Overvalued: Sweden’s Monetary Policy in the 1930s.*

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Abstract

The paper reconsiders the role of monetary policy in Sweden’s strong recovery from the Great Depression. Sweden has been viewed as an example showing that in the 1930s some central banks were more innovative than others. We estimate a small-scale, structural general equilibrium model of a small open economy using Bayesian methods. The model captures key dynamics of the period under analysis astonishingly well. Our results suggest that it was not innovative, but rather conservative monetary policy that did the trick. By keeping the krona at an undervalued level to replenish foreign reserves, Sweden’s exchange rate policy unintentionally contributed to the growth miracle in the 1930s, avoiding a major slump in 1932 and enabling the country to quickly benefit from the recovery of world demand.

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1 Introduction

In the era 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 of industrial production from 1933 to 1939 was higher than anywhere else in Europe. However, despite of this widely shared admiration, there has not been any econometric testing of the various hypotheses brought up ever since it happened. In particular, the crucial question Charles Kindleberger asked almost 40 years ago in his classic account of the Great Depression has not been addressed in a formal way, 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 try to provide an empirical answer by estimating a dynamic stochastic general equilibrium (DSGE) model for a small open economy. Despite its relatively simple structure, the model captures key dynamics of the factors driving the Swedish economy in the period under analysis. We show that by keeping the krona at an undervalued level, Swedish exchange rate policy helped to avoid a deep slump in 1932 and enabled the country to quickly benefit from the recovery of world demand.

This finding has implications not only for Kindleberger’s question, but also for the traditional view of Sweden’s monetary policy in the 1930s. Monetary economists have considered it a precursor of today’s inflation targeting (Svensson, 1995; Bernanke et al., 1999). Our econometric results, backed up by narrative evidence, suggest that this assessment overvalues the ingenuity of the Swedish central bank (Sveriges Riksbank). Archival sources show that the Riksbank was not primarily concerned about price stability, but about the stability of the exchange rate believing that the recovery would be hampered by a floating exchange rate. Therefore, it simply adjusted the principles of the gold exchange standard to the new conditions after the fall of the British pound in September 1931 without making a true regime shift. The minutes of the board show that the undervaluation resulted from the will to replenish foreign exchange reserves in order to dispose of the means
to fix the currency to the British pound. Therefore, Sweden’s exceptional recovery was not the consequence of an innovative monetary policy, but a mere byproduct of the Riksbank’s reserve accumulation.

The paper is structured as follows. Section 2 provides a brief summary of the historical setting and sketches Sweden’s exchange rate policy on the basis of narrative and statistical evidence. The model is explained in Section 3, Section 4 outlines the estimation approach and the empirical findings, and Section 5 concludes.

2 Explaining the Swedish Recovery

It is well established that those economies which abandoned the gold standard at an early stage of the Great Depression enjoyed a rapid 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 the same step and enjoyed a fast recovery as well. By contrast, the countries of the gold bloc (Belgium, France, Italy, Netherlands, Poland, Switzerland) which maintained the gold standard until 1935/36 suffered from a protracted economic depression.

Yet Sweden not only experienced a shorter crisis, but enjoyed a particularly strong industrial recovery after 1932. In 1937, Sweden’s index of industrial production amounted to 152 (1929 = 100) while the index in Denmark, Norway and the UK was at 135, 130 and 130 respectively (Figure 1). There seems to be a particularly favorable link making Swedish production exceptionally competitive during the 1930s.

To what extent was this growth miracle due to economic policies? In the empirical analysis, we will focus on the exchange rate policy and effect of foreign demand as suggested by Kindleberger. But other explanations have also been suggested in the literature. Schönb (2000) provides a useful survey of the Swedish literature. In 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 economy by pursuing a model counter-cyclical policy, based on the teachings of the younger generation of the Stockholm school (Gunnar Myrdal and Bertil Ohlin). The figures, however, show that the fiscal deficit was too small to account for the recovery: to achieve the actual increase in real GDP of 2237 million SEK (in prices of 1929) from 1932 to 1936, with the changes in fiscal policy observed in the data (Mitchell, 2003, Tables G5,H2,G6,J1) would have required much higher fiscal multipliers (> 10) than what can be found in the literature (e.g. Spilimbergo et al., 2009). As the other sterling block countries, Sweden ran a more or less balanced budget (Almunia et al., 2010, p. 235, Figure 13). Moreover, the size of the government sector was still small in period under consideration (on average 11 per cent of GDP). The Swedish Social Democrats did not implement a new fiscal regime, therefore, this explanation is hard to maintain.

