

Canst Thou Beggar Thy Neighbour? Evidence from the 1930s

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Abstract

Does an exchange rate depreciation depress trading partners' output? I address this question through the lens of a classic episode: from 1931 to 1936, the largest economies in the world successively devalued their currency. In theory, the effect is ambiguous for countries that had not devalued: expenditure switching can lower their output, but the monetary stimulus to foreign demand might raise it. I use cross-sectional evidence to discipline the strength of these two mechanisms in a multi-country model. Contrary to the popular narrative in modern policy debates, devaluation did not dramatically lower the output of trading partners in this context.

Keywords: beggar-thy-neighbour, devaluations, Great Depression, trade elasticities

JEL codes: E5, F3, F4

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1 Introduction

“Beggar thy neighbour, zero-sum game, currency war”: currency depreciation gets a bad rap. In theory, exchange rate depreciation can cause a contraction in foreign output: if prices or costs are sticky in the producer’s currency, a depreciation cheapens domestic goods on international markets, which shifts demand towards those goods, possibly lowering output in foreign countries. This mechanism is at play in prominent international macroeconomic models since at least Fleming (1962) and Mundell (1963). In policy circles, recriminations fly when a country engages in a monetary expansion that leads to a depreciation of the currency. In 2010, Guido Mantega, then Brazil’s finance minister, famously equated the Federal Reserve’s quantitative easing (QE) to monetary warfare.¹ Such claims resurfaced when the European Central Bank took the QE route in 2015.²

Are these concerns justified? My answer is no: a devaluation has a small effect on foreign output. It is, however, a big stimulus for domestic output. To reach that conclusion, I follow a micro to macro approach: I identify empirical moments in cross-country and new product-level trade data, use these moments to estimate a model, and run counter-factual experiments. To implement this approach, I focus on a specific historical episode: the currency devaluations of the 1930s.

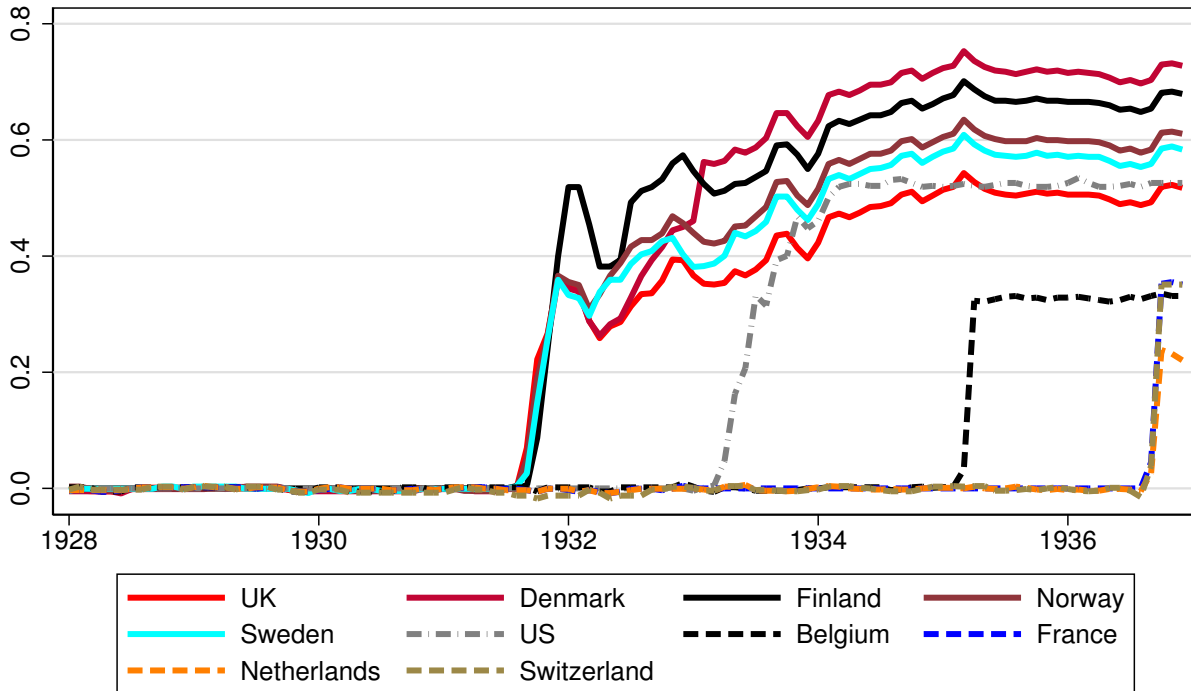
The 1930s currency devaluations are an attractive setting for several reasons. First, they are a classic example of what are generally thought to be competitive devaluations. Second, they form a sequence of large events: many countries, including the biggest economies in the world, devalued their currencies by 30 to 40% against gold. Last but not least, the staggered way in which these countries devalued is ideal for identification. This staggered feature is apparent on figure 1, which shows the nominal price of gold in selected currencies. Until 1931, the countries on the chart were on the gold-exchange standard: the price of gold — hence the exchange rate with other currencies that are on gold — was stable. In September 1931, Britain left the gold standard. It was quickly followed into devaluation by, among others, Scandinavian countries. On the other hand, several countries stayed on the gold standard, sometimes for years: the United States (US) devalued in April 1933; the so-called gold bloc, led by France, only dislocated in October 1936. Such discrepancies in timing create cross-sectional variation that is ripe for identification.

Eichengreen and Sachs (1985) offer the classic treatment of this episode. They show

¹“We’re in the midst of an international currency war, a general weakening of currency.” See Jonathan Wheatley, “Brazil in ‘currency war’ alert,” *Financial Times*, September 27, 2010, <https://www.ft.com/content/33ff9624-ca48-11df-a860-00144feab49a>.

²David Keohane, “All currency war, all the time”, *Financial Times*, February 5, 2015, <https://www.ft.com/content/c259d418-d0ca-37d5-a3bd-27748fc1024e>.

Figure 1: Gold price in selected currencies



Note: log of the nominal price of gold expressed in country's currency — 1930 is normalized to 0. An increase corresponds to a devaluation.

that countries which devalued earlier recovered earlier from the Great Depression. Albeit foundational, this result has several limitations. The first one is that it's not necessarily causal since it is only a regression of the change in industrial production on the change in the exchange rate. If the decision to devalue was endogenous to output, these estimates are biased. Second, even interpreted in a causal way, this evidence only speaks to the relative effect, not the absolute one. Indeed, one does not know if British output was going up compared to French output, because British output was going up compared to a counterfactual scenario where Britain hadn't devalued, or because French output was going down. Finally, as Eichengreen and Sachs (henceforth ES) emphasize, the exchange rate is not the only channel through which devaluations might have affected output. Cutting the gold content of the currency relaxes the gold cover constraint of the central bank. The latter can then expand the money supply or lower its discount rate, thereby stimulating aggregate demand. So the ES regression might capture a closed-economy monetary stimulus, instead of the effect of a competitive devaluation. Part of my contribution is to overcome these three limitations.

First, I analyze cross-country data to establish a causal relationship between output and devaluation. To do so, I conduct two empirical exercises.

The first one is a difference-in-difference (DD) estimation. Since some countries devalued in 1931 while others stayed on the gold standard, the episode is an ideal setup. Countries which devalued produced more, exported more, and experienced a drop in real wages following the devaluation, relative to countries that did not. They did not import less — in fact, they imported more after a few years — which runs against the beggar-thy-neighbour presumption. Nominal variables such as price and wage indices also increased. On the monetary side, the action did not come from the nominal but from the real interest rate: inflation was higher in devaluing countries, which pushed the real rate down. Finally, devaluing countries do not exhibit preexisting trends in these variables. That they do not rules out some endogeneity concerns — the devaluation decision does not depend on recent economic performance — but it does not rule out all of them. Devaluation may occur in reaction to a contemporaneous shock that would not appear in the preexisting trend but would affect future output. This caveat motivates another identification strategy.

The second empirical exercise relies on high-frequency identification (HFI). I first construct series of policy announcements based on newspaper articles. Most of these events are a devaluation, or an announcement that makes devaluation less likely, such as the fall of an easy money cabinet. I use the change in the forward exchange rate around these announcements as a shock. As long as financial markets anticipate devaluations that systematically correlate with economic conditions, changes in the forward exchange rate around policy announcements are exogenous to those same economic conditions. Armed with these shocks, I can use them as instruments for the spot exchange rate in low-frequency regressions of macroeconomic variables. The identification assumption is conceptually similar to that made by researchers who use changes in federal funds rate futures around Federal Open Market Committee (FOMC) meetings — a well-established identification scheme to infer the causal effect of monetary policy on macroeconomic variables.

These two independent estimation methods show that devaluation stimulated output powerfully. A 30% devaluation increased industrial production by 6% over the following 3 years according to the DD estimates, by 14% according to the HFI ones — compared to a country that did not devalue.

Second, a model is necessary to translate those relative effects into absolute ones. I develop a multi-country model which features three main ingredients: (i) incomplete pass-through of the exchange rate to international prices (which I show later is an essential feature of the data), (ii) sticky wages to generate monetary non-neutrality, and (iii) a gold standard to engineer the devaluation. The model allows for both expenditure switching and monetary stimulus. In the model, the strength of the expenditure switching channel depends on the elasticity of substitution between domestic and foreign varieties, the elasticity of substitution

among imported varieties, and the pass-through of the exchange rate to international prices.

Since those parameters are important, I digitize new product-level data on US imports to estimate the last two — the first one is estimated later out of cross-country data. This data comes from an official publication of the Department of Commerce, the *Foreign Commerce and Navigation of the United States*. Estimating a demand elasticity is always challenging: in general, the price of a good is correlated with demand shocks. An ordinary least square (OLS) regression of quantity on price would suffer from simultaneity bias. The 1930s, however, offer a readily available instrument: the exchange rate. I show that, as long as devaluation is exogenous to demand shocks for different national varieties of the same product, this instrument identifies the within-product elasticity of substitution among foreign goods. I defend this assumption by checking that prices and quantities do not display pre-existing trends. I find a demand elasticity between 2 and 4, and a pass-through of about 0.4. For a one percent decline in their relative price, US imports of British varieties increase by 2–4%, compared to French varieties. For a 1% depreciation of the pound, dollar prices of British products go down by 0.4%.

Third, I estimate the model by matching moments from cross-country and trade data and run counter-factual experiments. I find that the 1930s devaluations had small effects on non-devaluing countries' output. Put another way, British output was going up compared to French output mostly because British output was going up compared to a counter-factual scenario where Britain hadn't devalued — not because French output was going down. An equivalent way to state this conclusion is that the effect estimated in the cross-section is almost entirely attributable to higher output in devaluing countries, not less output in non-devaluing ones: the absolute effect is close to the relative one.

Finally, I clarify how cross-sectional evidence is informative about the absolute effect of a devaluation on devaluing and non-devaluing countries. The absolute effect is the sum of two terms. One depends on the effect on devaluing countries' output relative to non-devaluing countries, the other one is the absolute effect on world output. The first term is pinned down by cross-sectional evidence, but the second one is absorbed by time fixed effects. Since the model matches cross-sectional evidence, the result depends on the model's predictions for world output. Those predictions in turn rely on certain structural parameters which determine how powerful monetary policy is — expenditure switching is a wash and doesn't matter to world-level variables. The cross-section is informative about those parameters. For instance, the relative path of nominal wages is informative about how sticky they are, which conditions the ability of monetary policy to affect real interest rates. The relative path of output is informative about how it responds to changes in real rates. Overall, parameter estimates point toward a monetary stimulus that is big enough to offset expenditure switching

in non-devaluing countries. In devaluing countries, those two forces work together.

Literature review: I contribute to the literature on the Great Depression. Friedman and Schwartz (1963, p. 362) were the first ones to note a cross-country correlation between devaluation and recovery. Building on Eichengreen and Sachs's (1985) contribution, Campa (1990) or Bernanke and Carey (1996) study currency devaluations across countries; Mitchener and Wandschneider (2015) study capital controls. Eichengreen (1992) analyzes the interwar gold standard. Mathy and Meissner (2011) are interested in how trade and exchange rates affect business cycle co-movement. Accominotti (2009) investigates the credibility of the gold standard in Britain before the devaluation. Cohen-Setton et al. (2017) examine the consequences of supply-side reforms in France — reforms that were contemporaneous to its 1936 devaluation. Hausman et al. (2019) argue that the US devaluation bailed out US farmers through its effect on agricultural prices. de Bromhead et al. (2018) or Albers (2019) delve into tariff policies. Ellison et al. (2023) argue that devaluation affected ex-ante real interest rates. In contemporaneous work, Candia and Pedemonte (2021) are also interested in the spillovers of exchange-rate policy on trading partners. Compared to these papers, I bring causal evidence of the effect of devaluations across countries, translate it an absolute effect, and answer the beggar-thy-neighbour question.

The model builds on the open-economy New Keynesian literature. Svensson and van Wijnbergen (1989), Obstfeld and Rogoff (1995) are founding papers. Subsequent literature has been preoccupied with optimal monetary policy in the open economy. Clarida et al. (2002), Benigno and Benigno (2006) showed that under complete markets and local currency pricing, optimal policy consists in stabilizing producer price inflation and output gap, like in the closed economy. With local currency pricing, monetary policy trades off internal objectives with international prices misalignment (Devereux and Engel, 2003, Corsetti and Pesenti, 2005, Engel, 2009). In their handbook chapter, Corsetti et al. (2011) summarize the lessons of the international New Keynesian literature: they argue that concerns for competitive devaluations tend to be overrated since policy responses abroad offset strategic terms-of-trade manipulations. To that tradition, I bring more recent elements from the incomplete pass-through literature (Gopinath and Itskhoki, 2010, Amiti et al., 2014a, Burstein and Gopinath, 2014, Itskhoki and Mukhin, 2021). Compared to these papers, my contribution is to build a model with realistic cross-sectional implications for devaluations, and draw quantitative counter-factual conclusions.

I add to empirical studies of large devaluations. Most of it deals with developing countries in a modern context. For instance, Verhoogen (2008) analyzes firm-level data around the 1994 peso devaluation. Burstein et al. (2005, 2007) argue that the behavior of the real

exchange rate after a devaluation is attributable to the slow adjustment of non-tradable goods and services. Mattoo et al. (2017), Rose (2021), Alessandria et al. (2018), Rodnyansky (2019), Kohn et al. (2020) study the behavior of exports following a large depreciation. Compared to these papers, I answer the beggar-thy-neighbour question.

2 Cross-Country Evidence

2.1 Difference-in-Difference Estimation (DD)

From an empirical standpoint, the 1931 devaluations have an appealing feature: before 1931, most countries were on a fixed exchange rate; in 1931, a group of countries devalued their currencies while others stayed on the gold standard for several years, some until 1936. Setting endogeneity aside for now, it is tempting to see the first set of countries as a treated group, and the second one as a control group.

To apply this insight, I run the following specification:

$$\log \left(\frac{Z_t^j}{Z_{1930}^j} \right) = \beta_t \log \left(\frac{X R_{1932}^j}{X R_{1930}^j} \right) \times \mathbb{1}_t + \mu_t + e_t^j \quad (1)$$

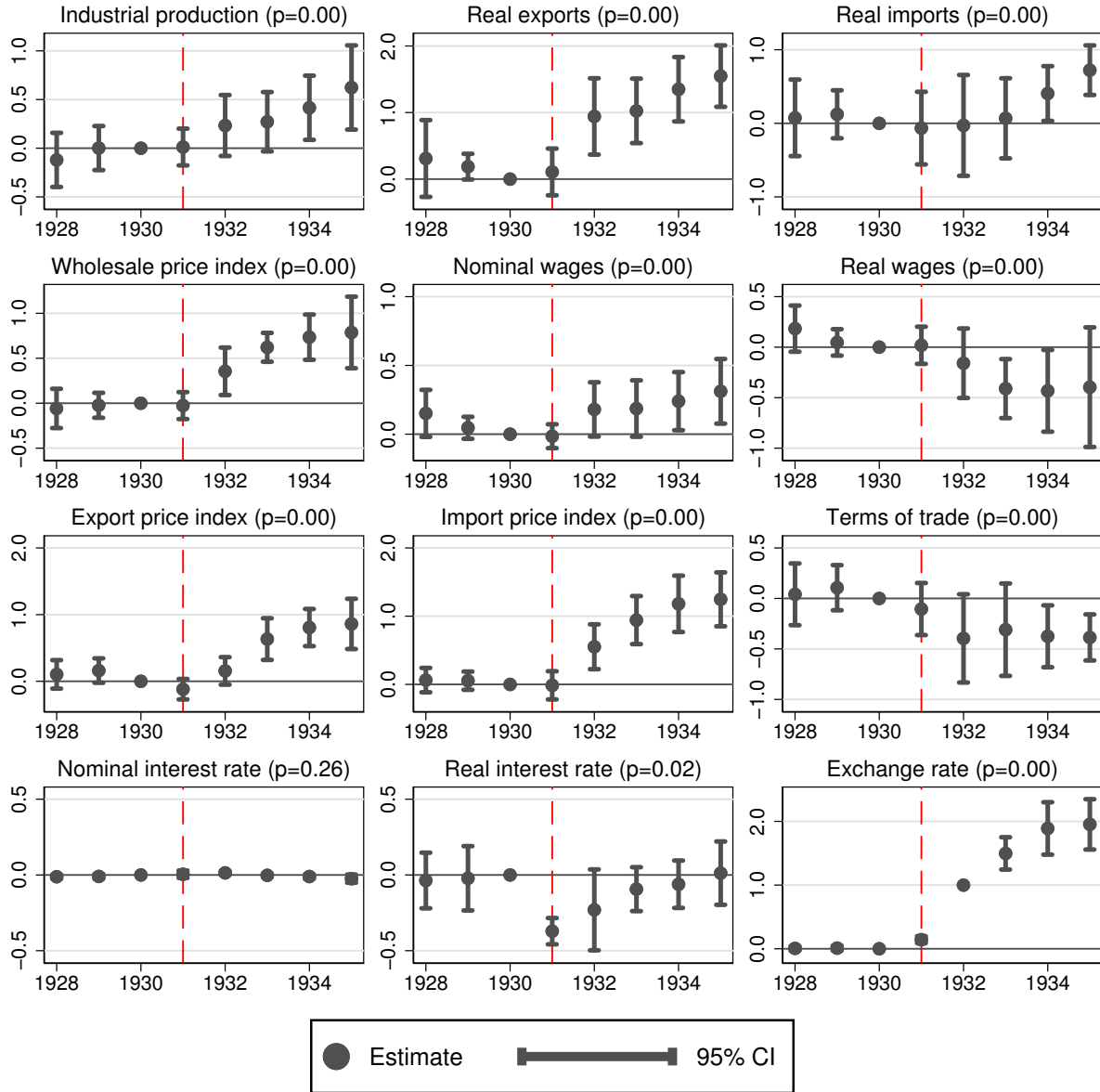
where Z_t^j is an aggregate variable of interest (industrial production, prices, etc.) in country j in year t ; $X R_t^j$ the exchange rate, expressed as the local-currency price of gold; $\mathbb{1}_t$ a year dummy; and μ_t a year-fixed effect. The sample is restricted to countries that either devalued in 1931 (e.g. Britain) or did not devalue before 1936 (e.g. France).³ I study years 1928 to 1935 in order to include pre- and post-treatment years.

The change in the exchange rate is instrumented with a devaluation dummy, so that β_t can be interpreted as the performance of devaluing countries, relative to non devaluers, scaled by the average change in the exchange rate. Figure 2 displays those coefficients for 9 macroeconomic variables. In the appendix, I also present results for a specification where I estimate equation (1) by ordinary least squares (figure A.2). These results are denoted DD-OLS while the baseline is DD-IV.

The devaluations were followed by a sharp relative increase in industrial production, exports and, after a few years, imports. The increase in imports may seem surprising since the expenditure switching channel would predict a fall as these become dearer. Nominal quantities also increased, but not one for one. Since the impulse response functions (IRF) are normalized by the change in the exchange rate, full pass-through of the 1930-32 change in the exchange rate to nominal quantities would correspond to a coefficient of 1. For instance,

³Country samples are summarized in the appendix (table A.1).

Figure 2: Aggregate variables (DD-IV)



Note: response of relevant variable in devaluing countries, relative to non-devaluing ones. Formally, the plots show the estimate of β_t in equation (1). β_{1930} is normalized to 0. Standard errors are bootstrapped with 2,000 replications, and clustered at the country level. The number in parenthesis is the P-value of a test of the joint significance of the 1932 to 1935 coefficients. The y-axis scale of the nominal and real interest rates are identical for visual convenience.

in 1935, wholesale prices had only increased by about 50% in countries that devalued, relative to countries that didn't. The pass-through is even lower for nominal wages, so that real wages went down in countries that devalued.

On the monetary front, the action did not come from the nominal interest rate, but from the real interest rate. The devaluations did not coincide with significant cuts in the discount rate of the central bank. On the other hand, the relative increase in the price level implies that the real interest rate fell sharply.⁴ The 1931 coefficient of -0.37 entails an 11% basis points cut in the real interest rate for a devaluation of 30%. Calling the 1931 depreciation of the pound a devaluation is a slight abuse of language. In truth, British authorities suspended the gold convertibility of the pound, let it depreciate for a few months, and actively managed the exchange rate from July 1932 onward. The tie to gold was never formally re-established. Other devaluers similarly allowed their currency to depreciate before pegging to the pound (Eichengreen, 1992, ch. 10). Therefore, I investigate the behavior of the exchange rate after 1932 by estimating equation (1) with the exchange rate on the left-hand side — $\hat{\beta}_{1932} = 1$ by construction. The exchange rate kept depreciating after 1932 (bottom right panel of figure 2).

The behavior of imports is a first dent into the beggar-thy-neighbour story. One side of that story is that, through devaluation, the country makes its domestic goods cheaper, importing less itself, and forcing others to import more. I find no evidence for that mechanism, suggesting either a low substitution between imports and domestic goods, or an offsetting response of domestic demand... or both. In fact, after a few years, those countries imported more, which is suggestive of a strong response of domestic demand. These estimates conflict with the findings of a contemporaneous paper by Candia and Pedemonte (2021). Looking at a cross-section of US cities around 1931, they argue that those that were more exposed to sectors which were exporting to devaluing countries experienced a fall in bank debits. (Bank debits are the only city-level measure of economic activity that is available at monthly frequency.) This is puzzling in light of my results: a necessary condition for those cities to be hurt would seem to be that devaluing countries imported less. That devaluing countries did not import less will be confirmed by the cleaner high frequency identification.

