t^h the real wage.

In the second step, we describe the optimal price-setting behavior. We assume staggered price setting as in Calvo (1983) and Yun (1996). Only a proportion $(1-\omega)$ of firms per period receive the random signal that they are allowed to reset prices. The probability of a newly chosen price being effective in period $t+k$ is ω^k, implying the average duration of a price of $(1-\omega)^{-1}$. There is domestic and foreign demand for domestic good variety j. Firm j faces the overall demand:

$$C_t^h(j) = \left(\frac{P_t^h(j)}{P_t^h}\right)^{-\theta} Y_t, \tag{12}$$

with $Y_t = C_t^h + C_t^{h\star}$, where the superscript '$\star$' denotes foreign demand for domestic goods. Given all firms face identical demand curves and have the same production technologies, all firms that are allowed to reoptimize choose the same price $\bar{P}_t^h$ in order to maximize the current value of the profits generated while the price stays effective:

$$\bar{P}_t^h = \arg\max_{P_t^h(j)} E_t \sum_{\tau=0}^{\infty} \omega^\tau Q_{t,t+\tau}(P_t^h(j) - P_{t+\tau}^h MC_{t+\tau}) \left(\frac{P_t^h(j)}{P_{t+\tau}^h}\right)^{-\theta} Y_{t+\tau}. \tag{13}$$

Note that $Q_{t,t+\tau}$ is the appropriate discount factor for nominal payoffs. The first-order condition for the choice of $\bar{P}_t^h$ is:

$$E_t \sum_{\tau=0}^{\infty} (\omega)^\tau Q_{t,t+\tau} Y_{t+\tau} \left((1-\theta)\left(\frac{\bar{P}_t^h}{P_{t+\tau}^h}\right)^{-\theta} + \theta \left(\frac{\bar{P}_t^h}{P_{t+\tau}^h}\right)^{-\theta-1} MC_{t+\tau}\right) = 0. \tag{14}$$

This infinite sum can be expressed more conveniently in recursive fashion using auxiliary variables (Schmitt-Grohé and Uribe, 2004). Using the gross growth rate of the aggregate price index $\Pi_t = \frac{P_t}{P_{t-1}}$ and the price index for

domestic goods $\Pi_t^h = \frac{P_t^h}{P_{t-1}^h}$, we can write the price-setting equation as:

$$\frac{\bar{P}_t^h}{P_t^h} = \frac{\theta}{\theta - 1} \frac{A_{1,t}}{A_{2,t}}. \tag{15}$$

with

$$\begin{aligned} A_{1,t} &= Y_t MC_t + \omega \beta E_t \frac{U_C(C_{t+1}, N_{t+1})}{U_C(C_t, N_t)} \Pi_{t+1}^{-1} (\Pi_{t+1}^h)^{\theta+1} A_{1,t+1}; \\ A_{2,t} &= Y_t + \omega \beta E_t \frac{U_C(C_{t+1}, N_{t+1})}{U_C(C_t, N_t)} \Pi_{t+1}^{-1} (\Pi_{t+1}^h)^{\theta} A_{2,t+1}. \end{aligned} \tag{16}$$

The remaining firms have to retain the price from the last period. Note that this implies a zero steady-state inflation rate, which is what we would expect under the gold standard. Using the definition of the domestic price index implies:

$$1 = (1 - \omega) \left(\frac{\theta}{\theta - 1} \frac{A_{1,t}}{A_{2,t}} \right)^{1-\theta} + \omega \left(\Pi_t^h \right)^{\theta - 1}. \tag{17}$$

3.4 International Consumption Risk-Sharing and Market Clearing

The foreign country is assumed large relative to the home country. Therefore, there is no need to distinguish between foreign changes in consumer prices and overall inflation and foreign consumption and production.[9] Consumption of the domestic good in the foreign country (export demand) is given by:

$$C_t^{h\star} = \gamma \left(\frac{P_t^h}{S_t P_t^\star} \right)^{-a} Y_t^\star, \tag{18}$$

[9]More precisely, regard the domestic country as one of a continuum of infinitesimally small countries making up the world (foreign) economy. This means that the domestic economy has zero mass in the foreign economy; see Galí and Monacelli (2005) for a more detailed description.

if foreign households have the same preferences as domestic households. We assume that $\log Y_t^\star$ follows an exogenously given stable AR(1) process:

$$\log Y_t^\star = (1-\rho^\star)\log Y^\star + \rho^\star \log Y_{t-1}^\star + \epsilon_t^\star,\ \epsilon_t^\star \sim N(0,\sigma_\star^2). \tag{19}$$

To place some discipline on our analysis, we will later compare the estimated structural shocks from (9) and (19) with data not used in the estimation.