Figure 1: Industrial Production

This finding leaves us with two other explanations discussed in the literature. The first one, advocated by Jonung (1984) and Fregert and Jo-
nung (2004), focuses on monetary policy. By leaving the gold standard, the Swedish central bank (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, the newly gained freedom enabled the Riksbank to act as lender of last resort in the aftermath of the Kreuger crash in March 1932 and to avert a major banking crisis. Moreover, the Riksbank adopted a new monetary policy framework, the so-called price level targeting, based on the seminal work of the eminent Swedish economist Knut Wicksell.

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

Which policy was more important for Sweden’s recovery, monetary policy 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 now on be aimed at stabilizing the internal price level. Due to Sweden’s subsequent excellent performance, its alleged adoption of price-level targeting has repeatedly been invoked as a new model, and some monetary economists have considered it a sort of precursor of today’s inflation targeting (Svensson, 1995; Bernanke et al., 1999). However, Straumann and Woitek (2009) present econometric results and narrative evidence suggesting that this positive assessment overestimates the ambitions of the Swedish central bank. They argue that there was a huge gap between official declarations and actual policies pursued. The Riksbank was
not primarily concerned about price stability, but about the stability of the exchange rate believing that the recovery would be hampered by a floating exchange rate. It simply adjusted the principles of the gold exchange standard to the new conditions after the fall of the British pound without making a true regime shift.

At first sight, this conclusion appears to be inconsistent with the volatility of the krona rate vis-à-vis sterling, the currency of the 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 old parity of 18.16 SEK per GBP. In November 1931, shortly after the end of the gold standard, the Riksbank tried to prevent the krona from rising above the old parity of 18.16 SEK per GBP. The attempt failed, the exchange rate fell to 19.40 SEK per GBP. In late 1932, the Riksbank tried to bring the krona rate back to this level. Again, the plan did not materialize. Thus, in the first phase the Swedish central bank only seemingly embraced flexible exchange rates. It is more appropriate to suppose the same policy orientation for the whole 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, 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.”

In early 1936, Roth argued that Sweden pegged the krona rate pegged to sterling because foreign business was for the most part 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.”

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

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1 Archives Bank of England, OV 29/26 (26 September 1933).
2 Archives Bank of England, OV 29/4 (January 1936). The text is in German, the English summary attached to the document is not very accurate.
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.”

As British prices were rising in 1936/37 and Sweden was concerned about importing inflation, the exchange rate policy was put to a test. Swedish economists such as Gustav Cassel and Bertil Ohlin were publicly suggesting a revaluation of the krona in order to contain the import of inflation, and investors began exchanging their pounds and dollars in kronor. As a result, the foreign exchange reserves of the Riksbank dramatically increased, starting in the summer of 1936. The Swedish authorities, however, maintained the parity in order to keep the competitive advantage of their exporting sectors. When British prices began to fall in the second half of 1937, investors began selling their krona assets.

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3 Archives Sveriges Riksbank, Rooth papers, Box 129 (10 February 1938).
In short, the Riksbank was determined to serve the interests of the exporting sectors by keeping the exchange rate as stable as possible right after the suspension of the gold standard. Stabilizing the exchange rate is one thing. But did the Riksbank, as Lundberg argues, also maintain the krona rate at an undervalued level? The steep rise of reserves suggests that this may have been the case (Figure 3). In the first six months of 1929, that is before the beginning of the world economic crisis, gold and foreign exchange reserves amounted to 350 million SEK; by the end of 1935, they had reached 1000 million SEK. The increase of reserves was so steep 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”.

The dramatic improvement of the trade balance after 1931 is another sign that the Swedish currency was presumably undervalued. In 1931/32, the trade balance was highly negative, since Sweden as a small open economy was

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immensely suffering from the collapse of world trade (Figure 4). By 1933/34, the trade deficit had disappeared, partly because exports had recovered. In 1932, the worst year of the depression, they amounted to 947 million SEK, two years later to 1302 million SEK. In the same period, imports rose from 1155 to 1305 million SEK.

Figure 4: Current Account, Visibles and Invisibles of Sweden

![Graph showing Current Account, Visibles and Invisibles of Sweden](image)

Source: Mitchell (2003, Table J3).