Did other policies correlate with exchange rate depreciation? The first possibility is changes in tariff. A relative tariff decline in countries that devalued may explain the behavior of imports on figure 1. Figure A.3 in the appendix shows that countries which devalued indeed experienced a relative decline in the ratio of tariff revenues divided by the value of their

⁴Absent direct measures on inflation expectations, I computed the ex-post real interest rate: $r_t \approx i_t - \pi_{t+1}$ where i_t is the discount rate of the central bank and π_{t+1} is the annual inflation rate of the wholesale price index.

imports. These changes were driven by tariff hikes in countries that did not devalue, instead of tariff cuts in countries that did (Eichengreen and Irwin, 2010). The second possibility is fiscal policy. After all, the pound devaluation occurred in the face of stalling negotiations around the government budget. It is conceivable that, by relaxing the constraint that it exerted on monetary policy, leaving the gold standard allowed the central bank to print money to finance the fiscal authority. Through higher spending, fiscal policy might have stimulated output. Evidence shown on figure A.3 disproves this story. If anything, real government spending declined after the devaluations. The test of joint significance of the 1932 to 1935 coefficients returns a p-value that is too high to reject the null that all coefficients are 0. The same is true about revenues.⁵ In any case, these policies do not explain the results. In figure A.1, I add the changes in tariff and fiscal variables as controls, without discernible effects on the point estimates of the main variables. They can, however, lower statistical significance for some variables (table A.3).

Why did countries devalue, why did they not? According to Eichengreen and Sachs (1985) and Eichengreen (1992), the decision to devalue was shaped by past experience with the gold standard more than contemporaneous economic performance. In Britain, where the pound had been brought back to its pre-WWI parity at the expense of deflation and unemployment, there was little appetite for more austerity. France, on the other hand, had come close to hyperinflation in 1926. The franc convertibility had been restored after a protracted war of attrition between political parties to decide who would bear the costs of adjustment. In 1930s France, even Communists opposed devaluation, which they thought would reduce workers' living standards.

Can figure 2 be interpreted as evidence of a causal link from devaluation to recovery? That none of the variables exhibits a preexisting trend — except nominal wages perhaps — is at least suggestive of a causal relationship. In particular, it rules out the possibility that results are driven by the economy bouncing back from a shock that would have led to devaluation. Nevertheless, devaluing countries may have been reacting to a contemporaneous shock that would have affected future output, such as banking difficulties.⁶ That kind of bias, however, would go in a direction opposite to my results.

Still, it is with these caveats in mind that I turn to a different identification strategy, one which relies on high frequency variation.

⁵Inspecting these results, I found that this (insignificant) fall in real spending and revenues was primarily driven by the increase in the wholesale price index (figure 2), which I use to deflate nominal spending and revenues. Thus, it is plausible that the decline in spending and revenues was due to nominal stickiness in civil servant's salaries or tax brackets.

⁶For instance, Accominotti (2012) argues that London merchant banks were in serious trouble because they were the guarantors of important quantities of Central European debt, whose payments were frozen when Austria, Germany and Hungary implemented capital controls.

2.2 High-Frequency Identification (HFI)

2.2.1 Identification Strategy

The decision to devalue may of course be influenced by fundamentals; but different policy-makers may take different decisions in the face of similar circumstances. The 1933 devaluation of the dollar is a good example. Franklin D. Roosevelt, who had just become president, had been unclear about his intentions. The Senate was sympathetic to a *de facto* abandonment of the gold standard in the form of massive purchases of silver. To avoid this radical policy, Roosevelt negotiated in secret an amendment to the Farm Relief Act that gave him authority to cut the gold content of the currency by up to 50%. Edwards (2018, pp. 57–58) tells how he broke the news to his advisers:

On the night of April 18, the president met with his close advisers to discuss issues related to the impending visit of British Prime Minister Ramsay MacDonald. [...] Only [Assistant Secretary of State] Moley knew that Roosevelt had been negotiating a new initiative for “controlled inflation” with a group of key senators, including Elmer Thomas from Oklahoma. When FDR told them, with a chuckle, that the next day he would announce his support for the Thomas Amendment, [adviser] Feis, [Budget Director] Douglas, and [Secretary of State] Warburg became livid; they couldn’t believe what they were hearing and interrupted each other in their efforts to convince the president that this was a mistake of historical proportions. In 1934, Warburg wrote that as late as April 18, those who were in daily contact with FDR had no “idea that he was seriously considering such a move.” [...] After leaving the White House late that night, Lew Douglas told the rest of the group that without a doubt this was “the end of Western civilization.”

That Roosevelt’s closest advisers were stunned by his decision suggests there was nothing ineluctable about it. Had he been president, Budget Director Douglas would have probably chosen a different path for the exchange rate. The silverites of the Senate would have picked yet another path.

That kind of variation is exogenous and can be isolated. To do so, I construct series of policy announcements and use changes in the 3-month forward exchange rate around those announcements as instruments for the exchange rate. Being an asset price, the forward exchange rate should incorporate market expectations about the future path of the exchange rate. So, as long as markets and policymakers have similar information about current and future economic conditions, movements in the forward rate that are prompted by policy

announcements are exogenous and can be used to infer the effect of exchange rate policy on the economy. Within that framework, a shock can be an unexpected devaluation that happened, or an expected devaluation that did not happen. This strategy is conceptually similar to that of a literature that uses, in a modern context, changes in federal funds rate futures on FOMC days as an instrument for changes in the federal funds rate target in a VAR or a local projection.⁷

2.2.2 Shock Construction

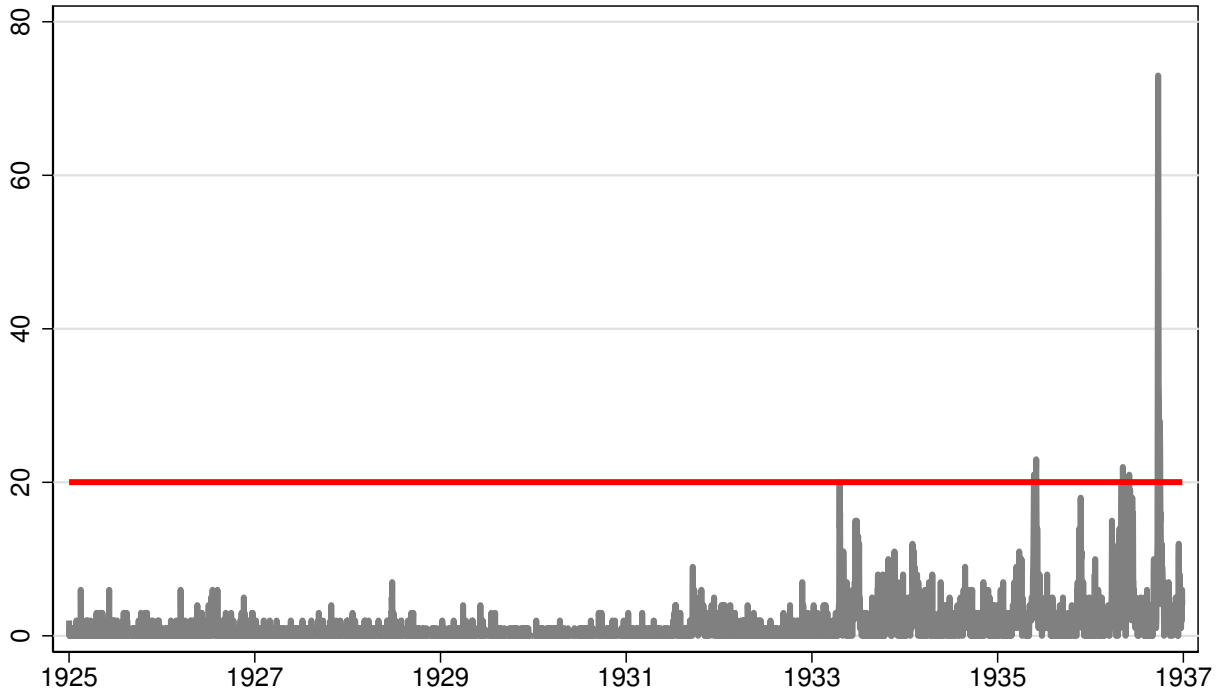
The main challenge of this identification strategy is to find the dates of the policy announcements. I implement a four-step procedure:

1. Search in ProQuest Historical Newspapers for articles featuring appropriate keywords for each day of the period during which the country is on the gold standard. The keywords are: (i) the name of the country or currency, and (ii) mentions of devaluation, leaving the gold standard, or exchange controls. ProQuest Historical Newspapers is a database of archives of the main US newspapers: New York Times, Wall Street Journal, Chicago Tribune;
2. Retain dates whose number of articles is 6 standard deviations above the mean. With this step, I seek to select days where an important amount of news is released about future exchange rate policy. The threshold of 6 is somewhat arbitrary. I picked it by trading-off quantity and relevance of those dates. A much higher threshold would leave me with too few days, a much lower one would return too many dates where nothing particular is announced;
3. Read those articles to identify the nature and exact timing of the news: retain dates that correspond to a policy announcement (e.g. devaluation), reject them if they're only conveying news about the economic situation (e.g. strike).
4. Use variation in the 3-month forward exchange rate around the announcement as a shock.

I illustrate this procedure with the case of France; other countries' details are given in the appendix. France is an ideal example because it waited until 1936 to devalue, and because

⁷See Ramey (2016) for a survey. Bagliano and Favero (1999), Cochrane and Piazzesi (2002), Faust et al. (2004), Barakchian and Crowe (2013), Gertler and Karadi (2015) are early contributors to this identification scheme. Weiss (2020) applies it to silverite agitation during the pre-WWI gold standard era. The use of forward exchange rates to infer devaluation expectations has some precedents in the Great Depression literature (Hsieh and Romer, 2006, Accominotti, 2009). These authors, however, do not study the effect of devaluation shocks on macroeconomic variables.

Figure 3: Daily number of articles for France



Note: number of daily articles returned by ProQuest Historical Newspapers with the keywords described above. The red line is the cutoff defined by the formula: $\text{mean} + 6 \times \text{standard deviations}$.

its decision to finally devalue was preceded by several false alarms — expected devaluations that did not happen. Figure 3 shows the number of daily articles returned by a search of the keywords:

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ti(France OR French OR franc) AND (devaluation OR ((off OR suspension
OR leave OR quit) AND "gold standard") OR (exchange control))
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These keywords mean that: (i) “France”, “French” or “franc” must be in the title of the article; and (ii) “devaluation”, or a reference to leaving the gold standard or “exchange control” must be in the title or text of the article. Over the period during which France was on the gold standard (June 1928 to September 1936), the mean of the number of such articles was 1.3 and the standard deviation 3.1. So a day must feature more than 20 articles in order to be retained. The red line on figure 3 is the cutoff.

Table 1 lists the dates that are above that cutoff. First, many dates neighbor each other. For instance, the September 1936 devaluation of the franc, which was announced on September 26, and officially ratified on October 2, sparked a flurry of articles from September 25 to October 5. Since these articles deal with the same event, I take them as a single shock, which happens on September 26, the day the devaluation was announced. Before

Table 1: France, shocks

Date	# articles	Event	Shock
27may1935	21	} Fall of Flandin's cabinet	-0.046
31may1935	21		
04jun1935	21		
05jun1935	23		
11may1936	22	Blum's devaluation speech	-0.013
05jun1936	21	Strikes	×
25sep1936	30	} Devaluation	+0.234
26sep1936	60		
27sep1936	73		
28sep1936	59		
29sep1936	33		
30sep1936	31		
01oct1936	25		
02oct1936	28		
03oct1936	28		
04oct1936	27		
05oct1936	24		

Note: shocks selected by the procedure described in section 2.2. The mean and standard deviations of the daily number of articles are 1.3 and 3.1 respectively. Other countries are shown in table A.4.

devaluation happened, my procedure detects two announcements that correspond to non-devaluations. The first one is the fall of Pierre-Etienne Flandin's cabinet. While officially opposed to devaluation, Flandin's government implemented policies that ran against the gold standard constraint: low interest rates, budget deficit, cartelization of the French industry... Flandin's fall and replacement by Fernand Bouisson, whose government was more committed to deflationary policies, were interpreted as a contractionary shock by the forward exchange rate market. The second non-devaluation is Léon Blum's speech on May 10, 1936. Blum was a Socialist who led a left-wing coalition, the Popular Front, to victory on May 3, 1936. This victory led to speculation that France would devalue. With that speech, the head of government reassured financial markets about his commitment to the gold standard, thereby generating a contractionary shock. Five months later, the same Blum would take the decision to devalue the franc...

One last difficulty is that, sometimes, financial markets were closed after major announcements. For instance, in 1936, the Paris bourse was closed from September 25 until October 1, when the devaluation law was passed. So there were no forward exchange quotations during that time. As a result, I take the narrowest possible window — 7 days in that case

— around the announcement. The French devaluation, however, is an extreme example. In most cases, that narrowest window is 1 or 2 trading days.

2.2.3 Results

I estimate a panel local projection with instrumental variable (Jordà, 2005, Jordà et al., 2015):

$$z_{t+k}^j - z_{t-1}^j = \beta_k(xr_t^j - xr_{t-1}^j) + \gamma_k' X_{t-1}^j + \delta_{t,k} + \zeta_k^j + e_{t,k}^j \quad (2)$$

where z_t^j is the log of the variable of interest in country j in month t , xr_t^j the log of the spot exchange rate, X_t^j is a vector of controls, $\delta_{t,k}$ and ζ_k^j are time and country fixed effects. The spot exchange rate is instrumented with the aforementioned shocks. I estimate equation (2) at quarterly frequency. The controls are a year of lagged changes in the outcome variable and the exchange rate.

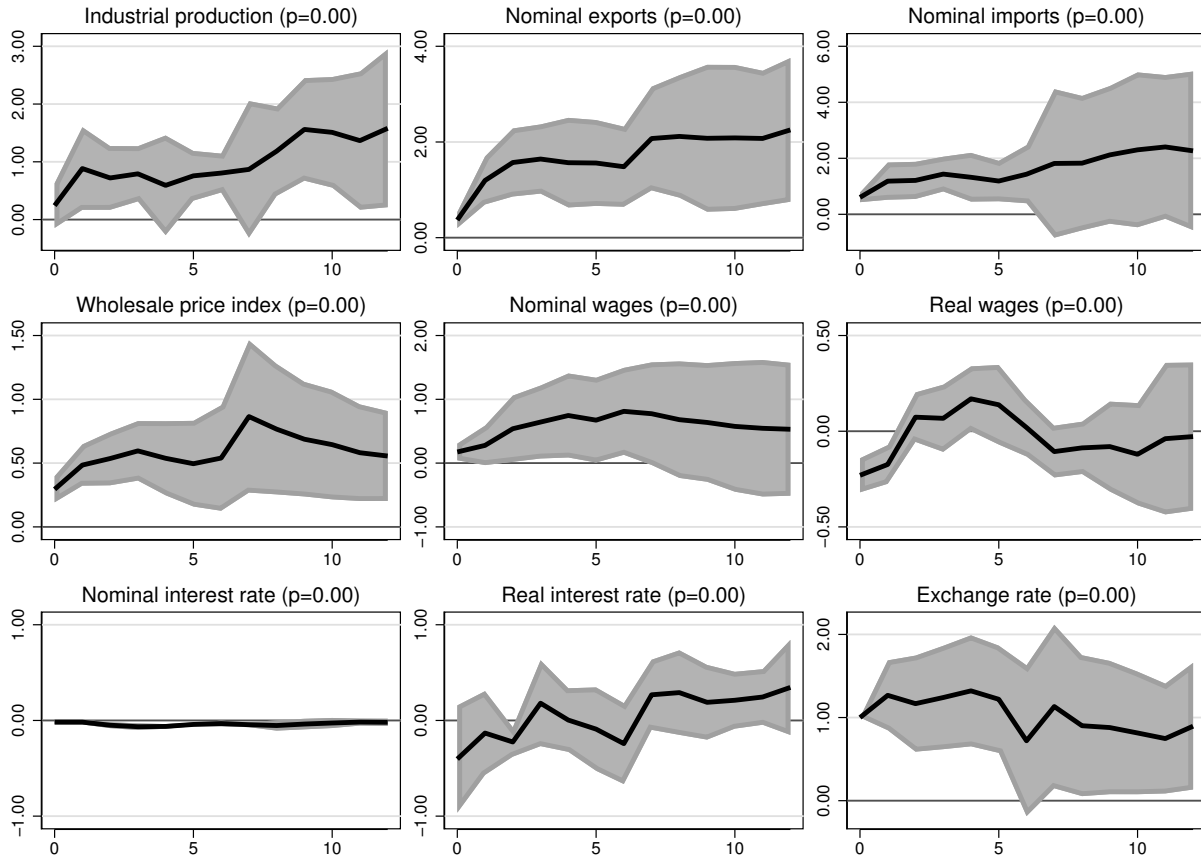
The countries and outcome variables differ from those of the difference-in-difference exercise. Before, the choice of countries was dictated by the desire to construct a quasi-experimental setup. Now, the sample is determined by data availability: it is made of the eight countries for which forward exchange rate data is continuously available from *The Financial Times* — Germany, Belgium, France, Italy, the Netherlands, Switzerland, the United Kingdom and the US. Moreover, since this exercise requires quarterly data, some of it comes with important limitations. First, exports and imports can only be nominal as quantity and price indices are typically not available above annual frequency. Second, I was not able to find nominal wage series for Belgium, the Netherlands and Switzerland; and that for France is for coal miners only. Third, industrial production is unavailable at quarterly frequency for the Netherlands and Switzerland. For each variable, I include every country for which the data is available.

Figure 4 shows the results for the baseline specification. The results are qualitatively similar to those of section 2.1. The devaluation stimulated industrial production, nominal exports and imports, prices and nominal wages and led to a fall in real wages. Again, the monetary action comes not from the nominal interest rate, but from the real one.

2.2.4 Potential Objections

What about the “information effect” (Nakamura and Steinsson, 2018)? If monetary authorities possess superior information about present and future economic conditions, policy shocks are not exogenous to those same economic conditions. They only reflect superior information. In this context, however, this is less likely to be a problem than with mod-

Figure 4: Impulse response functions (HFI)



Note: response of relevant variable to an exogenous 100 log-points devaluation in the exchange rate. Formally, the plots show the estimate of β_k in equation (2). The black line is the point estimate; the gray area is the 95% confidence interval with Driscoll-Kraay standard errors. The number in parenthesis is the p-value of a test of the joint significance of the coefficients. The y-axis scale of the nominal and real interest rates are identical for visual convenience.

ern data. Governments and central banks had smaller staff than they do today, and they shouldn't be expected to have had better information about the state of the economy.

Isn't the timing of the policy announcements endogenous? It certainly is. But this is not a problem as long as that endogeneity is reflected in the forward rate on the eve of the announcement. This would only be a problem if the announcements reflected information about future economic conditions that became known during the day. Since devaluations tended to be protracted affairs whose decisions took months, if not years, to be taken, this is unlikely to be an issue. In the case of the US, the quote above suggests that Roosevelt took his decision at least one day before announcing it.

Don't daily variations in the forward rate partly reflect background noise that correlates with economic fundamentals? It is possible. With modern data, one can keep background

noise to a minimum by using 30-minute windows around the announcement. Since only daily data is available in the 1930s, this cannot be done here. Hence, I must assume that there is more good (driven by the announcement) than bad (background noise that correlates with fundamentals) variation on the days of policy announcements. Put another way, the identifying assumption is really that most, if not all, variation in the forward rate, around policy announcements, is exogenous. At any rate, this assumption is much milder than the one required by the DD strategy: that all variation, every day, is exogenous.

Do forward exchange rates capture expectations about future spot rates? Even though, in modern data, the forward rate tends to be a poor proxy for the future spot rate (Fama, 1984), this is less true under fixed exchange rates. For instance, Accominotti et al. (2019) find zero return to the carry trade under fixed exchange rate regimes with the same data, currencies and time period. Their result is in line with other studies from different eras: Flood and Rose (1996) find smaller deviations from uncovered interest rate parity among currencies of the European Monetary System; so do Colacito and Croce (2013) with Bretton-Woods data.

2.3 DD vs. HFI: Comparison

A casual inspection of figures 2 and 4 suggest that, while the two exercises have qualitatively similar conclusions, they differ quantitatively. In the DD case, the industrial production coefficient is mostly below 0.5, meaning that a 30% devaluation stimulates output by less than 15% in relative terms. In the HFI case, that coefficient hovers above 0.5, sometimes even above 1. This kind of comparison has its limitations for two reasons. First, it does not take standard errors into account — the HFI confidence intervals often include numbers below 0.5. Second, the underlying policy change is not necessarily the same. In the DD case, the exchange rate keeps depreciating, particularly from 1932 to 1933; while the HFI case looks closer to a one-off devaluation.

To refine the comparison, I compute the integral below the coefficients. Formally, for some outcome variable z , I compute:

$$\mathcal{I}^z = \frac{1}{t_2 - t_1 + 1} \sum_{t=t_1}^{t_2} \beta_t^z$$

where β_t^z is the coefficient associated with variable z . To account for the differing exchange rate change, I compute the ratio of the integral for variable z and the integral for the exchange rate: $\mathcal{I}^z/\mathcal{I}^{xr}$. To make the timing of the two exercises as similar as possible, I use the 1932 to 1934 coefficient in the DD case, the horizon-1 to 12 coefficients in the HFI case. Since most of the 1931 devaluations happened in late September or early October, this procedure

Table 2: DD vs. HFI: Quantitative Comparison

	DD-IV		DD-OLS		HFI	
	Industrial production					
Numerator	0.39	[0.11,0.66]	0.54	[0.31,0.77]	1.05	[0.47,1.63]
Denominator	1.58	[1.32,1.85]	1.45	[1.22,1.69]	1.03	[0.42,1.64]
Ratio	0.24	[0.06,0.43]	0.37	[0.19,0.56]	1.03	[0.79,1.26]
	Wholesale price index					
Numerator	0.62	[0.38,0.87]	0.56	[0.36,0.76]	0.61	[0.30,0.92]
Denominator	1.44	[1.24,1.64]	1.38	[1.19,1.57]	1.19	[0.52,1.85]
Ratio	0.43	[0.25,0.62]	0.40	[0.25,0.56]	0.51	[0.47,0.56]

Note: point estimates and 95% confidence intervals retrieved from averaging the coefficients whose estimations is detailed in sections 2.1 and 2.2. The numerator is the average coefficient for the relevant variable, the denominator is the average coefficient for the exchange rate. The ratio is the ratio of the two. DD-IV: 1932 to 1934 coefficients of equation (1), instrumenting the change in the exchange rate with a devaluation dummy. DD-OLS: 1932 to 1934 coefficients of equation (1), estimated by OLS. HFI: horizon-1 to 12 coefficients of equation (2).

roughly captures the effect of the devaluation for 3 years, starting one quarter after the devaluation.

This exercise confirms that the HFI strategy delivers larger estimates for industrial production, but the confidence intervals sometimes overlap. In table 2, I present the results for the two versions of the DD strategy — DD-IV where the change in the exchange rate is instrumented with a devaluation dummy, DD-OLS where equation (1) is estimated by OLS — and the HFI strategy. For industrial production, the ratio is more than 3 times higher with the HFI strategy (0.68) than with the DD-IV one (0.20), while DD-OLS lies in between (0.35). The lower bound for the HFI 95% confidence interval is lower than the DD-IV upper bound for the ratio (0.64 against 0.40), but not for the numerator. The differences are smaller and insignificant when it comes to prices.