The existence of complete financial markets implies that movements in the ratio of marginal utilities in the two countries are related to movements in the real exchange rate. Noting that the internationally traded securities are denominated in the domestic currency, the optimal portfolio choice of foreign households can be characterized by the following Euler equation:

$$Q_{t,t+1} = \beta \frac{U_{C^\star}(C_{t+1}^\star, N_{t+1}^\star)}{U_{C^\star}(C_t^\star, N_t^\star)} \left(\frac{P_t^\star S_t}{P_{t+1}^\star S_{t+1}} \right). \tag{20}$$

When combining (20) with the optimal choice of the domestic households (7), the following condition is derived:[10]

$$\frac{U_{C^\star}(C_t^\star, N_t^\star)}{U_C(C_t, N_t)} = \mu \Phi_t, \tag{21}$$

where $\mu = \frac{U_{C^\star}(C_0^\star, N_0^\star)}{U_C(C_0, N_0)} \left(\frac{1}{\Phi_0} \right)$ is a constant that depends on the initial distribution of wealth across countries. Hence, the existence of complete security markets leads to a simple relationship linking the level of domestic consumption with the level of foreign consumption and the real exchange rate. This is an alternative way of stating the uncovered interest parity condition, which can also be derived by combining the first-order conditions of foreign and domestic consumers for optimal portfolio choice.

Market clearing in the domestic goods market requires:

$$Y_t = C_t^h + C_t^{h\star}, \tag{22}$$

[10] See also Chari et al. (2002). Schmitt-Grohé and Uribe (2003) provide different methods to close small open economy models. However, there are no major differences between the methods.

where $Y_t \equiv \left(\int_0^1 Y_t(j)^{\frac{\theta-1}{\theta}} dj\right)^{\frac{\theta}{\theta-1}}$ is an aggregate production index. Moreover, this output index can be related to aggregate employment. Using the labor and goods market clearing conditions together with the definition of the production technology (10), we can derive an implicit aggregate production function:

$$Y_t = \frac{N_t}{\varsigma_t}, \tag{23}$$

where $\varsigma_t = \int_0^1 \left(\frac{P_t^h(j)}{P_t}\right)^{-\theta} \mathrm{d}j$ is a measure of price dispersion.

For subsequent analysis, we log-linearize the system around the deterministic steady-state values. For the period utility function, we choose $U(C_t, N_t) = \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{N_t^{1+\eta}}{1+\eta}$, where σ^{-1} denotes the intertemporal elasticity of substitution and η^{-1} is the elasticity of labor supply.

4 Empirical Analysis

To gain a deeper insight, we estimate the structural small NOEM outlined above using Swedish data from the 1930s. In doing so, we build on a recent strand of the literature that deals with the estimation of new open economy models. A number of different empirical strategies have been applied, including that by Ghironi (2000), who applied nonlinear least squares at the single-equation level to estimate the structural parameters of this model. As alternatives, Smets and Wouters (2002) based their estimation on a model matching implied impulse responses with an identified vector autoregressive (VAR) model, while Bergin (2003, 2006) and Dib (2003) applied maximum likelihood estimation. Following the contributions of Lubik and Schorfheide (2006, 2007), Ambler et al. (2004), Justiniano and Preston (2004, 2010), and Adolfson et al. (2008, 2007), we use Bayesian methods for estimation. This has the advantage that the estimation need not be based solely on the likelihood function. It also allows us to incorporate additional information in a coherent way via prior distributions. In particular, the use of prior distributions is helpful when incorporating restrictions on structural parameters in

the estimation. The linearized system is solved with the generalized Schur decomposition technique proposed by Klein (2000). The following state–space representation mapping the unobservable states into the observable data vector $\mathbf{v}_t$ is derived:

$$\begin{aligned} \mathbf{v}_t &= \mathbf{L}\begin{pmatrix}\mathbf{w}_t\\ \mathbf{x}_t\end{pmatrix}, \\ \mathbf{w}_t &= \mathbf{L}_{ww}\mathbf{w}_{t-1} + \mathbf{L}_{wx}\mathbf{x}_{t-1}, \\ \mathbf{x}_t &= \mathbf{A}\mathbf{x}_{t-1} + \boldsymbol{\epsilon}_t. \end{aligned} \tag{24}$$