Looking at the changes in trade in more detail, we see that from 1932, 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 US from 100 to 221 million SEK (+121%). In other words, Great Britain remained the 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%), of wood and cork from 153 to 262 million SEK.

Statistika Centralbyråns (1972).
(+71%), of base metals from 140 to 322 million SEK (+130%) and of mineral and fossil products from 43 to 240 million SEK (+458%). In general, Sweden strongly profited from the rising exports of its raw materials (wood and iron ore) due to the recovery of world demand.

Figure 5: Change in Real Exchange Rate

Source: Sveriges Riksbank, Årsbok, various years.

A straightforward approach to test the Lundberg hypothesis would be to calculate the real exchange rate of the krona against sterling on the basis of foreign and domestic prices and the nominal exchange rate. For a first approximation, we consider only the percentage changes of 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 the British one, implying a real depreciation of the Swedish currency. The nominal devaluation in September 1931 then reinforced the

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6Statistika Centralbyrån (1972).
real depreciation. The question is what the effects of this depreciation were.

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 the 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).\footnote{An overview of the New Open Economy literature starting with Obstfeld and Rogoff (1995, 1996) can be found in Lane (2001) or Corsetti (2008).} These models are based on the optimizing behaviour of representative agents and feature monopolistic competition and nominal rigidities. The basic New Keynesian DSGE model has been adopted to the small open economy setting by Galí and Monacelli (2005) and Monacelli (2005).

Openness and nominal sticky-ness were defining characteristics of the Swedish economy in the interwar period. The ratio of imports and export in GPD of about 50 percent in 1929 gives an 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. From 1928 to 1933 wholesale prices decreased by roughly thirty percent, while consumer prices fell by little more than ten percent. And from 1933 to 1937, wholesale prices increased by almost forty percent, while consumer prices crept up by roughly 8 percent (Edvinsson and Söderberg, 2010).

3.1 Households

We consider a small open economy that is populated by an infinitely-lived representative household. The household seeks to maximize the current
present discounted expected value of utility defined by

\[ V = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t), \]  

(1)

where \( \beta \) is the discount factor, and \( U(.,.) \) denoted 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 \( C_t^f \),

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

(2)

and

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

(3)

The elasticity of substitution between domestic and foreign goods is measured by the parameter \( a \), and \( \gamma \) measures the degree of home bias in consumption and therefore is a natural indicator of the openness of the economy. Moreover, \( \theta \) is the elasticity of substitution between domestic varieties. The optimal allocation of expenditures across domestic and foreign goods implies the demand functions

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

(4)

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

\[ C_t^h(j) = \left( \frac{P_t^h(j)}{P_t^h} \right)^{-\theta} C_t^h, \]

(5)
where \( P^h_t = \left( \int_0^1 P^h_t(j)^{1-\theta} dj \right)^{1-\theta} \) is the appropriate domestic price index. The period budget constraint can be written as

\[
P_tC_t + E_t(Q_{t,t+1} B_{t+1}) = W_t N_t + B_t + T_t. \tag{6}
\]

Note that \( P_tC_t = \int_0^1 P^h_t(j)C^h_t(j) dj + P^f_t C^f_t \). 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 \( t-1 \). Therefore, \( E_t Q_{t,t+1} B_{t+1} \) 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 or tax. The remaining optimality conditions can be rewritten in the convenient form

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

The first equation describes the optimal intratemporal labor/leisure choice, and the second one 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 a 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

\[
P^f_t = S_t P^*_t, \tag{9}
\]
where $P^*_t$ is the foreign currency price of the foreign produced good, and $S_t$ 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) are defined as

$$\Delta_t \equiv \frac{P^*_t}{P^h_t} = \frac{S_t P^*_t}{P^h_t}.$$  

Note that $\Delta$ is equal to 1 in the steady-state (PPP holds). To study the effect of an undervalued currency, we treat $\log \Delta_t$ as an unobservable exogenous stable AR(1) process which allows us to estimate the time path of the terms of trade, $\log \Delta_t = \rho \delta \log \Delta_{t-1} + \epsilon^\delta_t, \epsilon^\delta_t \sim N(0, \sigma^2_\delta)$.