It is possible that these differences reflect downward bias in the DD estimates. If the 1931 devaluations were driven by negative shocks that affected future output in countries that devalued (such as stress in the financial system), and if these shocks were reflected in the forward rate, then one should expect the HFI strategy to deliver higher estimates. Indeed, the pound was trading at a discount in September 1931, reflecting some anticipations of a currency devaluation. But I caution against reading too much into those differences, for two reasons. First, and once again, the differences are not necessarily statistically significant. Second, the underlying country samples are different. Idiosyncrasies in different countries' experience with the Great Depression or recovery may also be explanations. For instance,

dropping the US from the HFI sample lowers the industrial production ratio from 1.03 to 0.79. This was to be expected as the US experienced a deep depression and a strong recovery.

To summarize section 2, I have presented evidence on the relative effects of devaluations across countries. Once again, a relative statement does not directly answer the question of interest: British output might have been going up compared to French output because it was going up in absolute terms, or because French output was going down. Interpreting these estimates and making a statement about the size of the absolute effect requires a model, to which I turn in the next section.

3 A Multi-Country Model

I consider a world made of a continuum of symmetric countries whose combined size is normalized to 1. In each country, there still are a continuum of firms that each produce a variety of that product. All production is consumed. I relegate detailed proofs to the appendix and focus on the main equations.

3.1 Demand System

In country j , the household minimizes expenditures:

$$\int_f P_t^{jj}(f) C_t^{jj}(f) df + \int_k \int_f P_t^{jk}(f) C_t^{jk}(f) df dk$$

subject to a Kimball (1995) aggregator:

$$C_t^j = (1 - \bar{\Gamma}) C_t^j \times g \left(\int_f g^* \left(\frac{C_t^{jj}(f)}{(1 - \bar{\Gamma}) C_t^j} \right) df \right) + \bar{\Gamma} C_t^j \times g \left(\int_j \int_f g^* \left(\frac{C_t^{jk}(f)}{\bar{\Gamma} C_t^j} \right) df \right) dj \quad (3)$$

$P_t^{jj}(f)$ and $C_t^{jj}(f)$ are the price and consumption, in country j , of the variety produced by firm f of country j . Their product is expenditures on that variety. Summing over all firms f corresponds to expenditures on domestic varieties. $P_t^{jk}(f)$ and $C_t^{jk}(f)$ are the price and consumption, in country j , of the variety produced by firm f of country k . Their product is expenditures on that variety. Summing over all firms f and foreign countries k corresponds to expenditures on foreign varieties. $\bar{\Gamma}$ is the coefficient of openness: the higher $\bar{\Gamma}$, the more the household consumes of the foreign good.

Equation (3) governs aggregation of those varieties through the functions $g(\cdot)$ and $g^*(\cdot)$.

I assume particular functional forms for those. $g(\cdot)$, the function that governs aggregation between domestic and foreign varieties, is of the form:

$$g(x) = 1 + \frac{1}{1 - \tilde{\rho}} (x^{1-\tilde{\rho}} - 1)$$

$g^*(\cdot)$ is the function that governs aggregation among domestic and foreign firms. I borrow the functional form used by Klenow and Willis (2016):

$$h(x) = g^{*-1}(x) = (1 - \bar{m}' \log(x))^{\frac{\theta}{\bar{m}'}} , \quad \theta > 1, \quad \bar{m}' > 0$$

The constant elasticity of substitution (CES) model is nested: this formulation collapses to a CES demand system with elasticity θ if $\tilde{\rho} = 0$ and $\bar{m}' \rightarrow 0$.

Solving the expenditure-minimization problem and log-linearizing around a symmetric steady state gives the following demand functions:

$$\hat{c}_t^{jk} = -\theta (p_t^{jk} - p_t^{j*}) + \hat{c}_t^{j*} \quad (4)$$

$$\hat{c}_t^{j*} = -\rho (p_t^{j*} - p_t^j) + \hat{c}_t^j \quad (5)$$

$$\hat{c}_t^{jj} = -\rho (p_t^{jj} - p_t^j) + \hat{c}_t^j \quad (6)$$

Equation (4) is the demand for country k 's varieties in country j as a function of their price (p_t^{jk}) relative to the import price index (p_t^{j*}) and of country j 's imports (c_t^{j*}). Equations (5) and (6) are the demand for imports (c_t^{j*}) and domestic goods (\hat{c}_t^{jj}) as a function of their prices (p_t^{j*} and p_t^{jj}) relative to the consumer price index (p_t^j).

These equations introduce a new parameter, ρ , the elasticity of substitution between domestic and foreign goods, which is given by:

$$\rho \equiv \frac{\theta}{1 + \theta \tilde{\rho}}$$

If $\tilde{\rho} > 0$, $g(\cdot)$ is concave so domestic and foreign varieties become less substitutable ($\rho < \theta$). If $\tilde{\rho} < 0$, $g(\cdot)$ is convex and the opposite happens. In the estimation, I shall argue that $\rho < \theta$ is the relevant case. In theory, however, the relationship is not restricted.

Kimball demand is a standard tool to generate incomplete pass-through of the exchange rate to international prices (Amiti et al., 2014b, Burstein and Gopinath, 2014, Itskhoki and Mukhin, 2021). Compared to these papers, however, I innovate along one dimension: the introduction of an extra aggregator, $g(\cdot)$. This addition allows me to distinguish the elasticity of substitution among imports (θ) from that between imports and domestic varieties (ρ). If

$g(\cdot)$ is the identity, then: $\rho = \theta$. Nested CES demand systems within and across sectors can also generate incomplete pass-through if firms are not atomistic within their sectors (Atkeson and Burstein, 2008). To be calibrated, however, this framework requires information on the share of exporting firms and on the concentration of production among producers in a sector, which is not available for this period. Therefore, I opt for the more parsimonious Kimball apparatus.

3.2 Pass-Through

Prices are flexible. Firm f sets its local currency price subject to the demand function that arises from the expenditure minimization of the household. I show in the appendix that this problem implies:

$$p_t^{jk} = (1 - \zeta_1 - \zeta_2)(\Theta + mc_t^k - xr_t^{kj}) + \zeta_1 p_t^{j*} + \zeta_2 p_t^j \quad (7)$$

where:

$$\Theta = \log \frac{\theta}{\theta - 1} \quad \zeta_1 = \frac{\bar{m}(1 - \rho/\theta)}{1 + \bar{m}} \quad \zeta_2 = \frac{\bar{m}\rho/\theta}{1 + \bar{m}} \quad \bar{m} = \frac{\bar{m}'}{\theta - 1}$$

ζ_1 and ζ_2 are the strategic complementarity parameters. Their presence implies that, when they set their price, foreign producers adapt their price to the import (p_t^{j*}) and domestic (p_t^j) price indices of the country of destination. Like the elasticities, the strategic complementarity parameters depend on the aggregator functions $g(\cdot)$ and $g^*(\cdot)$. They lie between 0 and 1. In the CES case, these parameters are equal to 0.

Equation (7) implies that the pass-through of the exchange rate is:

$$1 - \zeta_1 - \zeta_2 = \frac{1}{1 + \bar{m}} < 1 \quad (8)$$

In general this pass-through is below 1. Once again, the CES model is nested. A CES demand implies that the firm charges a constant markup, hence transmits any exchange rate movement one for one — the pass-through is 1. This is apparent in the latter formula: the pass-through converges to 1 if \bar{m} goes to 0. In fact, \bar{m} is the elasticity of the markup. With $\bar{m} \rightarrow 0$, the markup is inelastic, hence constant, which is a feature of the CES case.

3.3 Output

Gathering equations (4–7) implies that output in country j is equal to:

$$\hat{y}_t^j = \underbrace{\psi \left(\int_m (mc_t^m - xr_t^{jm}) dm - mc_t^j \right)}_{\text{expenditure switching}} + \underbrace{(1 - \bar{\Gamma})\hat{c}_t^j}_{\text{domestic consumption}} + \underbrace{\bar{\Gamma} \int_k \hat{c}_t^k dk}_{\text{foreign consumption}} \quad (9)$$

where:

$$\psi \equiv \bar{\Gamma} \left(\frac{(1 - \bar{\Gamma})\rho}{1 + \bar{m}\rho/\theta} + \frac{\theta}{1 + \bar{m}} \right)$$

The last two terms (domestic consumption and foreign consumption) are easy to interpret. If country j consumes more, it demands more of its own goods, hence produces more. Similarly, if its trading partners consume more, they demand more of the country's goods, hence country j produces more.

The first term embodies expenditure switching. It gathers marginal cost in the rest of the world (mc_t^m), adjusted for the bilateral exchange rate (xr_t^{jm}), relative to marginal cost in country j (mc_t^j). If country j 's currency depreciates (xr_t^{mj} increases), it lowers marginal cost expressed in foreign currency. The depreciation finds its way into the price of country j 's varieties through equation (7). Consumers shift expenditures towards those varieties. For given levels of domestic and foreign consumption, country j must produce more.

The beggar-thy-neighbour question amounts to whether the first term dominates the third one — and if so, by how much? Expenditure switching weighs non-devaluing country's output down, but the monetary stimulus to foreign demand pushes it up. In theory, the latter may trump the former. Of course, in equilibrium, whichever dominates will feed into domestic consumption.

The strength of the expenditure switching term is governed by ψ which, besides the coefficient of openness $\bar{\Gamma}$, depends on three parameters: (i) ρ , the elasticity of substitution between foreign and domestic varieties, (ii) θ the elasticity of substitution among foreign varieties and (iii) \bar{m} the elasticity of firms' markup which determines the pass-through.

I now turn to granular trade data to estimate the last two parameters, θ and \bar{m} — the first one, ρ , will be estimated out of the cross-country moments. Doing so, I relax some of the assumptions of this section: single product, absence of demand shocks, symmetric and atomistic countries.

4 Trade Evidence

4.1 Identification Strategy

I assume that demand for product r in country j , C_{rt}^j , is governed by a Kimball (1995) aggregator:

$$C_{rt}^j = (1 - \Gamma_{rt}^j) C_{rt}^j \times g \left(\int_f g^* \left(\frac{C_{rt}^{jj}(f)}{(1 - \Gamma_{rt}^j) C_{rt}^j} \right) df \right) + \Gamma_{rt}^j C_{rt}^j \times g \left(\sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \mathcal{K}_{rt}^{jk} \int_f g^* \left(\frac{C_{rt}^{jk}(f)}{\Gamma_{rt}^j \mathcal{K}_{rt}^{jk} C_{rt}^j} \right) df \right) \quad (10)$$

where $C_{rt}^{jk}(f)$ is demand in country j for product r from firm f of country j .

Equation (10) is a generalization of equation (3). The first generalization is the introduction of many products r : there is now an aggregator within each product category. The second generalization is the introduction of taste shocks for imported (Γ_{rt}^j) and foreign varieties (\mathcal{K}_{rt}^{jk}).

Solving the expenditure minimization problem and log-linearizing, I can write:

$$\Delta c_{rt}^{jk} = -\theta \Delta p_{rt}^{jk} + \theta \Delta p_{rt}^{j*} + \Delta c_{rt}^{j*} + \Delta \kappa_{rt}^{jk} \quad (11)$$

Δ denotes time differentiation, and lower case letters logarithms. c_{rt}^{jk} is country j 's demand for country k 's varieties of product r and p_{rt}^{jk} their price index. c_{rt}^{j*} and p_{rt}^{j*} are country k 's quantity and price of imports of product r . κ_{rt}^{jk} shifts expenditures to country j 's variety away from other foreign varieties.

θ is the price elasticity of substitution among foreign varieties. It is the parameter that I seek to estimate. It is given by: $\theta = -h'(1)$ where $h(\cdot) = (g^{*\prime})^{-1}(\cdot)$. Importantly, I did not assume a constant elasticity of substitution (CES) demand system to arrive at equation (11). The elasticity is not necessarily constant. On the other hand, θ is the elasticity around a symmetric equilibrium where relative prices are equal to 1.

The empirical analogue of equation (11) is:

$$\Delta c_{rt}^{jk} = -\theta \Delta p_{rt}^{jk} + \mu_{rt}^j + e_{rt}^{jk} \quad (12)$$

The fixed effect μ_{rt}^j soaks up the $\theta \Delta p_{rt}^{j*} + \Delta c_{rt}^{j*}$ term. Yet, simultaneity bias would be looming if I were to estimate equation (12) by OLS. To solve this problem, I instrument the price,

p_{rt}^{jk} , with the exchange rate, xr_t^k . Since I use data on US imports ($j = us$), this strategy identifies θ as long as devaluation is uncorrelated with within-product US relative demand shocks, $\Delta\kappa_{rt}^{us,k}$.

Proposition 1 (Elasticity) *Provided devaluation is exogenous to within-product US demand shocks, instrumenting prices with the exchange rate in regression (12) identifies the within-product elasticity of substitution among foreign varieties, θ .*

To understand the strengths and limitations of proposition 1, consider two examples, one where the identification assumption is satisfied and one where it's not. If Britain devalued because it exported a lot of steel and the world demand for steel had collapsed because of the Great Depression, the identification assumption holds. Indeed, such a confounding factor is controlled for by the product-time fixed effects, μ_{rt}^j . If, on the other hand, Britain devalued because the US was suddenly importing less steel from Britain than from France, then the identification assumption fails. Such a story doesn't seem particularly plausible. The identification assumption also allows for any correlation of devaluation with supply-driven shocks. Its failure can only come from a mechanism involving relative demand shocks.

4.2 Data

Probably because tariff revenues were the main source of revenues of the federal government in the first hundred years of its existence, the United States was already collecting detailed trade data in 1790. The first Treasury of the Secretary, Alexander Hamilton, would thus transmit to Congress annual statements on exports and imports. This tradition lasted for the whole 19th century. In the late 1890s, the Bureau of Statistics of the Treasury even started issuing monthly data. In 1904, this responsibility shifted to the newly created Department of Commerce and Labor.

In the 1930s, the annual data would be published in a report of the Department of Commerce called the *Foreign Commerce and Navigation of the United States*. This publication, which lasted until the 1960s, contains the equivalent of the trade data that one can download nowadays from the Census' website. It features yearly information at the product level, broken down by countries. Products are fairly narrow categories. For instance, in 1930, there are 98 products in the metals group alone. Among them are steel bars, hand-sewing and darning needles, or manganese ore. For each product, I observe yearly imports both in value and in the relevant quantity. For example, I know that, in 1931, the US imported 1,260,496 golf balls from the United Kingdom, for a value of \$387,513. Table 3 is a snapshot taken from the 1931 issue.

Table 3: An example of the data

No. 4.—GENERAL IMPORTS, 1931—GROUP 6—METALS														
COUNTRY	Zinc—Continued			Antimony						6660. Cobalt ore and metal (free)	6662. Quick-silver or mercury (dut.)	6740. Other ores, metals and alloys (free)		
	6558. Blocks, pigs, etc., dross, and old (dut.)	6559. Sheets, dust and manufactures (dut.)	6650. Ore (free)			6651. Needle or liquated, and regulus or metal (dut.)								
			Gross weight	Antimony content										
				Pounds	Pounds		Dollars	Pounds	Dollars					
TOTAL.....	Pounds	Dollars	Dollars	Pounds	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Dollars	
Austria.....	549,185	14,829	24,999	28,030,059	9,726,015	259,952	10,390,599	445,369	248,862	262,973	27,054	32,649	88,344	
Belgium.....	11,235	401	2,874				6,720	504	99,198	159,299			3,931	
France.....			4,480										327	
Germany.....	414	157	947				220	27	3,016	5,876			7,699	
Italy.....			13,812										303	
Soviet Russia in Europe.....			261										150	
Spain.....											26,609	32,027		
Sweden.....			7											
Switzerland.....			255											
United Kingdom.....	276,919	8,934	212				226,464	20,624	4,480	10,084			9,998	
Canada.....	567	35	2,023						118,872	83,172			63,216	
Panama.....													243	
Mexico.....	260,050	5,302		26,917,859	9,358,575	238,151	486,169	27,656			445	622	775	
Trinidad and Tobago.....													107	
Cuba.....													156	
Dominican Republic.....													284	
Argentina.....				1,112,200	367,440	21,801							80	
Brazil.....													161	
Chile.....													17	
British India.....													10	
China.....							9,671,026	396,558					35	
Hong Kong.....													9	
Japan.....			128										194	
Palestine.....													41	
Siam.....													46	
Australia.....									23,296	4,542				
Union of South Africa.....													582	

While this data is publicly available, it needs to be digitized.⁸ I used an optical character recognition software, ABBY FineReader. This process entails a lot of errors, and requires many manual adjustments and corrections. Luckily, the tables include subtotals for each product. I can thus check that imports add up at the product level, which greatly limits the possibility of reading mistakes. I digitized the data for years 1929 to 1933. In contemporaneous and independent work, Irwin and Soderbery (2021) also digitized this data to study optimal tariff policy in the interwar era.

A notable feature of this data is the way the value of imports is computed. Imported goods were appraised based on the prices prevailing in the country of origin, for domestic or export purposes, inflated with shipping costs. The procedure, as it is described in the Tariff Act of 1930 (p. 132 and following), worked as follows: (i) the importer filed an invoice that included “the purchase price of each item in the currency of the purchase”, (ii) an individual mandated by the Treasury appraised “the merchandise in the unit of quantity in which the merchandise is usually bought and sold by ascertaining or estimating the value thereof by all reasonable ways and means in his power, any statement of cost or cost of production in any invoice, affidavit, declaration, or other document to the contrary notwithstanding”, and (iii) the customs “collector shall give written notice of appraisal to the consignee [...] if

⁸I access it through NewsBank’s “U.S. Congressional Serial Set, 1817-1980” database. The files are high-quality but image-only PDF.

the appraised value is higher than the entered value”. This procedure was meant to avoid invoicing fraud. It is unclear how often and how much appraisers deviated from the value contained in the invoice. It is also unclear that it should bias my estimates in a particular way.

4.3 Samples

Since the bulk of the devaluations happened in 1931, I estimate equation (12) with data for two separate years: 1932 and 1933. The year that serves as the basis for comparison is 1930 in both cases. In each case, the identifying variation lies in the change in the exchange rate between 1930 and the relevant year. Moreover, the panel is made exclusively of countries that devalued in 1931, or had not devalued at the end of the relevant year. For instance, Australia, whose currency depreciated as soon as 1930, is dropped from both panels. Estonia, which devalued in 1933, is kept in the first panel (1932), but kicked out of the second one (1933). Among countries that make it in both panels are of course the United Kingdom (it devalued in 1931) and France (it waited until 1936 to devalue). The point of this procedure is to use as large a panel as possible, while avoiding mixing countries that did not devalue at the same time. Table A.1 in the appendix gives the country list of each sample.⁹ Section A.3.1 in the appendix contains further details on data construction.

4.4 Results: Elasticity

I show the baseline results in panel A of table 4. Columns (1), (2) and (3) respectively feature the results for the reduced form, first stage and instrumented equations using the 1930-32 change. The estimated elasticity of quantity with respect to the exchange rate is 0.910 in 1932, while the price response is -0.460. This means that, thanks to its devaluation of 28%, Britain increased the quantity of its exports by 26% compared to France that did not and decreased their average dollar price by 13% compared to French products. The implied elasticity of substitution among foreign varieties, $\hat{\theta}$, is 2.054. Columns (4), (5) and (6) show the results using the 1930-33 change. The point estimate of the elasticity goes up to 3.084.

Were devaluations exogenous to US demand shocks? To answer this reverse causality concern, I regress pre-devaluation changes in quantity and price on the later change in the exchange rate. To be precise, I estimate equation (12) with the 1929-30 change for Δc_{rt}^{jk} and

⁹I noticed only one case where this selection procedure seems to affect the results: Chile in the 1932 weighted specification. Chile officially devalued in 1932 so I do not include it in my sample. However, it set up an export exchange rate whose devaluation started in 1931. By 1933, this exchange rate was so devalued (-75.4%) that the log-change goes wild and that a few heavily-weighted observations can significantly affect the final result.

Table 4: Elasticity baseline

	1930-32 change			1930-33 change		
	(1) RF	(2) FS	(3) IV	(4) RF	(5) FS	(6) IV
Panel A: Estimate						
XR	0.910** (0.349)	-0.443*** (0.110)		1.205*** (0.233)	-0.391*** (0.105)	
Elasticity			2.054*** (0.578)			3.084*** (0.413)
Observations	3742	3742	3742	3446	3446	3446
F-statistic			16.142			13.915
Panel B: Placebo						
XR	0.027 (0.122)	0.049 (0.047)		0.102 (0.069)	0.024 (0.034)	
Elasticity			-0.550 (2.527)			-4.310 (6.439)
Observations	3755	3755	3755	3579	3579	3579
F-statistic			1.097			0.482

Note: reduced form (RF), first stage (FS) and instrumented (IV) estimates of equation (12). Standard errors are in parentheses. They are double clustered at the country and product levels. F-statistic is the Kleibergen-Paap Wald rk F-statistic of the first stage.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Δp_{rt}^{jk} , and the 1930-32 and 1930-33 changes for the instrument. The results of this exercise are presented in panel B. None of the quantity coefficients is significantly different from 0. Their sign varies with the specification. The price coefficients are always close to 0. The estimates for the elasticity of substitution are negative.

4.4.1 Elasticity: Other Results

In the appendix, I present other results related to the estimation of trade elasticities.

First, I redo the exercise in table 4 while weighting each product-country pair by its 1930 value (table A.5). For the quantity regression, this specification corresponds to the change in a quantity index, holding prices constant; while for the price regression, it corresponds to the change in a price index, holding quantity constant. The quantity coefficients are mostly unchanged. The price coefficients go down a bit — though not significantly so — which mechanically raises the point estimate for the price elasticity. One of the placebo coefficients — column (6) of panel D — is significant at the 10% level. Including table 4, there are 12 placebo regressions so one false positive at that level of confidence is what one should expect

when the true coefficients are zero. Moreover, the coefficient is of a different sign than the one for the unweighted placebo, and much smaller than its counterpart of panel A.

Second, I investigate whether the presence of tariffs in the form of fixed nominal duties biases the estimates (section A.3.2). I find slightly higher elasticities (up to 4) if I restrict the sample to products that are taxed with a proportional duty, suggesting that this feature of the interwar US tariff code may indeed slightly bias the estimates (table A.6).

4.5 Results: Pass-Through

4.5.1 Empirical Results

The coefficients of columns (2) and (5) of table 4 are not exactly comparable to standard pass-through estimates. Indeed, that literature usually adds a control like the price level to proxy for marginal cost (Burstein and Gopinath, 2014). Thus, to estimate pass-through, I now run:

$$\Delta p_{rt}^{jk} = \alpha \Delta x r_{rt}^{jk} + \beta \Delta w p i_t^{jk} + \nu_{rt}^i + e_{rt}^{jk} \quad (13)$$

where $w p i_t^{jk}$ the logarithm of the wholesale price index in the country of origin.

I show the results in table 5. The pass-through estimates are around 0.4. This number is similar to those reported by Burstein and Gopinath (2014).