The vector $\mathbf{x}_t$ is a collection of the structural shocks of the model consisting of the the terms of trade shock s_t and the foreign output shock $y_t^\star$. Hence, the matrix $\mathbf{A}$ is equal to diag($\rho_s,\ \rho_\star$) and the covariance matrix of $\boldsymbol{\epsilon}$ is given by $\boldsymbol{\Sigma} = \text{diag}(\ \sigma_s^2,\ \sigma_\star^2)$. To account for potential measurement error and model misspecification,[11] we add a VAR measurement error $\mathbf{e}_t$ for the estimation as proposed by Ireland (2004). The empirical model is thus given by:

$$\mathbf{v}_t = \mathbf{L}\begin{pmatrix}\mathbf{w}_t\\ \mathbf{x}_t\end{pmatrix} + \mathbf{e}_t, \tag{25a}$$

$$\mathbf{w}_t = \mathbf{L}_{ww}\mathbf{w}_{t-1} + \mathbf{L}_{wx}\mathbf{x}_{t-1}, \tag{25b}$$

$$\mathbf{x}_t = \mathbf{A}\mathbf{x}_{t-1} + \boldsymbol{\epsilon}_t, \tag{25c}$$

$$\mathbf{e}_t = \mathbf{D}\mathbf{e}_{t-1} + \boldsymbol{\xi}_t, \tag{25d}$$

where $\mathbf{D}$ is a matrix of VAR parameters of the measurement error representing the off-model dynamics and $\boldsymbol{\xi}_t$ is a zero-mean vector of disturbances with covariance matrix $\boldsymbol{\Upsilon}$.

4.1 Data and Prior Choice

To identify the empirical implications of the model, we use monthly data on industrial production and inflation for the observation period January 1928–September 1939. Based on the consumer price index published by the League

[11] See Schorfheide (2000) for a loss-function based comparison of potentially misspecified models.

of Nations, we calculated inflation as the seasonal first differences of the price index in logs and then demean. Industrial production (seasonally adjusted) is also from the League of Nations.[12] Following Rabanal and Rubio-Ramírez (2005), we calculated the log-deviation from a quadratic trend. The vector of observable variables for which we derive the state–space representation consists of $\mathbf{v}_t = [y_t,\ \pi_t]'$. As already emphasized by Sims (1980), strong a priori restrictions are necessary to identify rational expectation models. To overcome identification problems, a number of parameters are usually calibrated (infinitely strict priors used). Out of the 18 parameters of the model, we calibrate only two: we set the discount factor to the conventional value of 0.99, and the long-run share of imports in consumption γ to the sample average (using annual data).

We impose uniform priors with reasonable ranges for the rest of the structural parameters so as to be as flexible as possible: $\theta \sim U(5,7)$, $\eta \sim U(1.5,3)$, $\sigma \sim U(1.5,3)$, $a \sim U(3,6)$, $\omega \sim U(0.6,0.8)$, $\rho_\star \sim U(0,1)$, $\rho_s \sim U(0,1)$, $\sigma_\star \sim U(0.0001,0.001)$, $\sigma_s \sim U(0.0001,0.001)$. For the VAR-component, we require stationarity and positive semidefiniteness of the matrix $\boldsymbol{\Upsilon}$.[13]

To generate the parameter chain, we use the tailored randomized Markov chain Monte Carlo (MCMC) method proposed by Chib and Ramamurthy (2010). This procedure is a modification of the standard Metropolis–Hastings algorithm (e.g. Chib and Greenberg, 1995). In each simulation step, the parameters are randomly combined into blocks.[14] A proposal draw is generated from a multivariate t-distribution with a scale matrix derived at the conditional maximum of the posterior, which is maximized using simulated annealing.[15] The proposal is accepted if the value of the posterior at the

[12]Data available from the authors upon request.

[13]In addition, for the Markov chain to converge, we needed to impose a maximum absolute eigenvalue of 0.6 such that the maximum measurement error variances are less than 60% of the corresponding observable time series. This is similar but less restrictive than that found in García-Cicco et al. (2010, p. 2519), who restrict the measurement error variance to maximally 6% of the observable time series.

[14]The probability of staying in the same block is set to 0.8.