### 3.3 Domestic Firms

There exists a continuum of monopolistic competitive firms that produce differentiated domestic goods. All firms use identical constant returns to scale production functions

$$Y_t(j) = Z N_t(j), \quad j \in [0, 1],$$

where, we assume that $Z = 1$ for all firms. TFP shocks can be interpreted as reduced-form shocks that can have very heterogeneous causes. In our empirical methodology, we allow for a even more general reduced-from shock as the conventional autoregressive one, hence it is unnecessary here. We analyze the optimal behavior of the firms in two steps. First note that minimizing the cost of production $\frac{W_t}{P^h_t} N_t(j)$ subject to producing $Y_t(j) = N_t(j)$ implies

$$MC_t = \frac{W_t}{P^h_t},$$

where $MC$ is the real marginal cost of production and $W_t/P^h_t$ 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 \( \omega^k \), which means an 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

\[
C^h_t(j) = \left( \frac{P^h_t(j)}{P^h_t} \right)^{-\theta} Y_t, \quad (13)
\]

with \( Y_t = C^h_t + C^h_t^* \), where the superscript ‘∗’ denotes foreign demand for domestic goods. Since all firms face identical demand curves and have the same production technologies, all firms which are allowed to reoptimize, choose the same price \( \bar{P}^h_t \) in order to maximize the current value of the profits generated while the price stays effective:

\[
\bar{P}^h_t = \arg \max_{P^h_t(j)} E_t \sum_{\tau=0}^{\infty} \omega^\tau Q_{t,t+\tau}(P^h_t(j) - P^h_{t+\tau}MC_{t+\tau}) \left( \frac{P^h_t(j)}{P^h_{t+\tau}} \right)^{-\theta} Y_{t+\tau}. \quad (14)
\]

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

\[
E_t \sum_{\tau=0}^{\infty} (\omega)^\tau Q_{t,t+\tau} Y_{t+\tau} \left( 1 - \theta \right) \left( \frac{\bar{P}^h_t}{P^h_{t+\tau}} \right)^{-\theta} + \theta \left( \frac{\bar{P}^h_t}{P^h_{t+\tau}} \right)^{-\theta-1} MC_{t+\tau} = 0. \quad (15)
\]

This infinite sum can be expressed more conveniently in recursive fashion using auxiliary variables (Schmitt-Grohé and Uribe, 2004). The price setting equation can be written as

\[
\frac{\bar{P}^h_t}{P^h_t} = \frac{\theta}{\theta - 1} \frac{A_{1,t}}{A_{2,t}}, \quad (16)
\]

with

\[
A_{1,t} = Y_t MC_t + \omega \beta E_t \frac{U_C(C_{t+1}, N_{t+1})}{U_C(C_t, N_t)} \Pi_{t+1}^{-1}(\Pi_t^{h+1})^{\theta+1} A_{1,t+1};
\]

\[
A_{2,t} = Y_t + \omega \beta E_t \frac{U_C(C_{t+1}, N_{t+1})}{U_C(C_t, N_t)} \Pi_{t+1}^{-1}(\Pi_t^{h+1})^\theta A_{2,t+1}. \quad (17)
\]
The other firms have to keep 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 were price levels are stable in the long run. Using the definition of the domestic price index implies

\[ 1 = (1 - \omega) \left( \frac{\theta - 1}{\theta - 1 A_{1,t}} \right)^{1-\theta} + \omega (\Pi^h_t)^{\theta-1}. \]  

(18)

3.4 International Consumption Risk-Sharing and Market Clearing

The foreign country is assumed to be 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.\(^8\) Consumption of the domestic good in the foreign country (export demand) is given by

\[ C^{h*}_t = \gamma \left( P^h_t / S_t P^*_t \right)^{-a} Y^*_t, \]  

(19)

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

\[ \log Y^*_t = (1 - \rho^*) \log Y^* + \rho^* \log Y^*_{t-1} + \epsilon^*_t, \epsilon^*_t \sim N(0, \sigma^2_\epsilon). \]

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 the foreign households can be characterized by the following Euler equation

\[ Q_{t,t+1} = \beta \frac{U^*_{C^*}(C^*_{t+1}, N^*_{t+1})}{U_{C^*}(C^*_t, N^*_t)} \left( \frac{P^*_t S_t}{P^*_{t+1} S^*_{t+1}} \right). \]  

(20)