Table 5: Pass-Through

	1930-32 change		1930-33 change	
	(1) Unwght.	(2) Wght.	(3) Unwght.	(4) Unwght.
XR	-0.370** (0.159)	-0.491*** (0.176)	-0.442*** (0.148)	-0.355** (0.144)
WPI	-0.279 (0.286)	0.417 (0.353)	0.159 (0.300)	0.091 (0.357)
Observations	3592	3592	3405	3405

Note: Standard errors are in parentheses. They are double clustered at the country and product levels.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.5.2 Identification

Equation (7) makes clear that, if I were equipped with a proper control for marginal cost, I could identify $1 - \zeta_1 - \zeta_2$ by regressing p_t^{jk} on the exchange rate, that control and a time

fixed effect with the data of section 4. Since marginal cost is hard to observe, the standard approach — which I followed in section 4.5 — is to use the price level as a proxy. It turns out this control is not entirely valid in this model. As a matter of fact, the producer price index — which I interpret as the model equivalent of the wholesale price index — is given by:

$$p_t^{kk} = \Theta + (1 - \delta\bar{\Gamma})mc_t^k + \delta\bar{\Gamma} \int_m (mc_t^m - xr_t^{mj}) dm + \delta\bar{\Gamma}xr^{kj} \quad (14)$$

The first term after the constant Θ is the desired variation, the second term — which accounts for the marginal cost of foreign producers — does not depend on k and can be absorbed by a time fixed effect. The third term is problematic because it depends on the exchange rate. This means that the movement in the marginal cost will be overestimated, hence that pass-through will be overestimated. This bias is likely to be small since $\bar{\Gamma}$ is the coefficient of openness (0.1 in my calibration) and δ , the strategic complementarity between domestic and foreign producers, is less than 1. Formally, I prove in the appendix that:

Proposition 2 (Pass-through) *The pass-through regression (13) featuring the wholesale price index as control identifies:*

$$\hat{\alpha} = -\frac{1 - \zeta_1 - \zeta_2}{1 - \delta\bar{\Gamma}}$$

Moreover, ζ_1 , ζ_2 and δ are tied together by the elasticity of markups, \bar{m} :

$$\zeta_1 = \frac{\bar{m}(1 - \rho/\theta)}{1 + \bar{m}} \quad \zeta_2 = \frac{\bar{m}\rho/\theta}{1 + \bar{m}} \quad \delta = \frac{\bar{m}\rho}{\theta + \bar{m}\rho}$$

where: $\bar{m} = \bar{m}'/(\theta - 1)$.

To understand proposition 2, it is useful to, once again, go back to the CES benchmark. With CES demand, markups are constant so \bar{m} , the elasticity of markups, is 0. In that case, the pass-through is just 1. As markups become elastic, the true pass-through ($1 - \zeta_1 - \zeta_2$) declines and the bias ($1/(1 - \delta\bar{\Gamma})$) increases. So $\hat{\alpha}$ moves away from -1. Proposition 2 also makes clear that, given ρ , θ and $\bar{\Gamma}$, the pass-through regression pins down \bar{m} , from which one can recover ζ_1 , ζ_2 and δ .

To summarize section 4, I have used granular trade data to estimate an elasticity and a pass-through coefficient. Those will be key in disciplining expenditure switching in the model. I now go back to the model, and close it by presenting its dynamic side.

5 Model: Dynamics

5.1 Monetary Policy

The central bank commits to buy and sell gold at price \mathcal{E}_t^j , and it issues money in proportion of its gold reserves:

$$\Lambda M_t^j = \mathcal{E}_t^j G_t^j \quad (15)$$

Λ is the gold cover ratio, which is assumed to be constant for now. Gold is in fixed supply at the world level, and can only be held for monetary purposes. As a result, the world supply of money depends only on the price of gold, up to a first-order approximation:

$$\int_j m_t^j dj = \int_j \epsilon_t^j dj \quad (16)$$

The exchange rate between countries j and k is pinned down by arbitrage at the relative price of gold:

$$XR^{kj} = \frac{\mathcal{E}_t^k}{\mathcal{E}_t^j} \quad (17)$$

Otherwise, households could buy gold where it is cheap, sell it where it is expensive and make a risk-free profit on the exchange rate market. In log-linear terms, this can be written as: $xr^{kj} = \epsilon_t^k - \epsilon_t^j$. Since there is free capital mobility, uncovered interest rate parity holds to a first order: $i_t^j = i_t^k - E_t \Delta xr_{t+1}^{kj}$. As long as the gold standard is credible ($E_t \Delta xr_{t+1}^{kj} = 0$), all central banks have the same interest rate.

To induce stationarity, I follow Schmitt-Grohé and Uribe (2003) and assume that the interest rate earned by households slightly depends on the level of bonds owned by the country:

$$i_t^j = i_t^W - v b_t^j$$

where v is strictly positive but close to 0.

5.2 Rest of the Model

In each country, the representative household derives utility from consumption with internal habits, and money holdings. These assumptions yield an Euler equation and a demand for

money:¹⁰

$$\hat{\mu}_t^j = E_t \hat{\mu}_{t+1}^j + \hat{i}_t^j - E_t \pi_{ct+1}^j \quad (18)$$

$$\hat{i}_t^j = \frac{1-\beta}{\beta^2} \left(-\chi (\widehat{m}_t^j - \widehat{p}_t^j) - \hat{\mu}_t^j \right) \quad (19)$$

where μ_t^j is the marginal utility of consumption, i_t^j is the nominal interest rate, π_t^j inflation, and m_t^j the money stock. The world interest rate can be obtained by integrating over countries in the money demand and substituting out the world money supply thanks to equation (16):

$$\hat{i}_t^W = \frac{1-\beta}{\beta^2} \left(\chi \int_j (\widehat{p}_t^j - \widehat{\epsilon}_t^j) dj - \int_j \hat{\mu}_t^j dj \right) \quad (20)$$

Each firm produces output with only labor as an input:

$$Y_t^j(f) = f(N_t^j(f))$$

Therefore, marginal cost and aggregate output are, in log-linear terms:

$$m c_t^j = w_t^j + \frac{\alpha_1}{1-\alpha_2} \hat{y}_t^j \quad (21)$$

$$\hat{y}_t^j = (1-\alpha_2) \hat{n}_t^j \quad (22)$$

where:

$$\alpha_1 \equiv \frac{\bar{N} f''(\bar{N})}{f'(\bar{N})} \quad \alpha_2 \equiv 1 - \frac{\bar{N} f'(\bar{N})}{f(\bar{N})}$$

α_1 is the curvature of the production function. α_2 would be the profit share under competitive markets. In the Cobb-Douglas case, of course, α_1 and α_2 are equal. Assuming this more general production function will allow me, in the calibration, to match the behavior of producer prices by adjusting α_1 .

Wages are set *à la* Calvo, which yields a New Keynesian wage Phillips curve:

$$\pi_{wt}^j = \beta E_t \pi_{wt+1}^j + \tilde{\kappa} y_t^j - \kappa \hat{\mu}_t^j + \kappa (w_t^j - p_t^j) \quad (23)$$

Now that the static and dynamic sides of the model have been presented, I can estimate it and run counter-factual experiments.

¹⁰Once again, formal derivations are relegated to the appendix.

6 Structural Estimation and Counterfactual Analysis

6.1 Structural Estimation

6.1.1 Structural Estimation: Strategy

I simulate an unexpected devaluation in half of the world, and estimate 6 parameters by matching a set of empirical moments. Devaluation is modeled as exogenous. While I took endogeneity seriously in the empirical part, the goal of this theoretical exercise is not to model endogenous devaluation, but to infer the effect of a devaluation, for given economic conditions. Although the results are cast in terms of deviations from steady state, the linearity of the model guarantees that they can be interpreted as deviations from any set of fundamentals.

Following standard practice in the estimation of general equilibrium models, I calibrate some parameters with standard values from external sources, and estimate those that are essential to match the empirical moments (table 6).¹¹

I estimate 4 parameters, σ^{-1} , α_1 , ξ and ρ , with the impulse response functions of industrial production, the wholesale price index, nominal wages, imports, and the import price index. σ^{-1} is the inter-temporal elasticity of substitution (IES). In this environment, a devaluation is a proportional increase in the money supply. This stimulates domestic demand by lowering the real interest rate. So it is natural to adjust the IES in order to match the relative response of output. α_1 is the curvature of the production function. Equation (21) shows that it controls the response of marginal cost to output for a given nominal wage. Since marginal costs cannot be observed, their closest equivalent is the producer price index, as equation (14) suggests. So I adjust α_1 to match the response of wholesale prices. ξ is the Calvo parameter for wages. I adjust it to match the response of nominal wages. Finally, ρ is the elasticity of substitution between domestic goods and imports. I target the response of imports, and of import prices.

I estimate 2 parameters, θ and \bar{m} , in order to match the estimates of section 4. By proposition 1, the elasticity of substitution among foreign varieties, θ , was estimated in table 4. By proposition 2, the pass-through regression recovers \bar{m} for given ρ , θ and $\bar{\Gamma}$. I use the point estimates and standard deviations of the 1930-33 change in the unweighted case.

In section 3, I introduced the three parameters that determine the strength of expenditure switching: ρ , θ , and \bar{m} . In section 4, I explained how θ and \bar{m} are identified. Let me now focus on ρ . Identification of the other three parameters (σ^{-1} , ξ , α_1) will be explained in section 6.3. Looking back at equation (5), the demand for imports is a function of two

¹¹See Christiano et al. (2005) or Auclert et al. (2020) for instance.

Table 6: Parameters

Parameter	Value	Concept	Target or source
Calibrated			
β	0.99	Discount rate	Annual interest rate of 4%
ι	0.8	Habit	Eggertsson (2008)
χ	1	Concavity of utility for money	Standard
γ	0.1	Openness	British export-to-GDP ratio
α_2	0.37	Profit share	Labor share of 2/3
η	21	Elasticity of labor demand	Christiano et al. (2005)
v	0.0007	Stationarity-inducing device	Schmitt-Grohé and Uribe (2003)
g^*	0.14	Gold to output ratio	British gold-reserves-to-GDP ratio
Estimated			
σ^{-1}	0.63 (0.22)	IES	Industrial production
α_1	0.55 (0.13)	Curvature of production function	WPI
ξ	0.91 (0.02)	Calvo wage parameter	Nominal wages
ρ	0.44 (0.25)	Macro trade elasticity	Imports and IPI
θ	3.01 (0.2)	Micro trade elasticity	US imports
\bar{m}	1.3 (0.03)	Markup elasticity	Pass-through

Note: calibrated and estimated parameters. The estimation follows the procedure described in section 6.1. The targets are the DD-IV cross-country moments of section 2.1 and the trade estimates of section 4.

terms: the import price index (IPI) relative to that of domestic consumption (CPI), scaled by the elasticity (ρ), and domestic consumption: the cheaper imports are, the more a country imports; the more a country consumes, the more it imports. Playing with this equation, I can express ρ as:

$$\rho = -\frac{\hat{c}_t^{D*} - \hat{c}_t^{N*} - (c_t^D - c_t^N)}{p_t^{D*} - p_t^{N*} - (p_t^D - p_t^N)} \quad (24)$$

Superscripts D and N respectively denote devaluing and non-devaluing countries. Equation (24) means that what is informative about ρ is the relative response of imports ($\hat{c}_t^{D*} - \hat{c}_t^{N*}$) compared to the relative response of domestic consumption ($c_t^D - c_t^N$), versus the relative response of import prices ($p_t^{D*} - p_t^{N*}$) compared to the relative response of the domestic price index ($p_t^D - p_t^N$). Intuitively, for any given response of consumption and prices, a low response of imports is suggestive of a low elasticity of substitution.

6.1.2 Structural Estimation: Results

I report here the results where I target the DD-IV estimates as empirical targets. Results where I use the HFI ones are in the appendix.¹² I simulate the model at quarterly frequency with the devaluations happening in the last quarter of 1931. I then aggregate the simulated data over years to obtain regression coefficients that are consistent with the empirical ones.

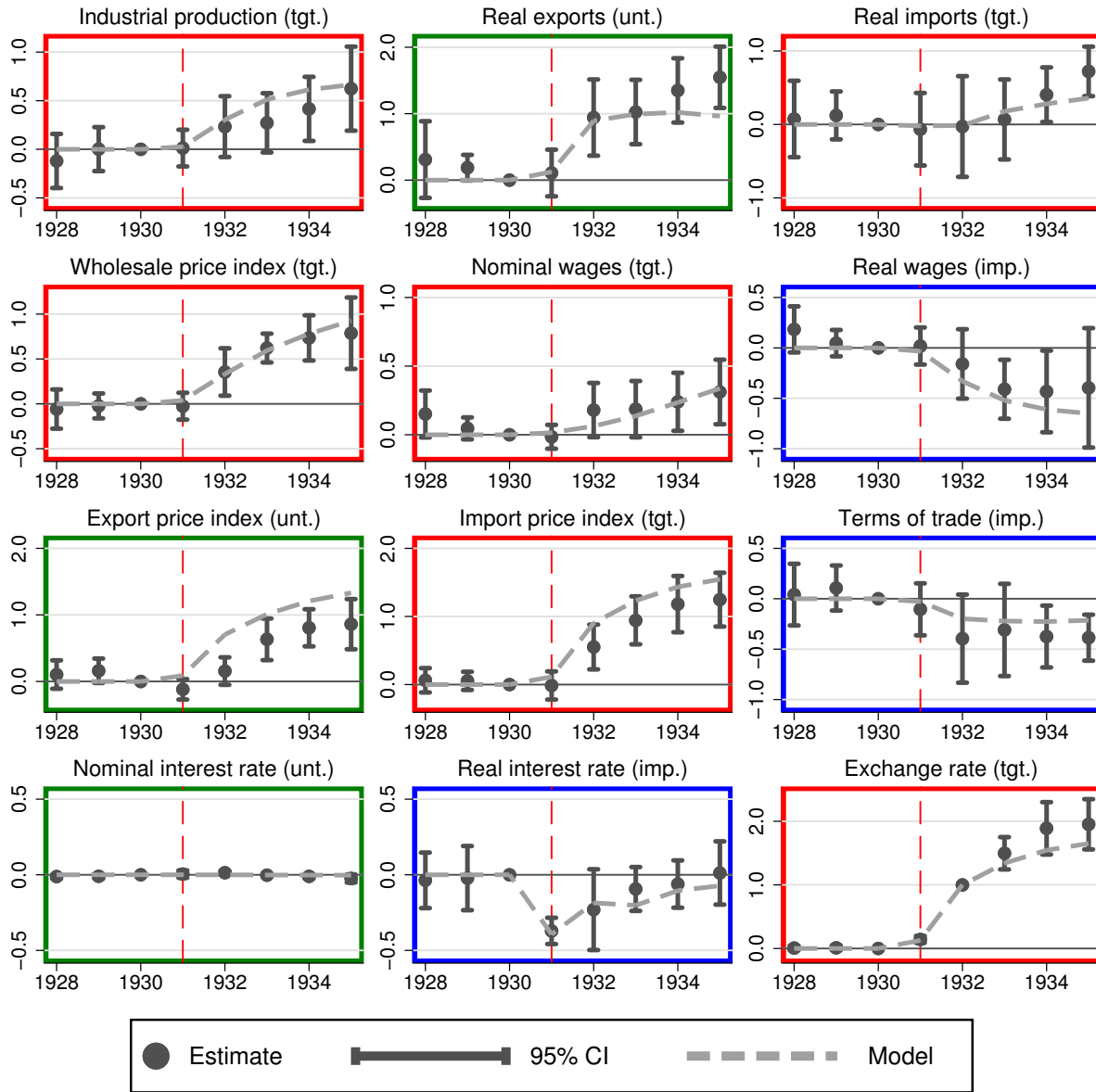
Formally, I assume that before time 0, the economy is in steady state. At time 0, half of the world experiences a sequence of unexpected cuts in the gold content of their currencies, $\Delta e_0^j > 0$. In order to reproduce the path of the exchange rate shown in the bottom right panel of figure 2, I assume that some unexpected shocks keep hitting the economy. The value of the shocks is set to minimize the distance with the empirical response of the exchange rate. An alternative route would be to assume that the whole path is expected from time 0 onward. The issue is that, through uncovered interest rate parity, this implies that the nominal interest rate shoots up in devaluing countries, which did not happen.

I estimate the model by the simulated method of moments (SMM). Technical details are relegated to appendix A.5. The estimation yields values for σ^{-1} and α_1 that are very close to conventional one. σ^{-1} is 0.63, the most commonly used values in calibration exercises being 1/2. $\alpha_1 = 0.55$ implies a slight departure from a Cobb-Douglas production function, but not a very significant one — $\alpha_1 = \alpha_2 = 0.37$ would be the Cobb-Douglas case. Compared to the Cobb-Douglas case, $\alpha_1 > \alpha_2$ makes marginal cost more elastic to output. $\xi = 0.9$ implies very sticky wages, with a mean duration of 10 quarters. This is the price of matching the data: 4 years after the devaluation, the pass-through of the exchange rate to nominal wages was only 20%. $\rho = 0.51$ is low but not out of line with other estimates, especially when considering the large confidence interval. For instance, using data from that period, Irwin (1998) estimates an elasticity of 0.8.

Figure 5 shows the fit of the model for real and nominal variables. For the reader's convenience, targeted IRF are circled in red and denoted "targ." Untargeted IRF are circled in green and denoted "unt." Implicitly targeted IRF are circled in blue and denoted "imp." By implicitly targeted, I mean that the variable is a function of variables that have been targeted. For instance, real wages are nominal wages divided by the price index. Since both are targeted, real wages are implicitly targeted. The model is able to match the cross-country evidence well. The fit is particularly good for wholesale prices and nominal wages. Even moments that I have not targeted, real exports and the export price index, are decently predicted.

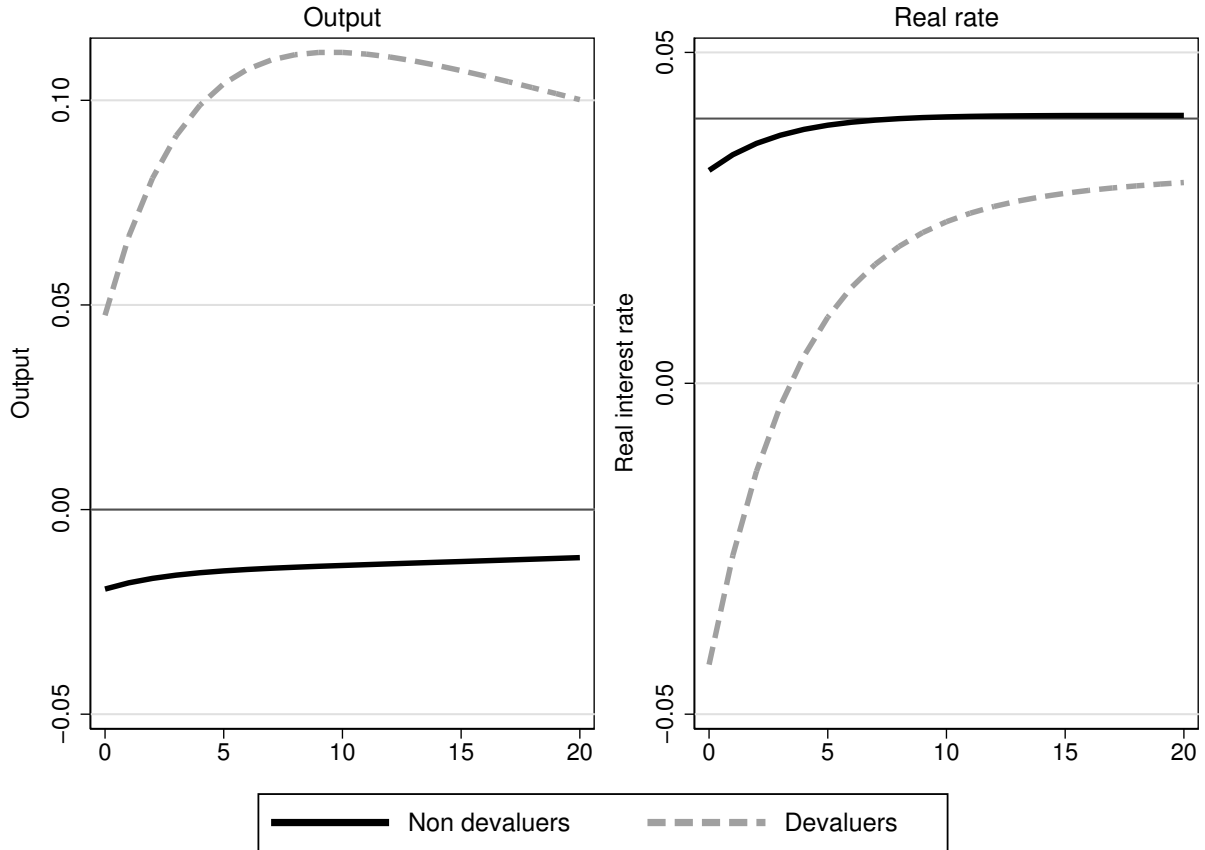
¹²See figures A.5, A.6 and table A.7.

Figure 5: Model fit (DD-IV)



Note: empirical and theoretical responses of relevant variables under estimated parameter values. The response circled in red (tgt.) are explicitly targeted. Those circled in green (utg.) are not. Those circled in blue (imp.) are implicitly targeted since they are functions of targeted moments.

Figure 6: Counterfactual analysis



Note: response of output and the real interest rate to a 30% devaluation by half of the world under parameter values estimated with the DD-IV cross-country moments of section 2.1 and the trade estimates of section 4. Those parameter values are shown in table 6.

6.2 Counterfactual Experiment

Armed with these parameter values, I can now answer the counterfactual questions of interest: how did devaluation affect countries which devalued, and countries which didn't? I consider a simple scenario: the world economy is in steady state; at time 0, half of the world devalues by 30% against gold.

Figure 6 illustrates that a foreign devaluation makes little quantitative difference for output (left-hand side panel). It lowers output for a few quarters but this effect is small and quickly dissipates. The explanation lies on the right-hand side panel. The devaluation entails a powerful real interest rate cut in countries that devalue. Through inter-temporal substitution, this cut stimulates consumption hence output. Beggar-thy-neighbour effects are dwarfed by this stimulus: the devaluation makes some countries more competitive, but those same countries consume more. On balance, the two effects compensate each other.

An equivalent way to state the conclusion is that the absolute effect is not very different from the relative effect. Britain was booming compared to France mostly because Britain was booming compared to a counterfactual scenario where it wouldn't have devalued, not because France was collapsing.

The conclusion was not foregone: the model can imply large negative spillovers on foreign output. I show in the appendix that it does if I simplify the Kimball aggregator to a constant elasticity of substitution demand system with a single elasticity of substitution, which I set equal to 3. This model implies full pass-through and as much substitution between imports and domestic goods, as among imports. Other parameters are left unchanged compared to table 6. This calibration implies a sharp fall of non-devaluing countries' output: about 5% on impact with substantial persistence (figure A.7). This calibration, however, has unrealistic implications: by construction, it implies a pass-through of 1, which is inconsistent with the estimates of section 4. Moreover, it fits the cross-country evidence, particularly the response of imports, very poorly (figure A.8). This exercise illustrates that incomplete pass-through is an important ingredient of the result: a theme that I come back to in the next section.