[15]The algorithm is a generalization of the Metropolis algorithm (Metropolis et al., 1953) developed by Kirkpatrick et al. (1983) and Černý (1985). For an overview, see e.g. van Laarhoven and Aarts (1987) or Press et al. (1992, Section 10.9). The parameters of the algorithm are set as follows: cooling constant 0.4, stage expansion factor 8, initial

new parameters is higher than for the old parameters. If not, it is accepted with an acceptance probability drawn from a uniform distribution $U(0,1)$ to ensure that we explore the entire posterior distribution.[16]

4.2 Results

The parameter estimates are summarized in Table 1. The table provides the posterior means and standard deviations together with the convergence statistics. Altogether, the priors are updated considerably by the information in the likelihood. The structural trade shock turns out to be very persistent. The variance parameters are estimated precisely, with the foreign demand shock having about twice the standard deviation as the terms of trade shock. The expected average duration of prices $((1-\omega)^{-1})$ is about five years, highlighting the importance of nominal rigidities in the Swedish economy.

Our focus is on the role of the exchange rate in the strong recovery of the Swedish economy after 1932. Figure 6 contains the estimated terms of trade and foreign output in the 1930s. As for the crucial period from 1930 to 1934, when Swedish exports increased and triggered the recovery, we can observe a strong depreciation of the Swedish real exchange rate.[17] From early 1932 until mid 1935, the mean and nearly all the probability mass of the estimated terms of trade are located in the region of undervaluation, indicating a lastingly undervalued Swedish krona by up to 4%. These results strongly suggest that Sweden's exporting sectors were profiting to a large extent from the exchange rate policy of the Riksbank. They are also highly compatible with the narrative evidence presented in Section 2. The Riksbank repeatedly expressed its concern over exchange rate stability. By attempting to keep the exchange rate fixed and accumulating even more reserves, the Riksbank keep the krona undervalued, which helped boost exports. The decrease in estimated world output lasting up until 1933 clearly shows the

temperature 10, and initial stage length 4.

[16] All programs were written from first principles in Matlab Version R2009b. To gain speed, we coded the Kalman filter to derive the likelihood in C.

[17] Note that in the log-linear version of the model, the real exchange rate is proportional to the terms of trade.

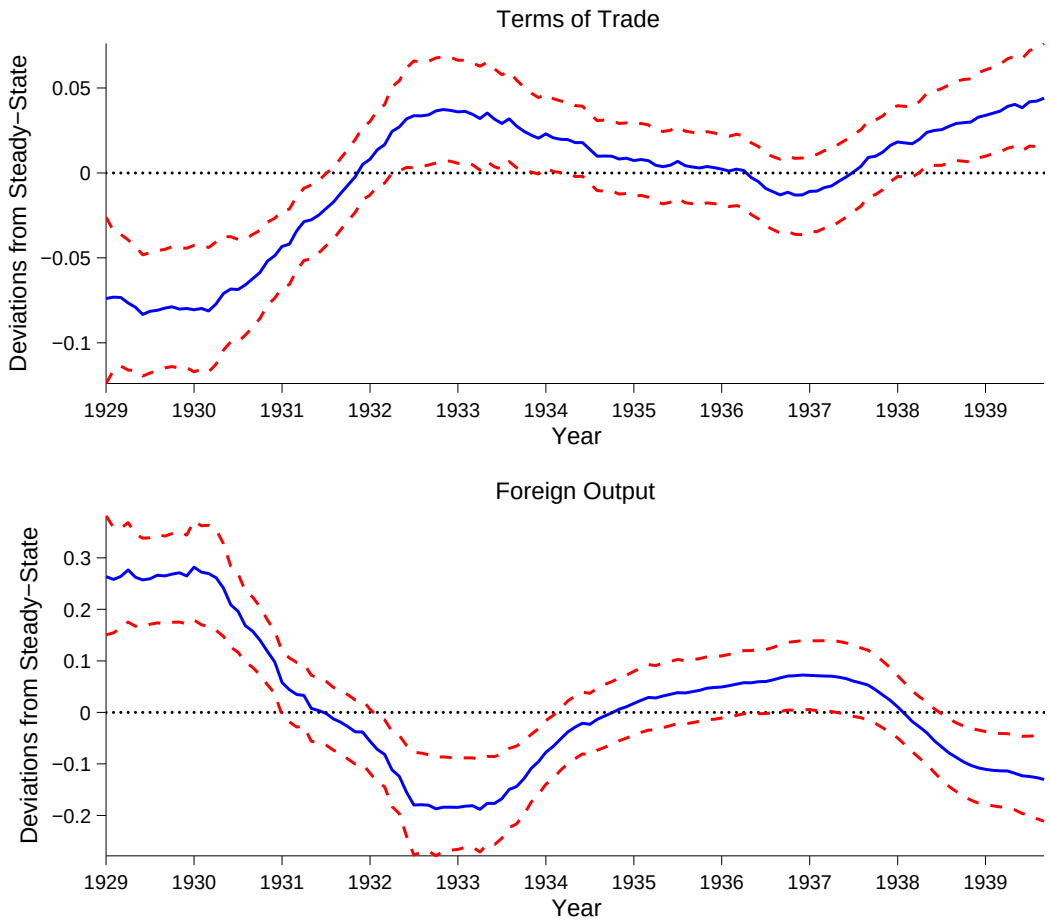
dire consequences of the Great Depression. However, we can also observe the recovery starting in 1933. Clearly, this also contributed to the recovery.