\(^8\)More precisely think of 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 Gali and Monacelli (2005) for a more detailed description.
When combining (20) with the optimal choice of the domestic households (7) the following condition can be derived:\footnote{See also Chari et al. (2002). Schmitt-Grohé and Uribe (2003) provide different methods to close small open economy models. However they make no big difference.}

\[
\frac{U_{C^*}(C^*_t, N^*_t)}{U_C(C_t, N_t)} = \mu \Phi_t, \tag{21}
\]

where \( \mu = \frac{U_{C^*}(C^*_0, N^*_0)}{U_C(C_0, N_0)} \left( \frac{1}{\Phi_0} \right) \) is a constant that depends on the initial distribution of wealth across countries. Note, that in the case of symmetric initial conditions, \( \mu \) equals 1. 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 the optimal portfolio choice.

Market clearing in the domestic goods market requires

\[
Y_t = C^h_t + C^*_t, \tag{22}
\]

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 labor and goods market clearing conditions together with the definition of the production technology (11), we can derive an implicit aggregate production function

\[
Y_t = \frac{N_t}{\varsigma_t}, \tag{23}
\]

where \( \varsigma_t = \int_0^1 \left( \frac{P^h_t(j)}{P_t} \right)^{\frac{\theta}{1+\theta}} \, dj \) is a measure of price dispersion.

For the further analysis we log-linearize the system around the deterministic steady-state values. For the period utility function, we choose \( U(C_t, N_t) = \frac{C^{\gamma-\sigma}_t}{1-\sigma} + \frac{N^{1+\eta}_t}{1+\eta} \), where \( \sigma^{-1} \) denotes the intertemporal elasticities of substitution, and \( \eta^{-1} \) is the labor supply elasticity.
4 Empirical Analysis

To gain deeper insight, we estimate the structural small new open economy model outlined above for the Swedish data in the 1930s. We built on a recent strand of the literature that deals with the estimation of new open economy models. Different empirical strategies have been applied, such as Ghironi (2000), who applied non-linear least squares at the single-equation level to estimate the structural parameters of such a model. Smets and Wouters (2002) based their estimation on matching model implied impulse responses with those of an an identified VAR, 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 the estimation. This has the advantage that the estimation has not to 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 to incorporate 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 $v_t$ is derived:

$$v_t = L \begin{pmatrix} y_t \\ x_t \end{pmatrix},$$

$$y_t = L_{yy}y_{t-1} + L_{yx}x_{t-1},$$

$$x_t = Ax_{t-1} + \epsilon_t.$$  \hfill (24)

The vector $x_t$ is a collection of the structural shocks of the model consisting of the terms of trade shock $\delta_t$ and the foreign output shock $y_t^*$. Hence, the matrix $A$ is equal to $\text{diag}(\rho_\delta, \rho_*)$ and the covariance matrix of $\epsilon$ is given by $\Sigma = \text{diag}(\sigma_\delta^2, \sigma_*^2)$. To account for potential measurement error and model misspecification $^{10}$ we add a vector autoregressive measurement error $\epsilon_t$ for

\hfill 10Del Negro et al. (2004) show that misspecification is also an issue for larger scale models. See also Schorfheide (2000) for a loss function based comparison of potentially
the estimation as proposed by Ireland (2004). The empirical model is thus
given by

\[ v_t = L \begin{pmatrix} y_t \\ x_t \end{pmatrix} + e_t, \quad (25a) \]

\[ y_t = L_{yy} y_{t-1} + L_{yx} x_{t-1}, \quad (25b) \]

\[ x_t = Ax_{t-1} + \epsilon_t, \quad (25c) \]

\[ e_t = De_{t-1} + \xi_t, \quad (25d) \]

where \( D \) is a matrix of VAR parameters of the measurement error represent-
ing off-model dynamics, and \( \xi_t \) is a zero mean vector of disturbances with
covariance matrix \( \Upsilon \).

### 4.1 Data and Prior Choice

To estimate 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 a consumer price index published by the League
of Nations, inflation is calculated as seasonal first differences of the price
index in logs and is demeaned. Industrial production (seasonally adjusted)
is also from the League of Nations.\(^{11}\) Following Rabanal and Rubio-Ramírez
(2005), we calculated log-deviation from a quadratic trend. The vector of
observable variables for which we derive the state-space representation con-
­sists of \( v_t = [y_t, \pi_t]' \). As already emphasized by Sims (1980), strong a priori
restrictions are necessary to identify rational expectation models. To over-
come identification problems a number of parameters usually are calibrated
(infinitely strict priors are used).\(^{12}\) We set the discount factor to the con-
ventional 0.99, and the long-run share of imports in consumption \( \gamma \) to the
sample average (annual data).