6.3 Identification

What, in the data, identifies the model, and determines the result? To understand it, I denote devaluing countries, non-devaluing countries, and world-level variables with superscripts D , N , and W . Up to a first-order approximation, the effect of a devaluation by a mass S^D of countries, can be written as

$$\text{devaluing countries:} \quad \hat{y}_t^D = (1 - S^D) (\hat{y}_t^D - \hat{y}_t^N) + \hat{y}_t^W \quad (25)$$

$$\text{non-devaluing countries:} \quad \hat{y}_t^N = -S^D (\hat{y}_t^D - \hat{y}_t^N) + \hat{y}_t^W \quad (26)$$

Those formulas do not depend on the details of the model — they're an immediate implication of symmetry and linearity. They are another way to express the identification problem: the term that features $\hat{y}_t^D - \hat{y}_t^N$ is pinned down by cross-sectional evidence, but \hat{y}_t^W is common across countries and soaked up by the time fixed effect. In so far as the model matches the relative effect, its conclusion is as good as the estimated effect on world-level output.

As table 6 showed, I estimate 6 parameters to match the cross-sectional evidence:

1. σ^{-1} : the inter-temporal elasticity of substitution (IES);
2. ξ : the Calvo parameter for wages;
3. α_1 : the curvature of the production function, which determines how sensitive prices are to changes in output;
4. ρ : the elasticity of substitution between imports and domestic goods;

5. θ : the elasticity of substitution among imports;
6. \bar{m} : the elasticity of the markup, which determines the exchange rate pass-through.

One can show analytically that the last three do not matter to world-level variables. The explanation is simple: those parameters are about substitution and strategic complementarity, hence only affect relative quantities and prices. On the other hand, the first three parameters matter. I focus on the first two here. Intuitively, they correspond to how powerful monetary policy is: how sensitive demand is to real interest rates, how sticky wages are...

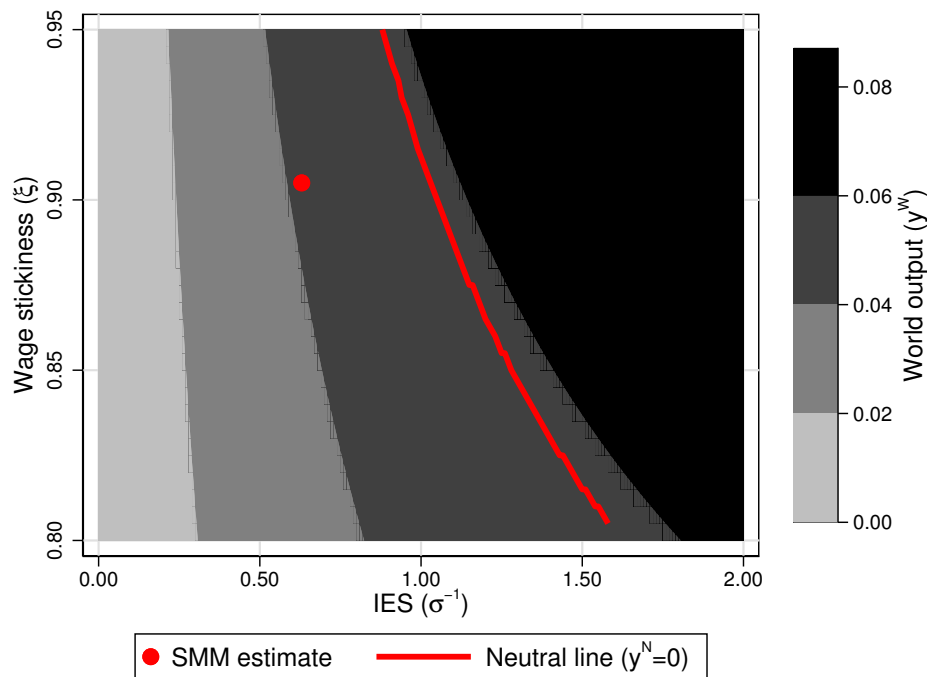
Figure 7.A shows the response of world output as a function of σ^{-1} and ξ . This response is computed as the mean increase in world output over the three years that follow a devaluation by half of the world. Darkest shades correspond to a bigger effect. The higher σ^{-1} and ξ , the bigger the effect. Indeed, a higher σ^{-1} means that consumption is more sensitive to a given cut in the real interest rate; a higher ξ means that wages are more sticky, hence nominal quantities adjust more slowly, and the real rate stays low for longer. The red line corresponds to the (σ^{-1}, ξ) pairs that imply no effect on non-devaluing countries (the neutral line). The red dot is the estimate that serves as the basis for the counter-factual experiments. It lands to the southwest of the red line, which explains why there is a negative effect on non-devaluing countries' output.

What, in the data, nails the red dot? Figure 7.B shows all combinations of σ^{-1} and ξ that imply the observed effect on output in devaluing countries relative to non-devaluing ones (the black line), and nominal wages in devaluing countries relative to non-devaluing ones (the gray line). The output line is downward-sloping because a higher σ^{-1} or a higher ξ act in the same direction: they raise relative output in devaluing countries. The intuition for why they do so is the same as that for world output: the higher these parameters, the less neutral money is. Since monetary stimulus happens in one type of countries but not in the other, a less neutral world means a bigger relative effect. As σ^{-1} and ξ act in the same direction, achieving a *given* relative response of output with a higher σ^{-1} requires a lower ξ . Relative wages effectively pin down ξ : the higher ξ , the faster wages adjust.

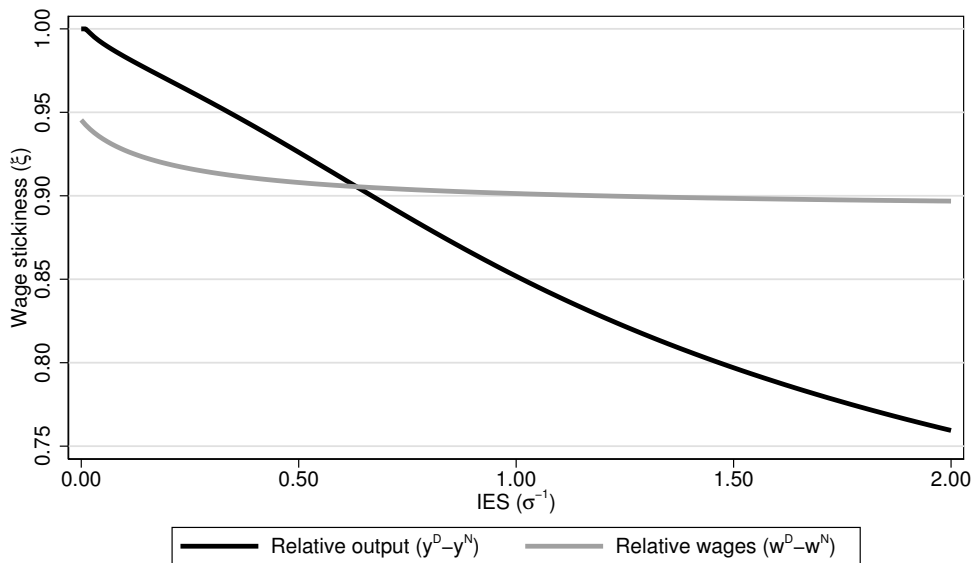
Was the work involving the granular trade data any useful? After all, the arguments invoked on figure 7 do not make any mention of the trade parameters. Perhaps matching relative output is sufficient. No, it's not. The position of the two lines on figure 7.B depends on those parameters. Figure 8.B shows what happens with complete pass-through ($\bar{m} = 0$). The solid black line moves to the left, becoming the dashed black line. Indeed, complete pass-through implies more responsive trade. Therefore, to obtain a given response of output, consumption needs to be less responsive, implying a lower σ^{-1} . Additionally, the solid gray line slightly moves up, becoming the dashed gray line. As a result, the estimated σ^{-1} goes down. The relevant point on figure 8.A becomes the blue triangle. Since σ^{-1} is lower, the

Figure 7: Identification

Panel A: Response of World Output as a function of σ^{-1} and ξ



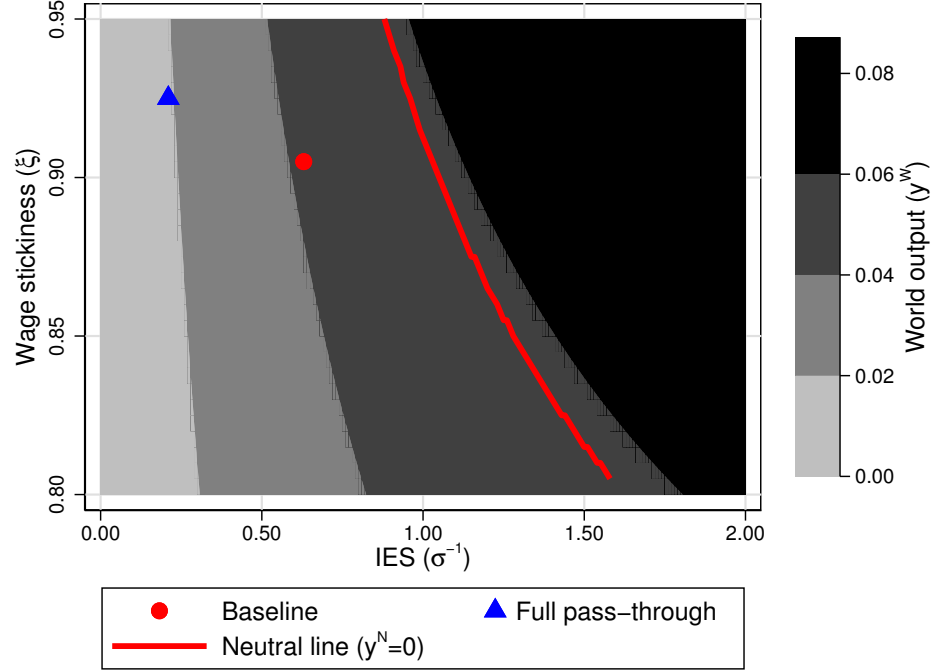
Panel B: Identification of σ^{-1} and ξ



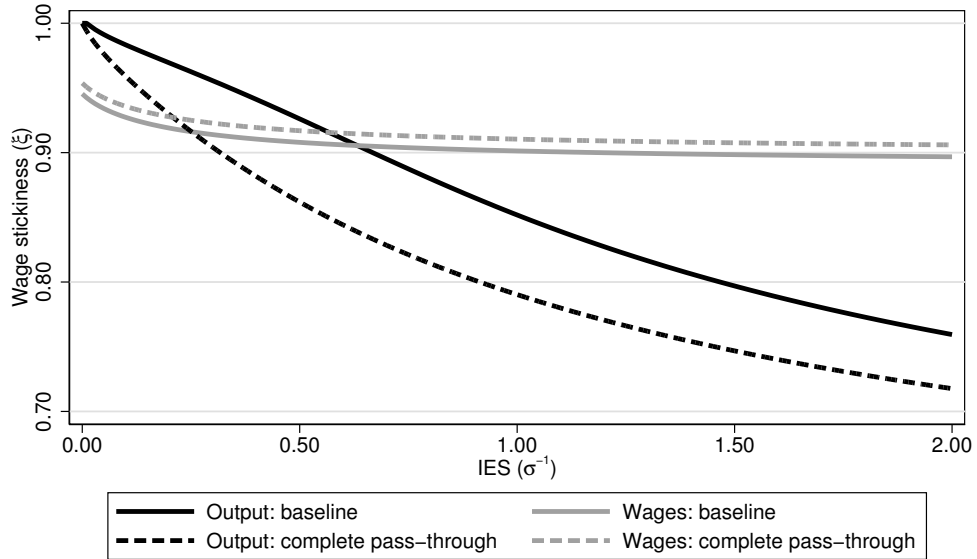
Note: panel A shows the response of world output over three years as a function of the inter-temporal elasticity of substitution (σ^{-1}) and the Calvo wage parameter (ξ). The darker the color, the bigger the effect on world output. The red dot corresponds to the (σ^{-1}, ξ) pair returned by the estimation. The red line draws the (σ^{-1}, ξ) pairs which imply no effect on non-devaluing countries' output. Panel B shows how the estimated moments pin down the two parameters: the black line is the (σ^{-1}, ξ) pairs which imply the observed relative effect on output, the gray line the (σ^{-1}, ξ) pairs which imply the observed relative effect on nominal wages. The intersection of the two lines corresponds to the red dot in panel A.

Figure 8: Identification: complete pass-through

Panel A: Response of World Output as a function of σ^{-1} and ξ



Panel B: Identification of σ^{-1} and ξ



Note: see note for figure 7. In panel A, the blue triangle is the (σ^{-1}, ξ) pair that matches the relative effects on output and wages, assuming full pass-through. This pair is pinned down by the intersection of the two dotted lines in panel B.

stimulus on world output is smaller by more than 2 percentage points. Therefore, the effect on non-devaluing countries is more negative by the same amount.

7 Conclusion

In this paper, I identified key moments from cross-country and granular trade data. Cross-country evidence shows that devaluation stimulated output, inflation, and trade in devaluing countries, compared to countries that did not. The effect on output is large: a 30% devaluation stimulated it by up to 14% over the next three years. Running against the competitive devaluation presumption, real imports did not go down. In fact, they went up after a few years. Trade evidence points toward an elasticity of substitution across foreign varieties between 2 and 4, and a pass-through of the exchange rate of about 0.4. I then used those moments to estimate a New Keynesian model with variable markups. The takeaway of this exercise is that devaluations had quantitatively small effects on the output of countries that did not devalue. Equivalently, the absolute effect of a devaluation is roughly similar to its relative effect. To the question “canst thou beggar thy neighbour,” this episode suggests a negative answer.

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ONLINE APPENDIX

A.1 Additional Tables

Table A.1: Country Samples

Difference-in-difference (section 2.1)		
Group	Countries	Comment
Treatment	Austria, Canada, Denmark, Finland, Japan, Mexico, Norway, Salvador, Sweden, United Kingdom	Devaluation in 1931
Control	France, Germany, Hungary, Netherlands, Poland, Switzerland	No devaluation before 1936
High frequency identification (section 2.2)		
	Belgium, France, Germany, Italy, Netherlands, United Kingdom, United States, Switzerland	Countries for which forward exchange rate data is available
US imports (section 4)		
Specification	Countries	Comment
1932, 1933	Austria, British India, British Malaya, Canada, Denmark, Egypt, Finland, Japan, Mexico, Norway, Portugal, Salvador, Sweden, United Kingdom	Devaluation in 1931
1932, 1933	Albania, Belgium, Bulgaria, Czechoslovakia, France, Germany, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland and Danzig, Rumania, Switzerland	No devaluation before 1934
1932	Estonia, South Africa	Devaluation in 1933
none	Argentina, Australia, Bolivia, Brazil, New Zealand, Uruguay, Venezuela	Devaluation before 1931
none	Chile, Costa Rica, Colombia, Ecuador, Greece, Peru, Siam, Yugoslavia	Devaluation in 1932
none	China, Hong Kong, Iran	Silver standard
none	Spain, Turkey	Floating currency
none	Cuba, Philippine Islands	Preferential tariff rates

Table A.2: Data Sources

Section	Variable	Source
2, 4	Spot exchange rate	League of Nations (1938b)
2.1	Industrial production	Mitchell (2003) for Europe except Latvia and Switzerland, David (1995) for Switzerland, Thorp (1984) for Latin America and League of Nations (1938b) otherwise
2.1	Exports and imports	League of Nations (1936): special trade, merchandise only, measured in metric tons for Belgium and the Netherlands, Economic Commission for Latin America (1951) for Argentina, Brazil and Mexico, League of Nations (1938a) otherwise
2.1	Wholesale price indices	League of Nations (1936)
2.1	Export and import price indices	League of Nations (1938a)
2.2	Forward exchange rate	<i>Financial Times</i>
2.2	Monthly data	Albers (2018), Mitchener and Wandschneider (2015)
4	US imports	United States Department of Commerce (1934)

Table A.3: P-values for DD Exercise

	IV			OLS		
	Baseline	Tariffs	Government	Baseline	Tariffs	Government
Industrial production	0.07	0.03	0.00	0.00	0.00	0.00
Real exports	0.00	0.19	0.00	0.00	0.00	0.00
Real imports	0.00	0.07	0.00	0.02	0.00	0.00
Wholesale price index	0.00	0.00	0.00	0.00	0.00	0.00
Consumer price index	0.04	0.04	0.00	0.00	0.00	0.00
Export price index	0.00	0.30	0.00	0.00	0.03	0.00
Import price index	0.00	0.00	0.00	0.00	0.00	0.00
Nominal wages	0.10	0.12	0.00	0.01	0.16	0.00
Real wages	0.03	0.73	0.00	0.20	0.00	0.00
Terms of trade	0.26	0.27	0.00	0.04	0.89	0.00
Nominal interest rate	0.13	0.27	0.26	0.17	0.27	0.25
Real interest rate	0.03	0.16	0.02	0.00	0.04	0.00

Note: p-value of a test of the joint significance of the 1932 to 1935 coefficients in equation (1) with no controls (baseline), controlling for the change in tariffs (tariff), or real government revenues and expenditures (government). In the IV columns, the change in the exchange rate is instrumented with a devaluation dummy. Standard errors are clustered at the country level, and bootstrapped with 2,000 replications. Point estimates are shown on figures A.1 and A.2.

Table A.4.1: Shocks

Date	# articles	Event	Shock
Panel A: Belgium (mean=0.2, sd=1.3)			
14nov1934	10	Catholics and liberals against devaluation	-0.007
17mar1935	14		
18mar1935	12		
19mar1935	22		
20mar1935	23		
21mar1935	8		
23mar1935	10		
25mar1935	11		
26mar1935	10		
27mar1935	12		
28mar1935	12		
29mar1935	25		
30mar1935	45		
31mar1935	24		
01apr1935	24		
02apr1935	14		
08apr1935	8		
Panel B: France (mean=1.3, sd=3.1)			
27may1935	21	Fall of Flandin's cabinet	-0.046
31may1935	21		
04jun1935	21		
05jun1935	23		
11may1936	22	Blum's devaluation speech	-0.013
05jun1936	21	Strikes	×
25sep1936	30	Devaluation	+0.234
26sep1936	60		
27sep1936	73		
28sep1936	59		
29sep1936	33		
30sep1936	31		
01oct1936	25		
02oct1936	28		
03oct1936	28		
04oct1936	27		
05oct1936	24		

Notes: shocks selected by the procedure described in section 2.2. The numbers in parenthesis are the mean and standard deviation of the daily number of articles for the selected country.

Table A.4.2: Shocks

Date	# articles	Event	Shock
Panel C: Germany (mean=0.7, sd=1.3)			
13jul1931	9	Exchange controls	-0.067
15jul1931	17		
16jul1931	10		
21jul1931	9		
22jul1931	9		
29sep1931	9	Stock exchange closed indefinitely	n.a.
05dec1931	13	Devaluation rumors	×
13jun1934	10		
15jun1934	20		
27sep1936	9	Gold bloc demise	×
28sep1936	10		
01oct1936	9		
Panel D: Italy (mean=0.3, sd=1.0)			
10dec1934	9	Exchange controls	-0.018
11dec1934	7	Gold coverage ratio suspended	+0.042
23jul1935	8		
24jul1935	16		
25jul1935	9		
20nov1935	11	Gold-buying monopoly	-0.002
29nov1935	8	International tensions	×
27sep1936	7	Gold bloc demise	×
28sep1936	9		
04oct1936	8		
06oct1936	38	Devaluation	n.a.
07oct1936	12		
09oct1936	8		
10nov1936	8	Austro-Italian trade pact	×

Note: shocks selected by the procedure described in section 2.2. The numbers in parenthesis are the mean and standard deviation of the daily number of articles for the selected country.

Table A.4.3: Shocks

Date	# articles	Event	Shock
Panel E: Netherlands (mean=0.2, sd=0.9)			
27jun1933	8	Devaluation rumors	×
06apr1935	8	Gold bloc reaffirms commitment	-0.023
07apr1935	7		
08apr1935	12	Pro-devaluation minister resigns	-0.009
04jun1935	9	New government	-0.014
24jul1935	8		
25jul1935	13		
26jul1935	8		
27jul1935	13		
28jul1935	11	Bank rate hike	-0.003
29jul1935	15		
17sep1935	7	Deflationary budget	-0.009
18sep1935	8	Devaluation rumors	×
26sep1935	8	Pro-devaluation speech by former minister	×
04feb1936	6	Devaluation	+0.175
27sep1936	18		
28sep1936	16		
29sep1936	7		
Panel F: Switzerland (mean=0.1, sd=0.5)			
21apr1933	4	US gold embargo	×
23mar1934	5	Pro-gold minister resigns	+0.003
24mar1934	4		
08apr1935	4	Gold bloc reaffirms commitment	-0.020
03jun1935	8	Devaluation proposal rejected	-0.011
04jun1935	4		
28oct1935	4	General elections	-0.003
27sep1936	14	Devaluation	+0.321
28sep1936	14		
30sep1936	6		
01oct1936	4		
09oct1936	4		

Note: shocks selected by the procedure described in section 2.2. The numbers in parenthesis are the mean and standard deviation of the daily number of articles for the selected country.

Table A.4.4: Shocks

Date	# articles	Event	Shock
Panel G: UK (mean=1.2, sd=2.1)			
21sep1931	40	Pound devaluation	+0.175
22sep1931	58		
23sep1931	26		
27sep1931	18		
28sep1931	27		
26nov1932	15	War debt discussions	×
02dec1932	16		
22apr1933	15	Dollar devaluation	×
26apr1933	17	Exchange equalisation fund increased	+0.018
26sep1936	18	Gold bloc demise	×
27sep1936	15		
Panel H: US (mean=18.3, sd=12.7)			
22sep1931	128	Pound devaluation	×
21apr1933	137	Gold embargo	+0.095
23apr1933	96		
16jan1934	156	Dollar devaluation	+0.022
02feb1934	107		
26sep1936	106		
27sep1936	138	Gold bloc demise	×
28sep1936	113		
29sep1936	111		

Note: shocks selected by the procedure described in section 2.2. The numbers in parenthesis are the mean and standard deviation of the daily number of articles for the selected country.