Table 1: Posterior Distribution of Parameters

Parameter	Mean	SD	NSE	Geweke's χ^2
θ	6.333960	0.500391	0.032881	0.462385
η	2.360571	0.413580	0.019320	0.600004
σ	2.588666	0.337404	0.019578	0.578641
a	3.598114	0.526474	0.020807	0.692470
ω	0.983331	0.003471	0.000197	0.639113
$\rho_\star$	0.998994	0.000170	0.000002	0.938818
ρ_s	0.998678	0.000274	0.000011	0.818986
$\sigma_\star$	0.020562	0.005095	0.000260	0.481140
σ_s	0.010788	0.000745	0.000019	0.918839
d_{11}	0.552966	0.055079	0.003597	0.801800
d_{21}	-0.116966	0.028224	0.001545	0.422040
d_{12}	0.056536	0.048719	0.002976	0.473774
d_{22}	0.618279	0.058291	0.003890	0.905990
$\sqrt{\upsilon_{11}}$	0.029215	0.003683	0.000221	0.928962
υ_{21}	–0.000165	0.000025	0.000001	0.628313
$\sqrt{\upsilon_{22}}$	0.006465	0.000961	0.000062	0.857368

Notes: The posterior distribution is based on 100,000 replications, of which the first 50,000 are discarded as burn-in. Second column: mean of posterior parameter distribution; third column: standard deviation (SD); fourth column: numerical standard error using 15% autocovariance taper (NSE); fifth column: Geweke's χ^2 test (H0: the mean of the first 20% of the chain is equal to the mean of the last 50% of the chain).

Figure 6: Estimated State Variables



Notes: Posterior median, 5th and 95th percentiles of estimated terms of trade and foreign demand in percentage deviations from the steady state.

Variance decomposition can be used to infer the role of the different shocks in driving output and inflation. The forecast error decompositions shown in Figure 7 confirm our claim. At all forecast horizons, the terms of trade shock plays an important role in explaining output. It is thus nearly as important as the world demand shock, which is remarkable in a sample that includes the Great Depression and accounts for about 40% of the overall forecast error variance at longer forecast horizons. The off-model dynamics are important at short horizons, while the foreign demand shock contributes

about half to the explained variance. Inflation is mostly captured by the off-model dynamics in the short-run but, for longer forecast horizons, the foreign demand shock is most important and, to a lesser degree, the terms of trade shock.