We impose uniform priors with reasonable ranges for the rest of the struc-

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\(^{11}\)Data are available on request.

\(^{12}\)On identification problems associated with the estimation of New Keynesian models, see e.g. Beyer and Farmer (2004) or Lubik and Schorfheide (2006).
tural parameters to be as loose as possible: $\theta \sim U(5, 7)$, $\eta \sim U(1.5, 3)$, $\sigma \sim U(1.5, 3)$, $a \sim U(3, 6)$, $\omega \sim U(0.6, 0.8)$, $\rho_* \sim U(0, 1)$, $\rho_\delta \sim U(0, 1)$, $\sigma_* \sim U(0.0001, 0.001)$, $\sigma_\delta \sim U(0.0001, 0.001)$. For the VAR-component, we require stationarity and positive semidefiniteness of the matrix $\Psi$.\textsuperscript{13}

To generate the parameter chain, we use the tailored randomized MCMC method proposed by Chib and Ramamurthy (2010). The 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.\textsuperscript{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.\textsuperscript{15} The proposal is accepted if the value of the posterior at the 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.\textsuperscript{16}

### 4.2 Results

The parameter estimates are summarized in Table 1. The table shows posterior means and standard deviations together with 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, the foreign demand shock having about twice the standard deviation as the terms of trade shock. The

\textsuperscript{13}In addition, for the Markov chain to converge, we had to impose a maximum absolute eigenvalue of 0.6, and that the maximum measurement error variances are less than 60 per cent of the corresponding observable time series. This is similar but less restrictive than García-Cicco et al. (2010, p. 2519), who restrict the measurement error variance to maximally 6 per cent of the observable time series.

\textsuperscript{14}The probability of staying in the same block is set to 0.8.

\textsuperscript{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 temperature 10, initial stage length 4.

\textsuperscript{16}All programs were written from first principles in Matlab version R2009b. For gaining speed, the Kalman filter to derive the likelihood was coded in C.
expected average duration of prices \((1 - \omega)^{-1}\) is about 5 years.

Our main 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 the estimated foreign output for Sweden 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.\(^\text{17}\) From early 1932 until mid 1935, the mean and nearly all probability mass of the estimated terms of trade are located in region of undervaluation, indicating a lastingly undervalued Swedish krona by up to 4 percent. 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. Repeatedly, the Riksbank expressed its concern over exchange rate stability. By trying to keep the exchange rate fixed and accumulating ever more reserves, the Riksbank kept the krona undervalued which boosted exports. The decrease in estimated world output until 1933 clearly shows the dire consequences of the Great Depression. However, a recovery starting in 1933 can also be observed. Clearly, this has also contributed to the recovery.