Table A.5: Elasticity—weighted specification

	1930-32 change			1930-33 change		
	(1) RF	(2) FS	(3) IV	(4) RF	(5) FS	(6) IV
Panel A: Estimate						
XR	0.998*** (0.348)	-0.351** (0.136)		0.965*** (0.264)	-0.327*** (0.088)	
Elasticity			2.843** (1.207)			2.951*** (0.853)
Observations	3742	3742	3742	3446	3446	3446
F-statistic			6.643			13.781
Panel B: Weighted placebo						
XR	-0.135 (0.233)	-0.049 (0.054)		-0.181 (0.173)	-0.061 (0.042)	
Elasticity			-2.755 (3.073)			-2.955* (1.565)
Observations	3755	3755	3755	3579	3579	3579
F-statistic			0.824			2.141

Note: reduced form (RF), first stage (FS) and instrumented (IV) estimates of equation (12). Standard errors are in parentheses. They are double clustered at the country and product levels. F-statistic is the Kleibergen-Paap Wald rk F-statistic of the first stage.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: Elasticity—tariff-induced bias

	Unweighted		Weighted	
	(1) All	(2) Ad-valorem	(3) All	(4) Ad-valorem
Panel A: IV				
Elasticity	2.731*** (0.379)	3.784*** (0.763)	2.964*** (0.938)	4.020** (1.689)
Observations	7042	2912	7042	2912
F-statistic	17.170	5.890	13.890	8.970
Panel B: OLS				
Elasticity	1.150*** (0.065)	1.013*** (0.080)	0.878*** (0.174)	0.629* (0.334)
Observations	7042	2912	7042	2912

Note: Observations are unweighted. Standard errors are in parentheses. They are two-way clustered at the country and product levels. F-statistics is the Kleibergen-Paap Wald rk F-statistic of the first stage.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

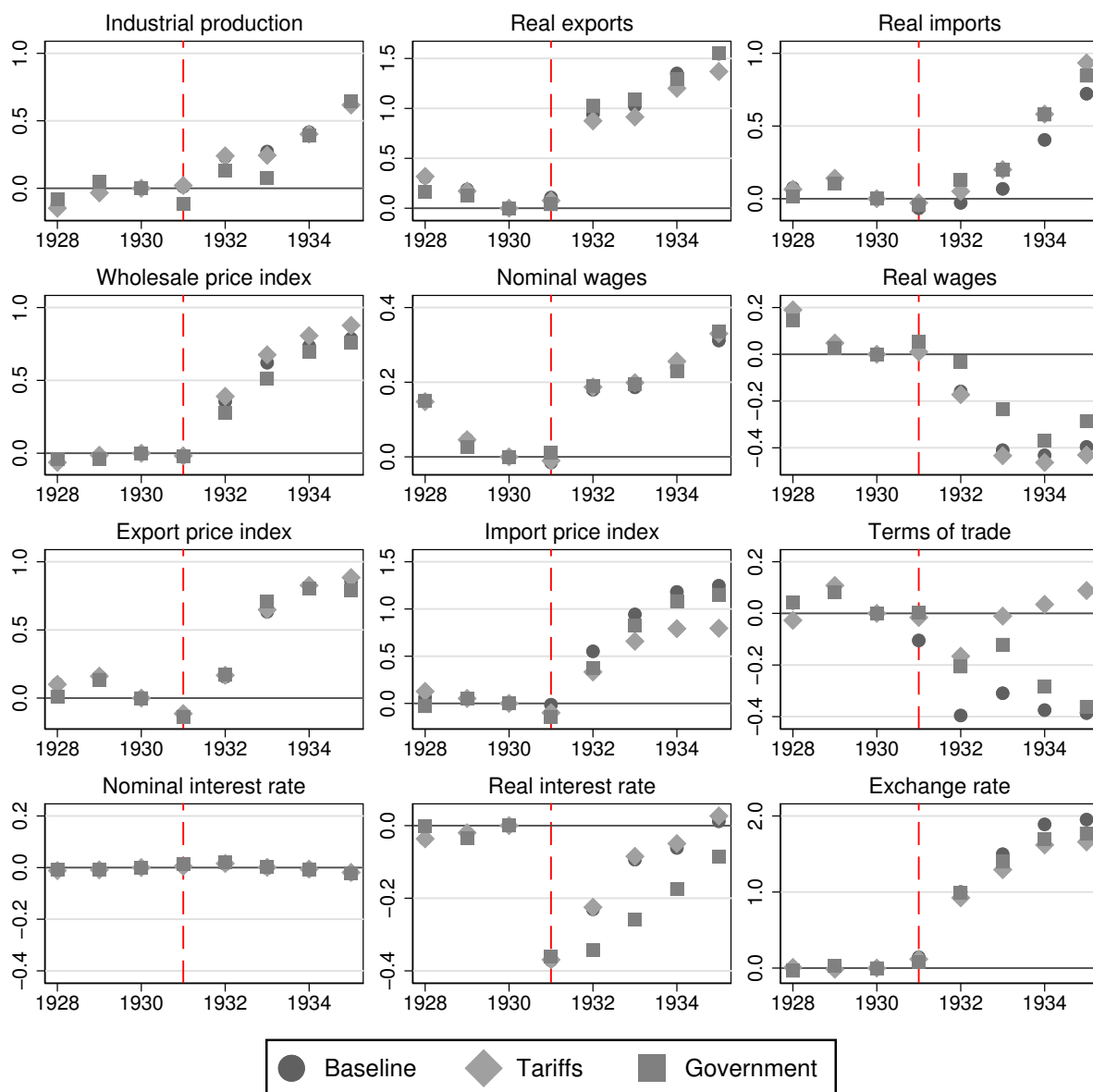
Table A.7: Parameters (HFI)

Parameter	Value	Concept	Target or source
Calibrated			
β	0.99	Discount rate	Annual interest rate of 4%
ι	0.8	Habit	Eggertsson (2008)
χ	1	Concavity of utility for money	Standard
γ	0.1	Openness	British export-to-GDP ratio
α_2	0.37	Profit share	Labor share of 2/3
η	21	Elasticity of labor demand	Christiano et al. (2005)
ν	0.0007	Stationarity-inducing device	Schmitt-Grohé and Uribe (2003)
g^*	0.14	Gold to output ratio	British gold-reserves-to-GDP ratio
Estimated			
σ^{-1}	4.67 (0.86)	IES	Industrial production
α_1	0.21 (0.06)	Curvature of production function	WPI
ξ	0.78 (0.04)	Calvo wage parameter	Nominal wages
ρ	1.2 (0.24)	Macro trade elasticity	Nominal imports
θ	3.08 (0.12)	Micro trade elasticity	US imports
\bar{m}	1.34 (0.02)	Markup elasticity	Pass-through

Note: calibrated and estimated parameters. The estimation follows the procedure described in section 6.1. The targets are the HFI cross-country moments of section 2.2 and the trade estimates of section 4.

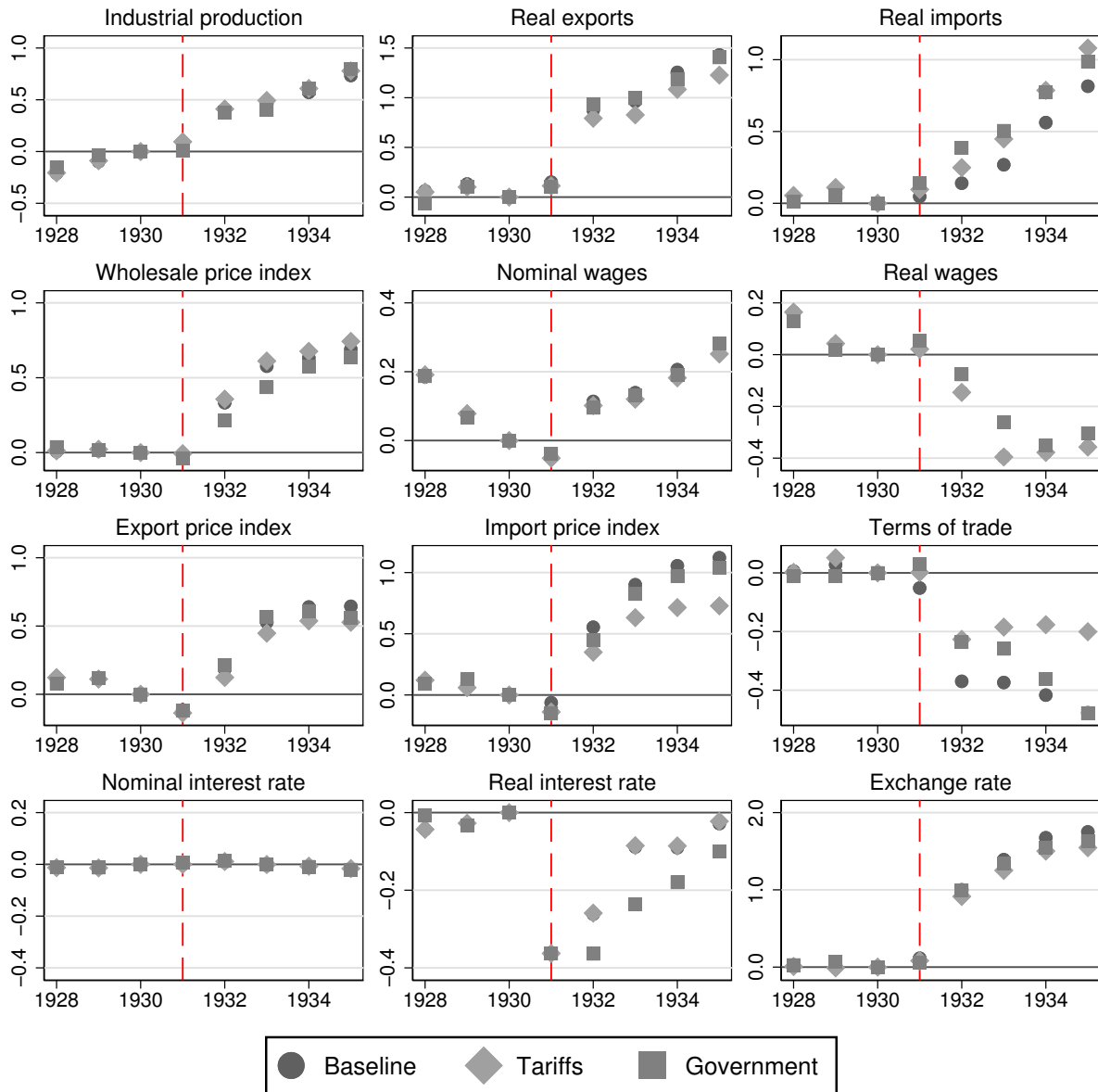
A.2 Additional Figures

Figure A.1: DD-IV with controls



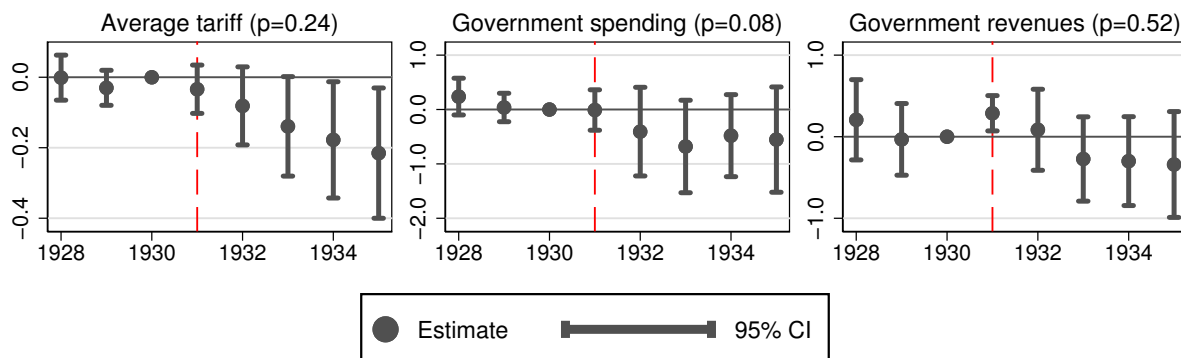
Note: response of relevant variable in devaluing countries, relative to non-devaluing ones. Formally, the plots show the estimate of β_t in equation (1) with no controls (baseline), controlling for the change in tariffs (tariff), or real government revenues and expenditures (government). The change in the exchange rate is instrumented with a devaluation dummy. β_{1930} is normalized to 0. P-values are shown in table A.3.

Figure A.2: DD-OLS with controls



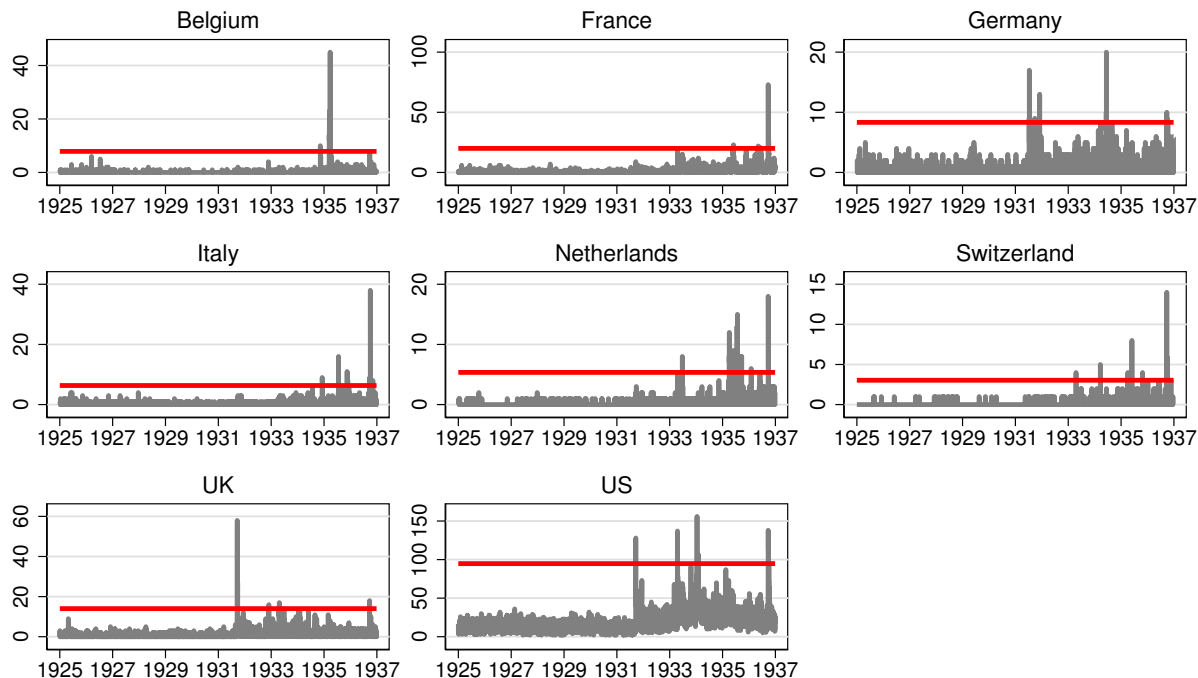
Note: response of relevant variable in devaluing countries, relative to non-devaluing ones. Formally, the plots show the estimate of β_t in equation (1) with no controls (baseline), controlling for the change in tariffs (tariff), or real government revenues and expenditures (government). β_{1930} is normalized to 0. P-values are shown in table A.3.

Figure A.3: Government variables



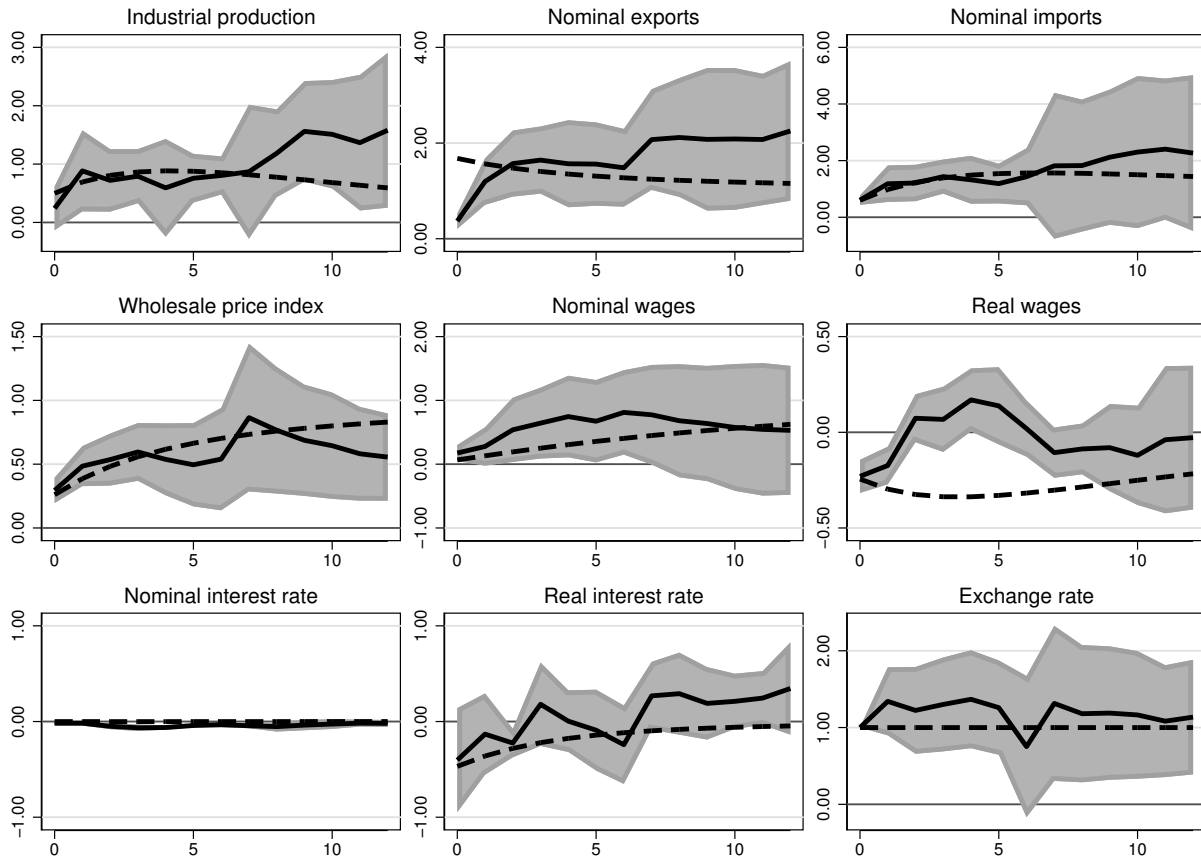
Note: response of relevant variable in devaluing countries, relative to non-devaluing ones. Formally, the plots show the estimate of β_t in equation (1). β_{1930} is normalized to 0. Standard errors are bootstrapped with 2,000 replications, and clustered at the country level. The number in parenthesis is the p-value of a test of the joint significance of the 1932 to 1935 coefficients.

Figure A.4: Daily number of articles for all countries



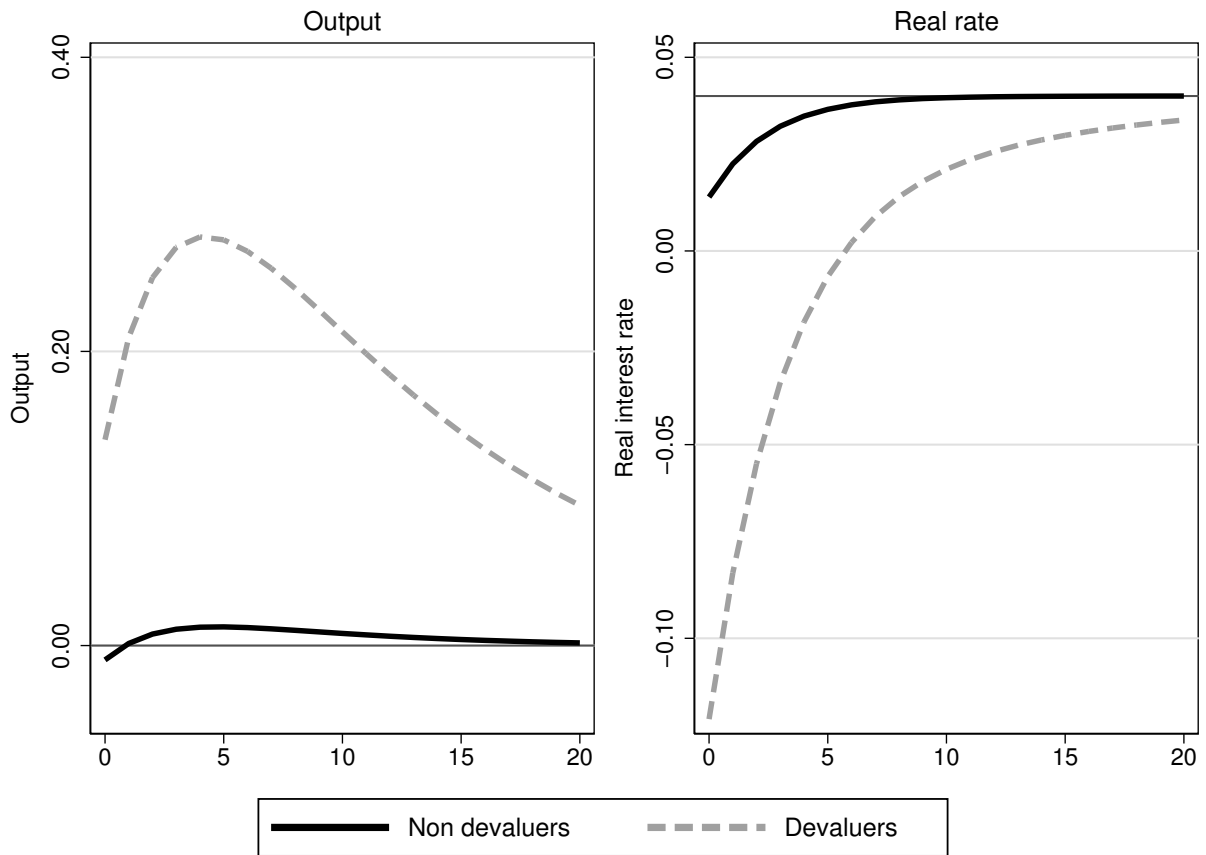
Note: number of daily articles returned by ProQuest Historical Newspapers with the keywords described in section 2.2. The red line is the cutoff defined by the formula: mean + 6 × standard deviations.

Figure A.5: Model fit (HFI)



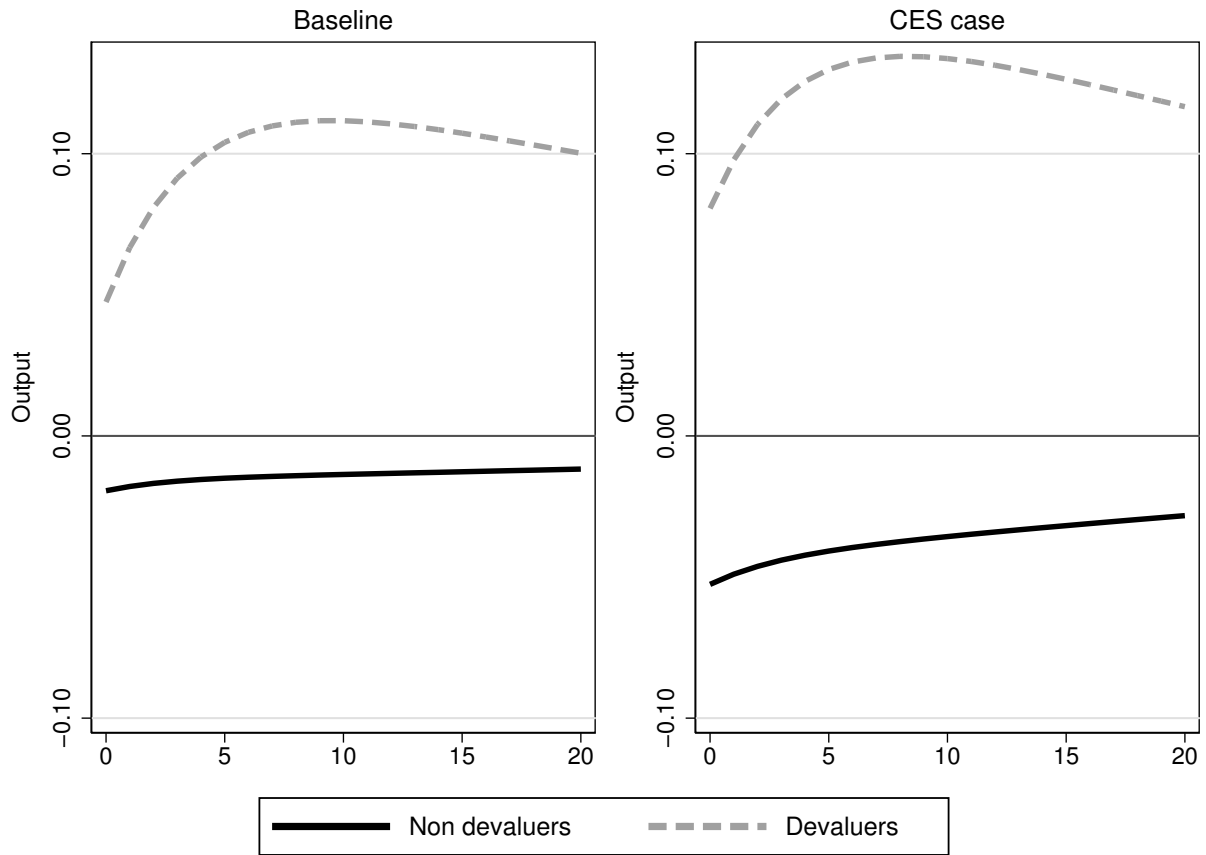
Note: empirical and theoretical responses of relevant variables under estimated parameter values. The black line is the point estimate, the gray area the 95% confidence interval, and the dashed grey line the theoretical response. The response of industrial production, nominal imports, wholesale prices, and nominal wages are explicitly targeted. Those of nominal exports are not. Real wages and the real interest rate are redundant since they respectively are the ratio of nominal wages to the wholesale price index and the difference between the nominal interest rate and wholesale price inflation.