Figure 7: Forecast Error Variance Decomposition

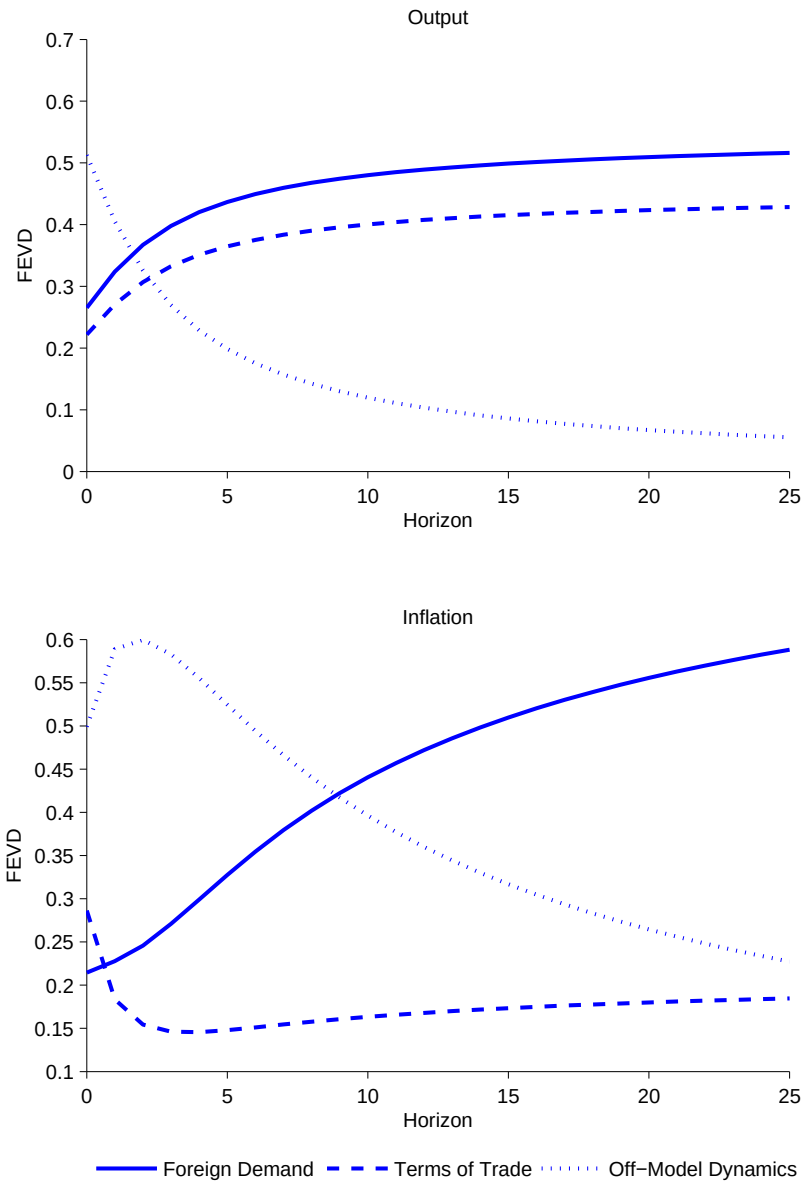
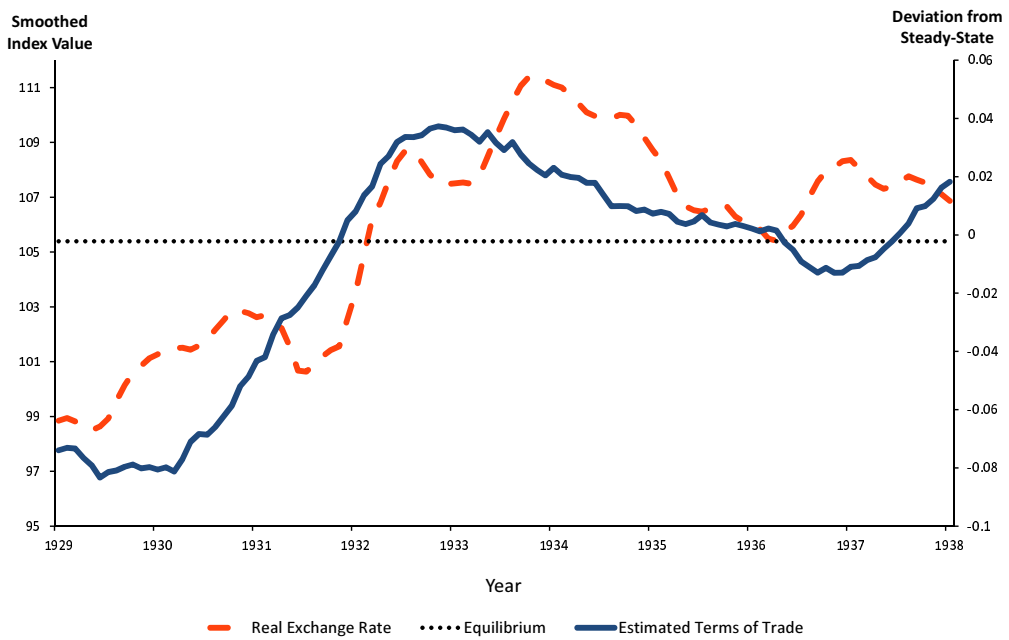


Figure 8: PPP vs. Estimated Terms of Trade



Notes: Left axis is 9-month moving average of monthly real exchange rate (Jan 1929 = 100), right axis is estimated median terms of trade in percentage deviation from the steady state.