\(^\text{17}\)The real exchange rate is proportional to the terms of trade. Hence, the movements of the real exchange rate are up to a constant factor the same as for the terms of trade.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>SD</th>
<th>NSE</th>
<th>Geweke’s $\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta$</td>
<td>6.333960</td>
<td>0.500391</td>
<td>0.032881</td>
<td>0.462385</td>
</tr>
<tr>
<td>$\eta$</td>
<td>2.360571</td>
<td>0.413580</td>
<td>0.019320</td>
<td>0.600004</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>2.588666</td>
<td>0.337404</td>
<td>0.019578</td>
<td>0.578641</td>
</tr>
<tr>
<td>$a$</td>
<td>3.598114</td>
<td>0.526474</td>
<td>0.020807</td>
<td>0.692470</td>
</tr>
<tr>
<td>$\omega$</td>
<td>0.983331</td>
<td>0.003471</td>
<td>0.000197</td>
<td>0.639113</td>
</tr>
<tr>
<td>$\rho_\star$</td>
<td>0.998994</td>
<td>0.000170</td>
<td>0.000002</td>
<td>0.938818</td>
</tr>
<tr>
<td>$\rho_\delta$</td>
<td>0.998678</td>
<td>0.000274</td>
<td>0.000011</td>
<td>0.818986</td>
</tr>
<tr>
<td>$\sigma_\star$</td>
<td>0.020562</td>
<td>0.005095</td>
<td>0.000260</td>
<td>0.481140</td>
</tr>
<tr>
<td>$\sigma_\delta$</td>
<td>0.010788</td>
<td>0.000745</td>
<td>0.000019</td>
<td>0.918839</td>
</tr>
<tr>
<td>$d_{11}$</td>
<td>0.552966</td>
<td>0.055079</td>
<td>0.003597</td>
<td>0.801800</td>
</tr>
<tr>
<td>$d_{21}$</td>
<td>-0.116966</td>
<td>0.028224</td>
<td>0.001545</td>
<td>0.422040</td>
</tr>
<tr>
<td>$d_{12}$</td>
<td>0.056536</td>
<td>0.048719</td>
<td>0.002976</td>
<td>0.473774</td>
</tr>
<tr>
<td>$d_{22}$</td>
<td>0.618279</td>
<td>0.058291</td>
<td>0.003890</td>
<td>0.905990</td>
</tr>
<tr>
<td>$\sqrt{v_{11}}$</td>
<td>0.029215</td>
<td>0.003683</td>
<td>0.000221</td>
<td>0.928962</td>
</tr>
<tr>
<td>$v_{21}$</td>
<td>-0.000165</td>
<td>0.000025</td>
<td>0.000001</td>
<td>0.628313</td>
</tr>
<tr>
<td>$\sqrt{v_{22}}$</td>
<td>0.006465</td>
<td>0.000961</td>
<td>0.000062</td>
<td>0.857368</td>
</tr>
</tbody>
</table>

Notes: The posterior distribution is based on 100,000 replications. 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 $\chi^2$ test ($H_0$: the mean of the first 20% of the chain is equal to the mean in the last 50% of the chain).
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 confirms our claim. At all forecast horizons, the terms of trade shock plays an important role in explaining output. It is nearly as important as the world demand shock, which is remarkable in a sample that includes the Great Depression. It accounts for about forty per cent of the overall forecast error variance at the longer forecast horizons. The 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 smaller degree also the terms of trade shock.

Figure 7: Forecast Error Variance Decomposition
4.2.1 Model Evaluation and Counterfactual Analysis

To see how well the estimated states reproduce the data they are supposed 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: it takes until 1936/37 before the two curves start to drift apart.

Figure 8: PPP vs. Estimated Terms of Trade

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

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 does actually mimic the movements almost perfectly.

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To further illustrate 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 able to isolate the effect of the devaluation from effect of the recovery of the world economy, we also examine a scenario in which the recovery of world demand did nor occur. Using the hypothetical path for the terms of trade and foreign output, it is possible to simulate the model. To compare the outcome of the counterfactual simulations to Sweden’s actual performance, annual averages of the simulated median monthly percentage changes in output are used to compute counterfactual annual industrial production series. The

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 steady-state.
The simulation shows an unfavorable picture. If Sweden had not depreciated, the downturn of the Great Depression would have been much more severe: counterfactual industrial production falls to 75 per cent of the 1929 level, similarly to the situation in Norway (Figure 1). In reality, the lower turning point was reached at about 90 per cent. Because Sweden could rely on the demand for its export goods, the recovery of foreign output would have helped to 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 performance in 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 to an overvalued level in 1930. The dashed line depicts counterfactual yearly output in the “No Recovery” scenario, which does not allow for a reviving of the world economy in 1933.
5 Conclusion

Sweden was among the first to recover from the depression in the early 1930s, and did so in a particularly impressive way. In this paper we test the contribution made by economic policies. Building on Lundberg (1983) who claimed on the basis of descriptive statistics that Sweden consciously kept its currency undervalued vis-a-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. Sweden would not have enjoyed such high growth rates after 1932 if the currency had not been relatively weak. Our counterfactual simulations show that industrial production would have reached the pre-crisis level in 1935 while in reality it already achieved this point in 1933.

This finding may contribute not only to the literature on Sweden’s growth miracle in the 1930s, but also to the study of the Great Depression in general. Sweden has been viewed as an example showing that some central banks were more innovative than others. In particular, the Swedish experiment with price level targeting has been cited by monetary economists as a sort of prototype of today’s inflation targeting. This paper argues that such a view overvalues the 1930s as a decade of policy innovation. Before as well as 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. The idea of targeting the domestic price level which implied a floating exchange rate was fully rejected. 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 an unintentional byproduct of a conservative central banking policy.
References


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