Figure A.6: Counterfactual analysis (HFI)



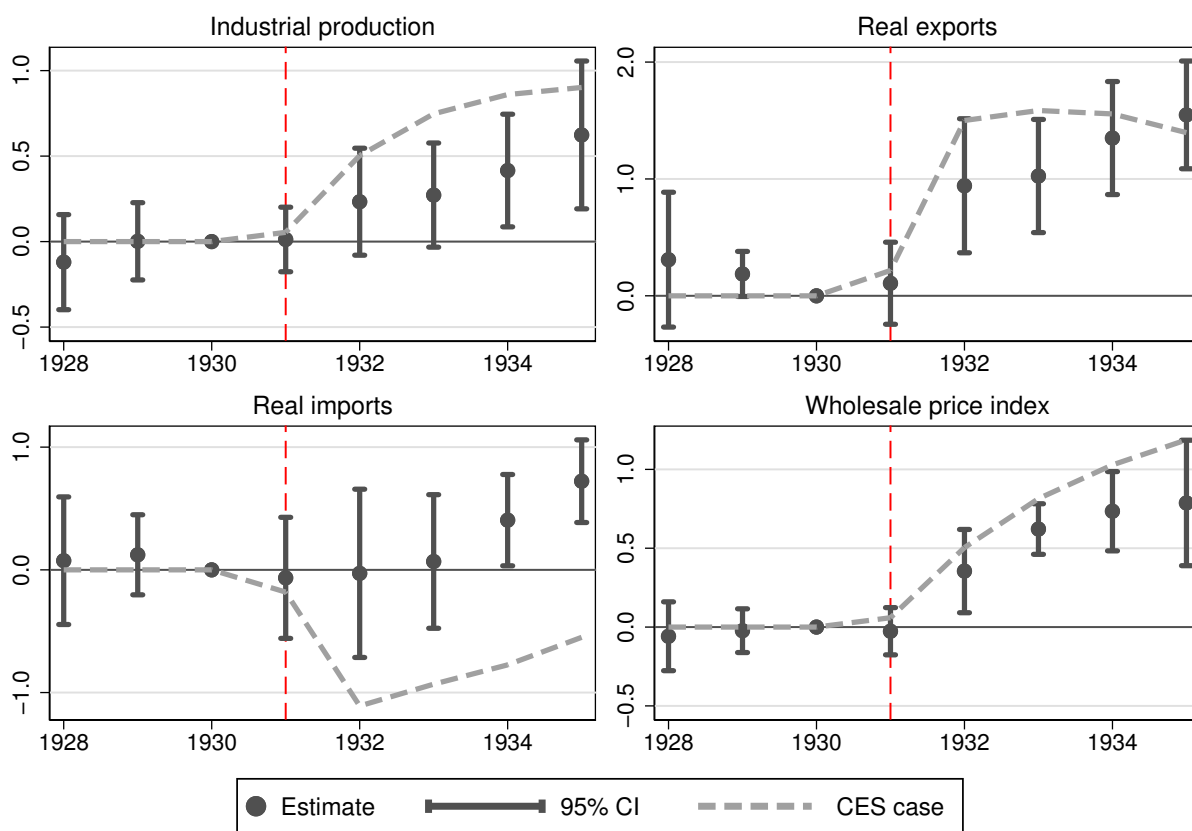
Note: response of output and the real interest rate to a 30% devaluation by half of the world under parameter values estimated with the HFI cross-country moments of section 2.2 and the trade estimates of section 4. Those parameter values are shown in table A.7.

Figure A.7: Counterfactual analysis in a CES world (DD)



Note: response of output to a 30% devaluation in half of the world with estimated parameter values (left-hand side) and with a CES demand for international goods ($\rho = \theta = 3$ and $\bar{m} = 0$). In the latter case, other parameters are set equal to their value in table 6. The left-hand side chart is the same as the left-hand side chart of figure 6.

Figure A.8: Poor fit of the CES world (DD)



Note: empirical and theoretical responses of relevant variables with a CES demand system for international goods ($\rho = \theta = 3$ and $\bar{m} = 0$)—other parameters are set equal to their value in table 6.

A.3 Additional Material on Elasticity Estimation

A.3.1 Data Construction

I discard imports from countries for which I do not have exchange rate data. After this step, I am left with 89% of the value of US imports from 1930 to 1933. I drop products for which I do not have value and quantity and for which there are two values but only one quantity. When a product is broken down between free and dutiable, I sum quantities and values. When there are two measures of quantity in the same unit, I drop the gross weight. When there are two measures of quantity in different units, I keep the one in pounds. Prices are recovered by dividing value with quantity.

Products are identified by their customs code. In all specifications, a product-country pair is dropped if its value is 0 in one of the relevant years. For instance, when I use 1930 and 1933 data, I only keep product-country pairs for which US imports are strictly positive in both years. This step drops up to 15% of the value of imports remaining from the previous steps. All in all, I am left with 44% of the value of US imports in 1931, 49% in 1932 and 56% in 1933.

The Hawley-Smoot tariff triggered the creation of several product categories in June 1930. As a result, the same product is not always classified consistently before and after the implementation of the tariff. Sometimes, the product category stays the same but switches from free to dutiable. Some other times, a product category is split into other categories. For instance, leather boots and shoes were divided into men's, women's and children's. Whenever possible, I merge all of these product categories to be consistent within and across years.

The customs code were reshuffled between 1929 and 1930, which makes it impossible to use those for the placebo tests. I manually match product categories based on their label. Whenever new product categories were created in 1930, I merge them as described in the previous paragraph.

A.3.2 Tariff-Induced Bias

A peculiar feature of inter-war US tariffs may bias my elasticities downward. While the US did not raise tariffs selectively against countries that devalued, custom duties on certain products were a fixed levy per physical unit of good. As a consequence, when the dollar price of these products decreased, the effective *ad valorem* tariff rate increased (Crucini, 1994, Irwin, 1998). Thus the tariff rate could have been correlated with the exchange rate which would compromise the validity of the instrument.

This point can be formalized by going back to equation (11). It is still valid with tariff if

p_{rt}^{jk} is interpreted as the after-tariff price. Unfortunately, I do not directly observe after-tariff prices at the product-country level.¹ Fortunately, I do not need the after-tariff price to infer the elasticity. Indeed, if I break down the price into its before-tariff and tariff components, the equation becomes:

$$\Delta c_{rt}^{jk} = -\theta \Delta \tilde{p}_{rt}^{jk} + \underbrace{\theta \Delta (\tau_{rt}^{jk*} + \tilde{p}_{rt}^{jk*})}_{\text{fixed effect}} + \underbrace{\Delta (\kappa_{rt}^{jk} - \theta \tau_{rt}^{jk})}_{\text{error term}} \quad (\text{A.1})$$

where \tilde{p}_{rt}^{jk} is the before-tariff price and τ_{rt}^{jk} is the effective tariff rate paid on varieties imported from country k . The equation again features a term that can be absorbed by a product-time fixed effect. But the error term now includes country-specific tariff.

While the US tariff code did not discriminate across countries until 1934,² the effective tariff rate is not necessarily the same across countries because some products were taxed through a fixed nominal duty, not by a fixed proportional rate. As a result, the effective tariff rate becomes inversely proportional to the price:

$$1 + \tau_{rt}^{jk} \left(\tilde{P}_{rt}^{jk} \right) \propto \frac{1}{\tilde{P}_{rt}^{jk}}$$

Which implies that the regression actually identifies:

$$\theta \left(1 + \tau_{rt}^{jk'} \left(\tilde{P}_{rt}^{jk} \right) \right) < \theta$$

There is a downward bias in the coefficient.

To quantify the extent of this bias, I re-estimate the elasticity with the same methodology but allowing it to differ for products that are taxed proportionally, and those that are taxed with a fixed nominal duty.³ The results are displayed in table A.6. I now pool 1930-1932 and 1930-33 changes in order to present the results in a more compact way. The products taxed with ad-valorem tariff indeed display a higher elasticity, closer to 4 than 3.

¹In theory, it should be possible to impute the relevant tariff duty to each product-country pair. In practice, this is impossible to do because the import data is more aggregated than the tariff data, and the tariff data is not broken down by country. As a result, there are several tariff subcategories within a product category as it is defined in the import data, and I do not observe the country information within those subcategories.

²Cuba and the Philippines benefited from preferential treatment but they are excluded from the sample.

³The data on tariff rates was first used by Bond et al. (2013). For the needs of this project, I re-digitized it in collaboration with Acosta and Cox (2021).

A.4 Theoretical Derivations

A.4.1 Demand Functions

The household minimizes expenditures:

$$\sum_{k \in \mathcal{J}} \int_f P_{rt}^{jk}(f) C_{rt}^{jk}(f) df$$

subject to:

$$C_{rt}^j = (1 - \Gamma_{rt}^j) C_{rt}^j \times g \left(\int_f g^* \left(\frac{C_{rt}^{jj}(f)}{(1 - \Gamma_{rt}^j) C_{rt}^j} \right) df \right) + \Gamma_{rt}^j C_{rt}^j \times g \left(\sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \Xi_{rt}^{jk} \int_f g^* \left(\frac{C_{rt}^{jk}(f)}{\Gamma_{rt}^j \Xi_{rt}^{jk} C_{rt}^j} \right) df \right) \quad (\text{A.2})$$

$$g(1) = g^*(1) = g'^*(1) = g'(1) = 1 \quad \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \Xi_{rt}^{jk} = 1$$

The measure of firms is normalized to 1.

The first-order conditions are:

$$P_{rt}^{jj}(f) = g^{*'} \left(\frac{C_{rt}^{jj}(f)}{(1 - \Gamma_{rt}^j) C_{rt}^j} \right) \times g' \left(\int_f g^* \left(\frac{C_{rt}^{jj}(f)}{(1 - \Gamma_{rt}^j) C_{rt}^j} \right) df \right) \Lambda_t^j$$

$$P_{rt}^{jk}(f) = g^{*'} \left(\frac{C_{rt}^{jk}(f)}{\Gamma_{rt}^j \Xi_{rt}^{jk} C_{rt}^j} \right) \times g' \left(\sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \Xi_{rt}^{jk} \int_f g^* \left(\frac{C_{rt}^{jk}(f)}{\Gamma_{rt}^j \Xi_{rt}^{jk} C_{rt}^j} \right) df \right) \Lambda_t^j$$

where Λ_t^j is the Lagrange multiplier on the constraint. Rearranging:

$$C_{rt}^{jj}(f) = (1 - \Gamma_{rt}^j) \times h \left(\frac{P_{rt}^{jj}(f)}{\Lambda_t^j \times g' \left(\int_f g^* \left(\frac{C_{rt}^{jj}(f)}{(1 - \Gamma_{rt}^j) C_{rt}^j} \right) df \right)} \right) C_{rt}^j \quad (\text{A.3})$$

$$C_{rt}^{jk}(f) = \Gamma_t^j \Xi_t^{jk} \times h \left(\frac{P_{rt}^{jk}(f)}{\Lambda_t^j g' \left(\sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \Xi_{rt}^{jk} \int_f g^* \left(\frac{C_{rt}^{jk}(f)}{\Gamma_{rt}^j \Xi_{rt}^{jk} C_{rt}^j} \right) df \right)} \right) C_{rt}^j \quad (\text{A.4})$$

where $h(\cdot) = (g^*)^{-1}(\cdot)$. Note that $h(1) = 1$ since $g^*(\cdot) = 1$.

Using the first-order conditions, one can check that if relative prices are equal to 1:

$$\begin{aligned} C_{rt}^{jj}(f) &= (1 - \Gamma_t^j) C_{rt}^j \\ C_{rt}^{jk}(f) &= \Gamma_{rt}^j \Xi_{rt}^{jk} C_{rt}^j \end{aligned}$$

Log-linearizing around that symmetric equilibrium when demand shocks are equal to their mean ($\Gamma_{rt}^j = \bar{\Gamma}_{rt}^j$ and $\Xi_{rt}^{jk} = \bar{\Xi}_r^{jk}$):

$$\begin{aligned} \hat{c}_{rt}^j &= (1 - \bar{\Gamma}^j) \hat{c}_{rt}^{jj} + \bar{\Gamma}^j \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}_r^{jk} \hat{c}_{rt}^{jk} \\ \hat{c}_{rt}^{jj} &\equiv \int_f \hat{c}_{rt}^{jj}(f) \quad \hat{c}_{rt}^{jk} \equiv \int_f \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}_r^{jk} \hat{c}_{rt}^{jk}(f) df \end{aligned}$$

Similarly defining the price index as:

$$P_{rt}^j C_{rt}^j \equiv \sum_{k \in \mathcal{J}} \int_f P_{rt}^{jk}(f) C_{rt}^{jk}(f) df$$

One can show:

$$\begin{aligned} p_{rt}^j &= (1 - \bar{\Gamma}^j) p_{rt}^{jj} + \bar{\Gamma}^j \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}_r^{jk} p_{rt}^{jk} \\ p_{rt}^{jj} &\equiv \int_f p_{rt}^{jj}(f) \quad p_{rt}^{jk} \equiv \int_f \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}_r^{jk} p_{rt}^{jk}(f) df \end{aligned}$$

I now log-linearize the demand functions around the symmetric equilibrium:

$$\hat{c}_{rt}^{jj}(f) = \hat{c}_{rt}^j - \theta (p_{rt}^{jj}(f) - \lambda_t^j + \tilde{\rho} (\hat{c}_{rt}^{jj} - \hat{c}_{rt}^j)) - \frac{\bar{\Gamma}^j}{1 - \bar{\Gamma}^j} (1 + \theta \tilde{\rho}) \hat{\gamma}_{rt}^j$$

$$\hat{c}_{rt}^{jk}(f) = \hat{c}_{rt}^j - \theta \left(p_{rt}^{jk}(f) - \lambda_t^j + \tilde{\rho} (\hat{c}_{rt}^{j*} - \hat{c}_{rt}^j) \right) + (1 + \theta \tilde{\rho}) \hat{\gamma}_{rt}^j + \hat{\xi}_{rt}^{jk}$$

where:

$$\begin{aligned} \hat{c}_{rt}^{jj} &\equiv \int_f \hat{c}_{rt}^{jj}(f) df & \hat{c}_{rt}^{j*} &\equiv \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}_r^{jk} \int_f \hat{c}_{rt}^{jk}(f) df \\ \theta &\equiv -\frac{h'(1)}{h(1)} & \tilde{\rho} &= -\frac{g^{*'}(1)g''(1)}{g'(1)} \end{aligned}$$

I then aggregate over f :

$$\hat{c}_{rt}^{jj} = \hat{c}_{rt}^j - \theta \left(p_{rt}^{jj} - \lambda_t^j + \tilde{\rho} (\hat{c}_{rt}^{jj} - \hat{c}_{rt}^j) \right) - \frac{\bar{\Gamma}^j}{1 - \bar{\Gamma}^j} (1 + \theta \tilde{\rho}) \hat{\gamma}_{rt}^j \quad (\text{A.5})$$

$$\hat{c}_{rt}^{jk} = \hat{c}_{rt}^j - \theta \left(p_{rt}^{jk} - \lambda_t^j + \tilde{\rho} (\hat{c}_{rt}^{j*} - \hat{c}_{rt}^j) \right) + (1 + \theta \tilde{\rho}) \hat{\gamma}_{rt}^j + \hat{\xi}_{rt}^{jk} \quad (\text{A.6})$$

The demand for imports is given by averaging over k in equation (A.6):

$$\hat{c}_{rt}^{j*} = \hat{c}_{rt}^j - \theta \left(p_{rt}^{j*} - \lambda_t^j + \tilde{\rho} (\hat{c}_{rt}^{j*} - \hat{c}_{rt}^j) \right) + (1 + \theta \tilde{\rho}) \hat{\gamma}_{rt}^j \quad (\text{A.7})$$

Subtracting equation (A.7) from equation (A.6):

$$\hat{c}_{rt}^{jk} = \hat{c}_{rt}^{j*} - \theta \left(p_{rt}^{jk} - p_{rt}^{j*} \right) + \hat{\xi}_{rt}^{jk} \quad (\text{A.8})$$

Taking the weighted average of equations (A.5) and (A.7), I can check that: $\lambda_{rt}^j = p_{rt}^j$. Then, equations (A.5) and (A.7) can be rearranged to:

$$\hat{c}_{rt}^{jj} = \hat{c}_{rt}^j - \rho \left(p_{rt}^{jj} - p_{rt}^j \right) - \frac{\bar{\Gamma}^j}{1 - \bar{\Gamma}^j} \hat{\gamma}_{rt}^j \quad (\text{A.9})$$

$$\hat{c}_{rt}^{j*} = \hat{c}_{rt}^j - \rho \left(p_{rt}^{j*} - p_{rt}^j \right) + \hat{\gamma}_{rt}^j \quad (\text{A.10})$$

where:

$$\rho \equiv \frac{\theta}{1 + \theta \tilde{\rho}}$$

ρ is the elasticity of substitution between domestic and foreign varieties, while θ is the elasticity of substitution among foreign varieties.

CES case: Suppose that:

$$g(x) = x \quad g^*(x) = 1 + \frac{\theta}{\theta - 1} \left(x^{\frac{\theta-1}{\theta}} - 1 \right)$$

The Kimball aggregator simplifies to:

$$C_{rt}^j = (1 - \Gamma_{rt}^j) C_{rt}^j \times \int_f \left(\frac{C_{rt}^{jj}(f)}{(1 - \Gamma_{rt}^j) C_{rt}^j} \right)^{\frac{\theta-1}{\theta}} df + \Gamma_{rt}^j C_{rt}^j \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \Xi_{rt}^{jk} \int_f \left(\frac{C_{rt}^{jk}(f)}{\Gamma_{rt}^j \Xi_{rt}^{jk} C_{rt}^j} \right)^{\frac{\theta-1}{\theta}} df$$

Which can be rewritten in a more traditional form:

$$C_{rt}^j = \left[(1 - \Gamma_{rt}^j)^{\frac{1}{\theta}} \int_f (C_{rt}^{jj}(f))^{\frac{\theta-1}{\theta}} df + (\Gamma_{rt}^j)^{\frac{1}{\theta}} \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} (\Xi_{rt}^{jk})^{\frac{1}{\theta}} \int_f (C_{rt}^{jk}(f))^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}}$$

A.4.2 Strategic Complementarities

A.4.2.1 Price indices

A firm maximizes:

$$\left(P_{rt}^{jk}(f) - \frac{MC_t^k(f)}{XR_t^{kj}} \right) C_t^{jk}(f)$$

subject to equations (A.3) or (A.4). The first-order condition for $k \neq j$ is:

$$h(X) + \left(1 - \frac{MC_{rt}^k(f)/XR_t^{kj}}{P_{rt}^{jk}} \right) Xh'(X) = 0$$

where:

$$X = \frac{P_{rt}^{jk}(f)}{\Lambda_t^j g' \left(\sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \Xi_{rt}^{jk} \int_f g^* \left(\frac{C_{rt}^{jk}(f)}{\Gamma_{rt}^j \Xi_{rt}^{jk} C_{rt}^j} \right) df \right)}$$

Rearranging:

$$P_{rt}^{jk}(f) = \mathcal{M}(X) \frac{MC_{rt}^k(f)}{XR_t^{kj}}$$

where:

$$\mathcal{M}(X) = \frac{-\frac{Xh'(X)}{h(X)}}{-\frac{Xh'(X)}{h(X)} - 1}$$

Log-linearizing:

$$p_t^{jk}(f) = (-\bar{m} \left(p_t^{jk}(f) - p_t^j + \tilde{\rho}(\hat{c}_{rt}^{j*} - \hat{c}_{rt}^j - \hat{\gamma}_{rt}^j) \right) + (\Theta + mc_t^k(f) - xr_t^{kj}))$$

$$\bar{m} = \frac{d \log \mathcal{M}(X)}{d \log X} \Big|_{X=1} \quad \Theta = \log \frac{\theta}{\theta - 1}$$

Aggregating over f :

$$p_{rt}^{jk} = -\bar{m} \left(p_{rt}^{jk} - p_{rt}^j + \tilde{\rho}(\hat{c}_{rt}^{j*} - \hat{c}_{rt}^j - \hat{\gamma}_{rt}^j) \right) + (\Theta + mc_{rt}^k - xr_t^{kj})$$

Substituting equation (A.10) and rearranging:

$$p_{rt}^{jk} = \frac{\bar{m}\tilde{\rho}\rho}{1 + \bar{m}} p_{rt}^{j*} + \frac{\bar{m}(1 - \tilde{\rho}\rho)}{1 + \bar{m}} p_{rt}^j + \frac{1}{1 + \bar{m}} (\Theta + mc_{rt}^k - xr_t^{kj})$$

Aggregating over k :

$$p_{rt}^{j*} = \frac{\bar{m}(1 - \tilde{\rho}\rho)}{1 + \bar{m}(1 - \tilde{\rho}\rho)} p_{rt}^j + \frac{1}{1 + \bar{m}(1 - \tilde{\rho}\rho)} \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}^{jk} (\Theta + mc_{rt}^k - xr_t^{kj})$$

Similarly, for the domestic good:

$$p_{rt}^{jj}(f) = -\bar{m} \left(p_{rt}^{jk} - p_{rt}^j + \tilde{\rho} \left(\hat{c}_{rt}^{jj} - \hat{c}_{rt}^j + \frac{\bar{\Gamma}^j}{1 - \bar{\Gamma}^j} \hat{\gamma}_{rt}^j \right) \right) + \Theta + mc_{rt}^j(f)$$

Aggregating over f :

$$p_{rt}^{jj} = \frac{\bar{m}(1 - \tilde{\rho}\rho)}{1 + \bar{m}(1 - \tilde{\rho}\rho)} p_{rt}^j + \frac{1}{1 + \bar{m}(1 - \tilde{\rho}\rho)} (\Theta + mc_{rt}^j)$$

Therefore:

$$p_{rt}^{jk} = \zeta_1 p_{rt}^{j*} + \zeta_2 p_{rt}^j + (1 - \zeta_1 - \zeta_2) (\Theta + mc_{rt}^k - xr_t^{kj}) \quad (\text{A.11})$$

$$p_{rt}^{j*} = \delta p_{rt}^j + (1 - \delta) \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}^{jk} (\Theta + mc_{rt}^k - xr_t^{kj}) \quad (\text{A.12})$$

$$p_{rt}^{jj} = \delta p_{rt}^j + (1 - \delta) (\Theta + mc_{rt}^j) \quad (\text{A.13})$$

where:

$$\zeta_1 \equiv \frac{\bar{m}\tilde{\rho}\rho}{1 + \bar{m}} \quad \zeta_2 \equiv \frac{\bar{m}(1 - \tilde{\rho}\rho)}{1 + \bar{m}} \quad \delta \equiv \frac{\bar{m}(1 - \tilde{\rho}\rho)}{1 + \bar{m}(1 - \tilde{\rho}\rho)}$$

Substituting in the formula for $\tilde{\rho}$:

$$\zeta_1 = \frac{\bar{m}(1 - \rho/\theta)}{1 + \bar{m}} \quad \zeta_2 = \frac{\bar{m}\rho/\theta}{1 + \bar{m}} \quad \delta = \frac{\bar{m}\rho}{\theta + \bar{m}\rho}$$

Combining equations (A.12) and (A.13):

$$p_{rt}^j = \Theta + (1 - \bar{\Gamma}^j)mc_{rt}^j + \bar{\Gamma}^j \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}^{jk} (mc_{rt}^k - xr_t^{kj}) \quad (\text{A.14})$$

Invoking equation (A.12) one more time:

$$p_{rt}^{j*} = \Theta + \delta(1 - \bar{\Gamma}^j)mc_{rt}^j + (1 - \delta(1 - \bar{\Gamma}^j)) \sum_{\substack{k \in \mathcal{J} \\ k \neq j}} \bar{\Xi}^{jk} (mc_{rt}^k - xr_t^{kj}) \quad (\text{A.15})$$

Plugging the latter two results into equation (7):

$$\begin{aligned} p_{rt}^{jk} = & \Theta + \delta(1 - \bar{\Gamma}^j)mc_{rt}^j + (\zeta_1 + \zeta_2 - \delta(1 - \bar{\Gamma}^j)) \sum_{\substack{m \in \mathcal{J} \\ m \neq j}} \bar{\Xi}^{jm} (mc_{rt}^m - xr_t^{mj}) \\ & + (1 - \zeta_1 - \zeta_2)(mc_{rt}^k - xr_t^{kj}) \end{aligned} \quad (\text{A.16})$$

Klenow and Willis (2016) case: Suppose that: $h(x) = (1 - \bar{m}' \log(x))^{\frac{\theta}{\bar{m}'}}$. Then: $\bar{m} = \bar{m}'/(\theta - 1)$.⁴ \bar{m} can take any value from 0 to infinity as long as $\theta > 1$. So $(1 - \zeta_1 - \zeta_2)$ can take any value between 0 and 1.