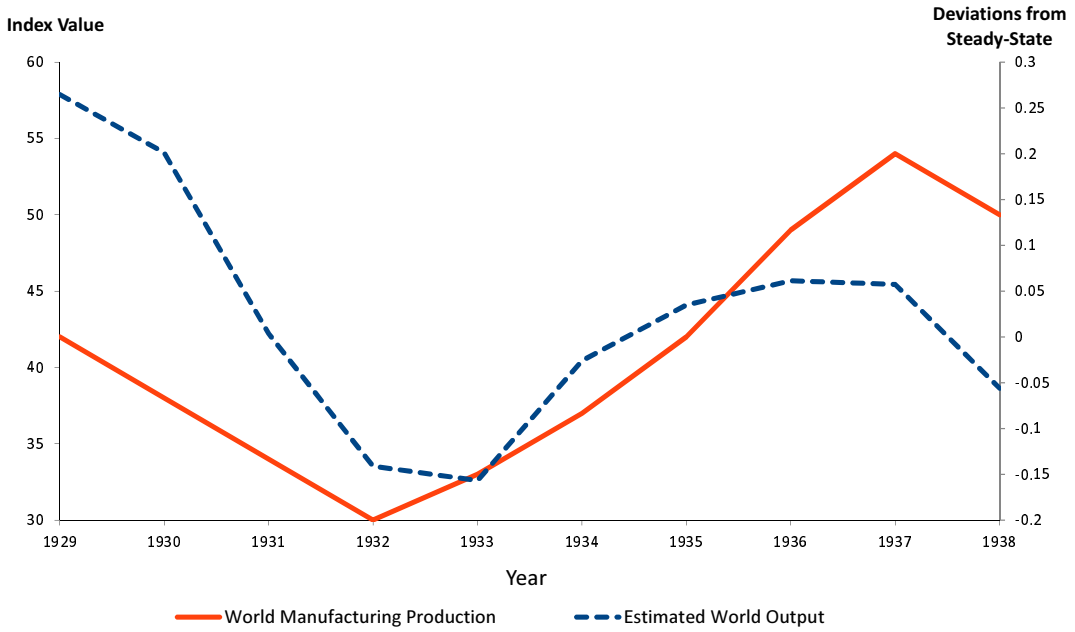
4.2.1 Model Evaluation and Counterfactual Analysis

To see how well the estimated states reproduce the data they are intended to represent, we plot the terms of trade against the real exchange rate of the krona against sterling, assuming that the equilibrium exchange rate is the sample average (Figure 8). The fit is striking: as shown, it is not until 1936–37 that the two curves start to drift apart. The orders of magnitude of the implied deviations from steady state are comparable and the correlation is high (0.79). Most importantly, we match the strong devaluation that triggers the recovery and we nearly perfectly match the time period of undervaluation between 1932 and 1936. Hence using a simple PPP approach or our general equilibrium model gives qualitatively the same results.[18]

[18]Discussing different methods to measure currency misalignments Hinkel and Montiel conclude *"one would be more confident of the results, if were determined in a complete*

If we conduct a similar exercise for the estimated world demand shock by plotting it against an annual world manufacturing index taken from the historical data on international merchandise trade statistics published by the United Nations, we also find that our estimated shock mimics the actual movements almost perfectly.

Figure 9: World Manufacturing vs. Estimated World Output



Notes: Left axis, annual world manufacturing output index (United Nations, Historical data on international merchandise trade statistics, 1953=100; `unstats.un.org/unsd/trade/imts/historical_data.htm`); right axis, annual averages of estimated median world output in percentage deviations from the steady state.