A.4.2.2 Proof of Proposition 2

The producer price index is given by combining equations (A.13) and (A.14):

$$p_t^{kk} = \Theta + (1 - \delta\bar{\Gamma})mc_t^k + \delta\bar{\Gamma} \int_m (mc_t^m - xr_t^{km}) dm$$

Rearranging:

$$\begin{aligned} mc_t^k &= -\frac{\Theta}{1 - \delta\bar{\Gamma}} + \frac{1}{1 - \delta\bar{\Gamma}} p_t^k - \frac{\delta\bar{\Gamma}}{1 - \delta\bar{\Gamma}} \int_m (mc_t^m - xr_t^{km}) dm \\ &= -\frac{\Theta}{1 - \delta\bar{\Gamma}} + \frac{1}{1 - \delta\bar{\Gamma}} p_t^k - \frac{\delta\bar{\Gamma}}{1 - \delta\bar{\Gamma}} \int_m (mc_t^m - xr_t^{mj}) dm - \frac{\delta\bar{\Gamma}}{1 - \delta\bar{\Gamma}} xr_t^{kj} \end{aligned}$$

⁴See Itskhoki and Mukhin (2021) for a detailed proof.

Plugging into the simplified version of equation (A.11):

$$p_t^{jk} = -\frac{1 - \zeta_1 - \zeta_2}{1 - \delta\bar{\Gamma}} x r_t^{kj} + \frac{1 - \zeta_1 - \zeta_2}{1 - \delta\bar{\Gamma}} \left(p_t^k - \delta\bar{\Gamma} \int_m (m c_t^m - x r_t^{mj}) dm \right) + \zeta_1 p_t^{j*} + \zeta_2 p_t^j$$

A.4.3 Market Clearing

To a first order, demand for the varieties of country j are:

$$\hat{y}_t^j = (1 - \bar{\Gamma}) \hat{c}_t^{jj} + \bar{\Gamma} \int_k \hat{c}_t^{kj} dk$$

Using equations (A.8) and (A.10):

$$\hat{c}_t^{kj} = \hat{c}_t^{k*} - \theta \left(p_t^{kj} - p_t^{k*} \right) = \hat{c}_t^k - \rho \left(p_t^{k*} - p_t^k \right) - \theta \left(p_t^{kj} - p_t^{k*} \right)$$

Now, using equations (A.14) and (A.15):

$$p_t^{k*} - p_t^k = (1 - \delta(1 - \bar{\Gamma})) \left(\int_m (m c_t^m - x r_t^{km}) dm - m c_t^k \right)$$

Moreover, using equations (A.15) and (A.16):

$$p_t^{kj} - p_t^{k*} = (1 - \zeta_1 - \zeta_2) \left(m c_t^j - x r_t^{kj} - \int_m (m c_t^m - x r_t^{km}) dm \right)$$

So:

$$\begin{aligned} \hat{c}_t^{kj} &= \hat{c}_t^k - \rho(1 - \delta(1 - \bar{\Gamma})) \left(\int_m (m c_t^m - x r_t^{km}) dm - m c_t^k \right) \\ &\quad - \theta(1 - \zeta_1 - \zeta_2) \left(m c_t^j - x r_t^{kj} - \int_m (m c_t^m - x r_t^{km}) dm \right) \end{aligned}$$

Note that: $x r^{km} = x r^{mj} - x r^{kj}$. Using this identity and integrating over k :

$$\begin{aligned} \int_k \hat{c}_t^{kj} dk &= \int_k \hat{c}_t^k dk \\ &\quad - \theta(1 - \zeta_1 - \zeta_2) \left(m c_t^j - \int_m (m c_t^m - x r_t^{mj}) dm \right) \end{aligned}$$

Moreover, using equations (A.9) and (A.14):

$$\hat{c}_t^{jj} = \hat{c}_t^j - \rho \left(p_t^{jj} - p_t^j \right) = \hat{c}_t^j - \rho(1 - \delta)\bar{\Gamma} \left(m c_t^j - \int_m (m c_t^m - x r_t^{mj}) dm \right)$$

Gathering those results:

$$\begin{aligned}\hat{y}_t^j &= \psi \left(\int_m (m c_t^m - x r_t^{mj}) dm - m c_t^j \right) + (1 - \bar{\Gamma}) \hat{c}_t^j + \bar{\Gamma} \int_k \hat{c}_t^k dk \\ \psi &\equiv \bar{\Gamma} [(1 - \delta)(1 - \bar{\Gamma})\rho + (1 - \zeta_1 - \zeta_2)\theta]\end{aligned}\tag{A.17}$$

A.4.4 Households

The utility of the country's representative household is:

$$E_0 \sum_{t=0}^{\infty} \left(\frac{(C_t^j - \iota C_{t-1}^j)^{1-\sigma} - 1}{1-\sigma} - \int_l \frac{(N_t^j(l))^{1+\phi}}{1+\phi} dl + \frac{(M_t^j/P_t^j)^{1-\chi} - 1}{1-\chi} \right)$$

subject to:

$$\begin{aligned}\frac{B_t^j}{1 + \hat{i}_t^j} - B_{t-1}^j + M_t^j - M_{t-1}^j &= \int_l W_t^j(l) N_t^j(l) dl - P_t^j C_t^j + \text{profits} \\ N_t^j(l) &= \left(\frac{W_t^j(l)}{W_t^j} \right)^{-\eta} N_t^j\end{aligned}$$

The Euler equation is:

$$\begin{aligned}\hat{\mu}_t^j &= E_t \hat{\mu}_{t+1}^j + \hat{v}_t^j - E_t \pi_{ct+1}^j \\ \hat{\mu}_t^j &\equiv \frac{\sigma}{(1-\iota)(1-\beta\iota)} (\beta\iota \hat{c}_{t+1}^j - (1 + \beta\iota^2) \hat{c}_t^j + \iota \hat{c}_{t-1}^j)\end{aligned}$$

The first-order condition for money holdings is:

$$\hat{v}_t^j = \frac{1-\beta}{\beta^2} \left(-\chi (\widehat{m}_t^j - \widehat{p}_t^j) - \hat{\mu}_t^j \right)$$

The Phillips curve can be written as:⁵

$$\begin{aligned}\pi_{wt}^j &= \beta E_t \pi_{wt+1}^j + \tilde{\kappa} \hat{y}_t^j - \kappa \hat{\mu}_t^j + \kappa (\widehat{w}_t^j - \widehat{p}_t^j) \\ \kappa &\equiv \frac{(1-\xi)(1-\beta\xi)}{\xi(1+\eta\phi)} \quad \tilde{\kappa} \equiv \kappa \frac{\phi}{1-\alpha_2}\end{aligned}$$

⁵See Galí (2015, ch. 6) for a derivation.

A.4.5 International Payments

Profits of the central bank are:

$$\Pi_{cbt}^j = M_t^j - M_{t-1}^j - \mathcal{E}_t^j (G_t^j - G_{t-1}^j)$$

Profits of the firms are:

$$(P_t^{jj} - W_t^j) C_t^{jj}(f) + \int_k \left(\frac{P_t^{kj}}{XR_t^{kj}} - W_t^j \right) C_t^{kj}(f) dk$$

The balance of payments of the country is given by:

$$\frac{B_t^j}{1+i_t^j} - B_{t-1}^j + \mathcal{E}_t^j (G_t^j - G_{t-1}^j) = \int_f P_t^{jj} C_t^{jj}(f) df + \int_k \int_f \frac{P_t^{kj}}{XR_t^{kj}} C_t^{kj}(f) dk df - P_t^j C_t^j$$

To a first-order, this is:

$$\begin{aligned} \beta b_t^j - b_{t-1}^j + \bar{g} \Delta g_t^j &= \bar{\Gamma} \int_k \left(p_t^{kj} - xr_t^{kj} - p_t^{jk} \right) dk + \bar{\Gamma} \int_k \left(\hat{c}_t^{kj} dk - \hat{c}_t^{kj} \right) dk \\ b_t^j &= \frac{B_t^j}{P_t^j Y_t^j} \\ \bar{g} &= \frac{\mathcal{E}_t^j G_t^j}{P_t^j Y_t^j} \text{ expressed in steady state} \end{aligned}$$

A.4.6 Model Summary

For each country, there are 17 variables: output (y), consumption (c), marginal cost (mc), wage (w), price charged in country k (p^{jk}),⁶ import price index (IPI, p^{j*}), producer price index (PPI, p^{jj}), consumer price index (CPI, p^j), CPI inflation (π_c^j), wage inflation (π_w^j), marginal utility (μ^j), nominal interest rate (i^j), money supply (m^j), exchange rate (xr^j), nominal gold price (ϵ^j), bonds owned (b^j) and gold stock (g^j). The endogenous state variables are p_{t-1}^j , w_{t-1}^j , b_{t-1}^j and g_{t-1}^j . The exogenous state variables are ϵ_t^j . Other variables are controls.

There are 18 equations:

$$\text{market clearing: } \hat{y}_t^j = \psi \left(\int_m (mc_t^m - xr_t^{mj}) dm - mc_t^j \right) + (1 - \bar{\Gamma}) \hat{c}_t^j + \bar{\Gamma} \int_k \hat{c}_t^k dk \quad (\text{A.18})$$

$$\text{marginal cost: } mc_t^j = w_t^j + \frac{\alpha_1}{1 - \alpha_2} \hat{y}_t^j \quad (\text{A.19})$$

⁶To be precise, p^{jk} is not a single variable, but a continuum of variables as there is a continuum of countries k .

$$\text{CPI: } p_t^j = \Theta + (1 - \bar{\Gamma})mc_t^j + \bar{\Gamma} \int_m (mc_t^m - xr_t^{mj}) \quad (\text{A.20})$$

$$\text{CPI inflation: } \pi_{ct}^j = p_t^j - p_{t-1}^j \quad (\text{A.21})$$

$$\text{wage inflation: } \pi_{wt}^j = w_t^j - w_{t-1}^j \quad (\text{A.22})$$

$$\text{marginal utility: } \hat{\mu}_t^j = \frac{\sigma}{(1 - \iota)(1 - \beta\iota)} (\beta\iota E_t \hat{c}_{t+1}^j - (1 + \beta\iota^2) \hat{c}_t^j + \iota \hat{c}_{t-1}^j) \quad (\text{A.23})$$

$$\text{Euler equation: } \hat{\mu}_t^j = E_t \hat{\mu}_{t+1}^j + \hat{\iota}_t^j - E_t \pi_{c,t+1}^j \quad (\text{A.24})$$

$$\text{money holdings: } \hat{v}_t^j = \frac{1 - \beta}{\beta^2} \left(-\chi(\widehat{m}_t^j - p_t^j) - \hat{\mu}_t^j \right) \quad (\text{A.25})$$

$$\text{Phillips curve: } \pi_{wt}^j = \beta E_t \pi_{wt+1}^j + \tilde{\kappa} \hat{y}_t^j - \kappa \hat{\mu}_t^j + \kappa(\widehat{w}_t^j - p_t^j) \quad (\text{A.26})$$

$$\text{money supply: } \hat{m}_t^j - \hat{e}_t^j = \hat{g}_t^j \quad (\text{A.27})$$

$$\text{gold peg: } E_t \epsilon_{t+1}^j = \epsilon_t^j \quad (\text{A.28})$$

$$\text{exchange rate: } xr_t^{jk} = \epsilon_t^j - \epsilon_t^k \quad (\text{A.29})$$

$$\text{quasi UIP: } \hat{i}_t^j - \hat{i}_t^k - E_t(\Delta \epsilon_t^j - \epsilon_t^k) = v(b_t^k - b_t^j) \quad (\text{A.30})$$

$$\text{price setting: } p_t^{jk} = (1 - \zeta_1 - \zeta_2)\Theta + \zeta_1 p_t^{j*} + \zeta_2 p_t^j + (1 - \zeta_1 - \zeta_2)(mc_t^k - xr_t^{kj}) \quad (\text{A.31})$$

$$\text{IPI: } p_t^{j*} = (1 - \delta)\Theta + \delta p_t^j + (1 - \delta) \int_k (mc_t^k - xr_t^{kj}) \quad (\text{A.32})$$

$$\text{PPI: } p_t^{jj} = (1 - \delta)\Theta + \delta p_t^j + (1 - \delta)mc_t^j \quad (\text{A.33})$$

$$\text{bop: } \beta b_t^j - b_{t-1}^j + \bar{g} \Delta g_t^j = \bar{\Gamma} \int_k (p_t^{kj} - xr_t^{kj} - p_t^{jk}) dk + \bar{\Gamma} \int_k (\hat{c}_t^{kj} dk - \hat{c}_t^{kj}) dk \quad (\text{A.34})$$

Since equations (A.29) and (A.30) are expressed in relative terms, they are redundant for one country. In which case, they can be replaced with market clearing for gold — the world stock is constant — and bonds at the world level:

$$\int_k \hat{g}_t^k dk = 0 \quad (\text{A.35})$$

$$\int_k b_t^k dk = 0 \quad (\text{A.36})$$

Equation (A.36) is redundant as well. Indeed, it can be deduced from summing over j in equation (A.34). The right-hand side drops out, so:

$$\beta \int_j b_t^j dj = \int_j b_{t-1}^j dj - \bar{g} \Delta \int_j g_t^j dj$$

The last term is 0 for all t by equation (A.35). The initial condition guarantees: $\int_j b_{-1}^j dj = 0$,

so that: $\int_j b_0^j dj = 0$. Iterating over t implies equation (A.36). This redundancy verifies Walras law: if the markets for goods and gold clear, so does the market for bonds.

To make the model stationary, I subtract the local gold price from nominal quantities (p^{kj} , p^{j*} , p^j , w^j , $m c^j$), ϵ^j . The exchange rate can be substituted out. I denote those transformed variables with tildes. Random walk variables can be expressed in first difference: $\Delta \epsilon_t^j = \epsilon_t^j - \epsilon_{t-1}^j$.

$$\text{market clearing: } \hat{y}_t^j = \psi \left(\int_m \hat{m} c_t^m dm - \hat{m} c_t^j \right) + (1 - \bar{\Gamma}) \hat{c}_t^j + \bar{\Gamma} \int_k \hat{c}_t^k dk \quad (\text{A.37})$$

$$\text{marginal cost: } \hat{m} c_t^j = \hat{w}_t^j + \frac{\alpha_1}{1 - \alpha_2} \hat{y}_t^j \quad (\text{A.38})$$

$$\text{CPI: } \hat{p}_t^j = (1 - \bar{\Gamma}) \hat{m} c_t^j + \bar{\Gamma} \int_m \hat{m} c_t^m \quad (\text{A.39})$$

$$\text{CPI inflation: } \pi_{ct}^j = \hat{p}_t^j - \hat{p}_{t-1}^j + \Delta \epsilon_t^j \quad (\text{A.40})$$

$$\text{wage inflation: } \pi_{wt}^j = \hat{w}_t^j - \hat{w}_{t-1}^j + \Delta \epsilon_t^j \quad (\text{A.41})$$

$$\text{marginal utility: } \hat{\mu}_t^j = \frac{\sigma}{(1 - \iota)(1 - \beta \iota)} (\beta \iota E_t \hat{c}_{t+1}^j - (1 + \beta \iota^2) \hat{c}_t^j + \iota \hat{c}_{t-1}^j) \quad (\text{A.42})$$

$$\text{Euler equation: } \hat{\mu}_t^j = E_t \hat{\mu}_{t+1}^j + \hat{i}_t^j - E_t \pi_{c,t+1}^j \quad (\text{A.43})$$

$$\text{money holdings: } \hat{i}_t^j = \frac{1 - \beta}{\beta^2} \left(-\chi (\hat{m}_t^j - \hat{p}_t^j) - \hat{\mu}_t^j \right) \quad (\text{A.44})$$

$$\text{Phillips curve: } \pi_{wt}^j = \beta E_t \pi_{wt+1}^j + \tilde{\kappa} \hat{y}_t^j - \kappa \hat{\mu}_t^j + \kappa (\hat{w}_t^j - \hat{p}_t^j) \quad (\text{A.45})$$

$$\text{money supply: } \hat{m}_t^j = \hat{g}_t^j \quad (\text{A.46})$$

$$\text{gold peg: } E_t \Delta \epsilon_{t+1}^j = 0 \quad (\text{A.47})$$

$$\text{quasi UIP: } \hat{i}_t^j - \hat{i}_t^k - E_t (\Delta \epsilon_t^j - \Delta \epsilon_t^k) = v (b_t^k - b_t^j) \quad (\text{A.48})$$

$$\text{price setting: } \hat{p}_t^{jk} = \zeta_1 \hat{p}_t^{j*} + \zeta_2 \hat{p}_t^j + (1 - \zeta_1 - \zeta_2) \hat{m} c_t^k \quad (\text{A.49})$$

$$\text{IPI: } \hat{p}_t^{j*} = \delta \hat{p}_t^j + (1 - \delta) \int_k \hat{m} c_t^k \quad (\text{A.50})$$

$$\text{PPI: } \hat{p}_t^{jj} = \delta \hat{p}_t^j + (1 - \delta) \hat{m} c_t^j \quad (\text{A.51})$$

$$\begin{aligned} \text{bop: } \beta b_t^j - b_{t-1}^j + \bar{g} \left(\Delta \hat{g}_t^j \right) \\ = \bar{\Gamma} \int_k \left(\hat{p}_t^{kj} - \hat{p}_t^{jk} \right) dk + \bar{\Gamma} \int_k \left(\hat{c}_t^{kj} dk - \hat{c}_t^{kj} \right) dk \end{aligned} \quad (\text{A.52})$$

A.5 SMM Estimation

To estimate the model, I minimize the weighted sum of the empirical moments:

$$(\hat{\mathcal{B}} - \bar{\mathcal{B}})' \times \hat{V}^{-1} \times (\hat{\mathcal{B}} - \bar{\mathcal{B}})$$

where:

$$\mathcal{B} = \begin{pmatrix} \mathcal{B}^{xr} \\ \mathcal{B}^{ip} \\ \mathcal{B}^{wpi} \\ \mathcal{B}^{nw} \\ \mathcal{B}^{imp} \\ \mathcal{B}^{ipi} \\ \mathcal{B}^{tar} \\ \beta^{elas} \\ \beta^{pt} \end{pmatrix}, \quad V = \begin{pmatrix} V^{xr} & (0) & (0) & (0) & (0) & (0) & (0) & (0) & (0) \\ (0) & V^{ip} & (0) & (0) & (0) & (0) & (0) & (0) & (0) \\ (0) & (0) & V^{wpi} & (0) & (0) & (0) & (0) & (0) & (0) \\ (0) & (0) & (0) & V^{nw} & (0) & (0) & (0) & (0) & (0) \\ (0) & (0) & (0) & (0) & V^{imp} & (0) & (0) & (0) & (0) \\ (0) & (0) & (0) & (0) & (0) & V^{ipi} & (0) & (0) & (0) \\ (0) & (0) & (0) & (0) & (0) & (0) & V^{tar} & (0) & (0) \\ (0) & (0) & (0) & (0) & (0) & (0) & (0) & (\sigma^{elas})^2/4 & 0 \\ (0) & (0) & (0) & (0) & (0) & (0) & (0) & 0 & (\sigma^{pt})^2/4 \end{pmatrix}$$

Each \mathcal{B}^y is itself a vector containing the IRF of y from 1932 to 1935:

$$\mathcal{B}^y = \begin{pmatrix} \beta_{1932}^y \\ \vdots \\ \beta_{1935}^y \end{pmatrix}$$

where \mathcal{B} is a vector containing the estimated moments and V the diagonal matrix whose elements are the variance of those moments. A $\hat{\cdot}$ denotes the empirical estimate, and a $\bar{\cdot}$ the model equivalent. Since each IRF is made of four moments, I re-weight the elasticity and pass-through estimates by a factor of 4; so that they receive the same weight than an IRF, for a given variance.

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