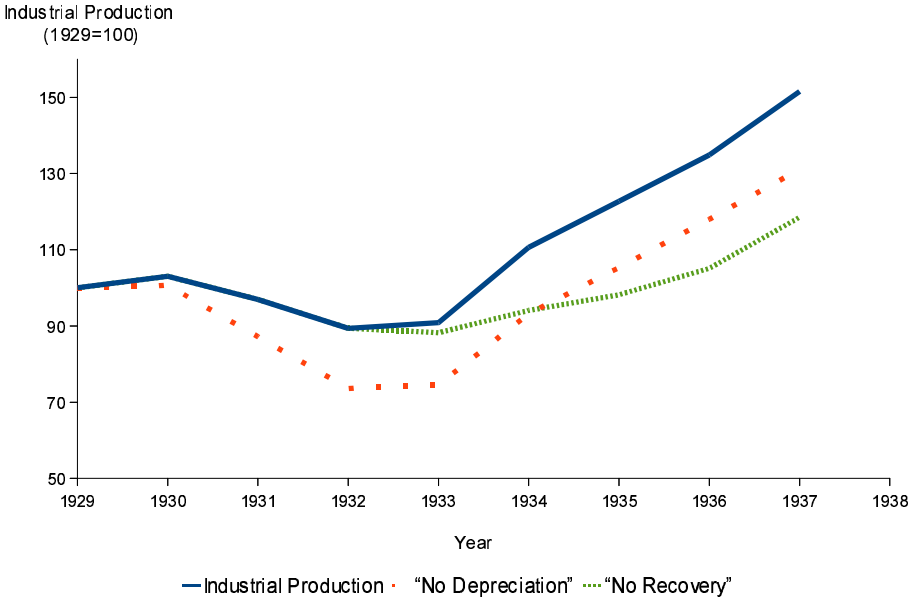
To illustrate further the role of Sweden's exchange rate policy, we conduct a counterfactual experiment. For this purpose, we impose the hypothetical scenario that there would not have been a real devaluation after 1930 (Figure 6), which represents a natural lower bound for the implied recovery. To be

general-equilibrium framework that takes into account all important macroeconomic interactions in a fully consistent manner" (Hinkle and Montiel, 1999, p. 22).

able to isolate the effect of the devaluation from that of the recovery of the world economy, we also examine a scenario in which the recovery of world demand did not occur. It is possible to simulate the model using the hypothetical path for the terms of trade and foreign output. To compare the outcome of the counterfactual simulations with Sweden's actual performance, we use annual averages of the simulated median monthly percentage changes in output to compute a counterfactual annual industrial production series. The results of this exercise are displayed in Figure 10.

The simulation provides an unfavorable picture. If Sweden had not depreciated its currency, the downturn of the Great Depression would have been much more severe: counterfactual industrial production falls to 75% of its 1929 level, similar to the situation in Norway (Figure 1). In reality, the lower turning point was at about 90%. Because Sweden could rely on the demand for its export goods, the recovery of foreign output would have helped it escape the slump, but without industrial production reaching the actually observed level. Thus, the counterfactual simulations show that a different exchange rate policy could have eliminated Sweden's exceptional economic performance of the 1930s.

Figure 10: Counterfactual Industrial Production, 1932–1937



Notes: The dotted line depicts counterfactual yearly output in the "No Depreciation" scenario, where the terms of trade are fixed at an overvalued level in 1930. The dashed line depicts counterfactual annual output in the "No Recovery" scenario, which does not allow for the revival of the world economy in 1933.

5 Conclusion

Sweden was among the first economies to recover from the depression in the early 1930s, and it did so in a particularly impressive way. In this paper, we test the contribution made to this recovery by economic policy. Building on Lundberg (1983), who claimed on the basis of descriptive statistics that Sweden consciously kept its currency undervalued vis-à-vis the British pound, we apply a DSGE model for a small open economy. Our results show that Sweden's exchange rate policy in fact had a strong impact on the course of recovery. Indeed, Sweden would not have been able to avoid a deeper crisis if the currency had not been relatively weak. Instead, our counterfactual simulations indicate that industrial production would have reached its pre-

crisis level in 1935, whereas in reality it had already achieved this two years earlier in 1933.

This finding potentially contributes not only to the literature on the Swedish growth miracle of the 1930s but also to the study of the Great Depression more generally. The Riksbank in the 1930s has sometimes been seen as an example of a central bank that was relatively innovative in terms of the conduct of monetary policy. In particular, monetary economists have cited the Swedish experiment with price level targeting as the prototype of modern inflation targeting. This present paper instead argues that this view overvalues the 1930s as a decade of policy innovation. Before and after the collapse of the gold standard in 1931, the Riksbank was determined to have a stable currency, believing that it was a necessary condition for international trade. Further, the Riksbank fully rejected the idea of targeting the domestic price level, which implied a floating exchange rate. Moreover, in order to be more resilient in future currency crises, the Riksbank aimed at replenishing its foreign exchange reserves by fixing the exchange rate at an undervalued level. In other words, the strong recovery was the unintentional byproduct of conservative central banking policy.

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