Enforcement of sovereign debt under war reparations

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Abstract

The difference between sovereign debt and war reparations lies in the enforcement of debt contracts. Periods around war reparations exhibit many of the same macroeconomic characteristics as sovereign defaults, yet they are usually repaid. Neither France following the Franco-Prussian War nor Finland after World War II were in positions to default because its creditors' strong political and military position. It meant there was a real transfer of resources because of reparations. In a sovereign debt model, I show the ability to default is what sets German interwar reparations apart. Its creditors were too weak to enforce reparations militarily.

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1. Introduction

Sovereign debt is paid back most of the time, despite creditors not having many remedies to enforce debt contracts. Countries pay back their loans because they want to be able to borrow again, or to avoid financial sanctions. Unlike in corporate bankruptcies, no one can force a country to pay, outside of military intervention. An extreme and rare exception is that of war reparations, which has often been directly linked to the removal of occupying troops. As a result, the only sovereign default on reparations is the German default in 1932. Defaults on reparations have high political costs, but normal sovereign defaults are not free of political consequences. In recent years, Greece saw political interference in exchange for financing during the Eurozone crisis, and China has taken possession of critical infrastructure from its debtors.[2] Default therefore comes down to a political judgment of the costs and the enforcement of debt contracts, which is not quantifiable.

The paper explains why Germany defaulted on reparations, while everyone else repaid. It does so by contrasting war reparations with other cases of sovereign defaults, which are typically accompanied by several stylised facts: default occurs after a sharp contraction in output and is followed by a devaluation of the currency, to lower the relative price level and real wages. The periods around large war reparations exhibit many of the same macroeconomic characteristics, yet they are not usually followed by a default.

I show it would have been optimal economic policy to default on several large reparations throughout history. In a sovereign debt model where default is accompanied by a devaluation (Na et al. 2018), default was the optimal policy for both German interwar reparations and Finnish World War II reparations. The case of Franco-Prussian War indemnities features several default-like characteristics (output contraction and high debt levels) but no devaluation nor a fall in real wages. This narrow set of reparations cases are the largest (over 20 percent of GDP) where there was agreement to pay in a relatively short time span (less than ten

[2] An example is Sri Lanka handing over control of its Hambantota Port to China in 2017 (Abi-Habib 2018).

years). I collected data for the macroeconomic indicators for each episode and common was that debt was paid while it was enforced by military power.

The paper shows that the difference between French, German, and Finnish reparations is not necessarily the size of the transfer. German headline reparations were bigger in terms of GDP, but not in terms of the government's capacity to pay. French reparations in the 19th century represented 70 percent of government tax revenue, while in Germany it was 44 percent and for Finland as low as 15 percent. The difference is neither in the size of the net output loss associated with the transfer. All three countries saw steep output declines, well over what is normally associated with sovereign defaults. Instead, France is different because military occupation incentivised a quick repayment, after which economic growth rebounded. For Finland, default was the optimal policy as output saw a steep decline, credit spread on its external debt increased, real wages declined, and Finland devalued its currency three times. The money to pay reparations could have been used to free up domestic balance sheets. Alas, Finland paid because of its political and economic reliance on the Soviet Union.

The approach explains both the German default and the timing of the default. German real output contracted by over 20 percent during the hyperinflation of the Weimar Republic (1921-23). Germany refused in 1922 to pay reparations according to the provisional schedule as it viewed the debt as odious. It was forced to resume negotiations by military force after the Allied occupation of the Ruhr. Reparations were rescheduled in 1924 and were subsequent paid throughout the 1920s, helped by capital inflows (Feldman 1993, p. 631-69). Once capital flows reversed by the 1930s, deflation was translated into output losses and an adjustment to real wages, which were too high because of the gold standard. At this point, the European nations did not have the ability to enforce debt contracts. Despite no obvious nominal devaluation accompanying the default, once stealth interventions and export subsidies are accounted for, the German default is well explained in the model.

In all three historical episodes, default was close to the optimal economic policy. Because it was not possible to default for France and Finland (and Germany initially), the economic adjustment had to come from elsewhere. It suggests that there was a real transfer of wealth from debtor to creditor. The German case was not fundamentally different in terms of the macroeconomic setting, but the political and military situation was very different.

2. Related literature

Sovereign defaults are unlike private defaults because creditors generally cannot take control of sovereign assets through an enforcement of contracts. Commercial assets can be seized, but official foreign assets (embassies, military bases, consulates) tend to be immune from creditor attachment (Buchheit 2013). Despite the limited enforcement mechanism, most sovereign debt is repaid. Two reasons have generally been offered to explain why: countries want to maintain a good reputation, and they want to avoid facing financial sanction. The reputational explanation originating with Eaton and Gersovitz (1981) explains repayment of sovereign debt as an incentive to borrow again. A default causes an exclusion from capital markets for a period, which means the country cannot borrow to smooth consumption.[3] The incentive to repay sovereign debt is thus not a legal one. In the literature on sanctions, meanwhile, creditors have certain legal remedies to force economic sanctions on the defaulter (Bulow and Rogoff 1989a, 1989b).[4]

War reparations are a special case of sovereign debt because the enforcement mechanism is binding. Recent sovereign defaults in emerging markets and the Eurozone carried high costs but countries were nevertheless able to default (e.g. Kuvshinov and Zimmermann 2019). That was not the case historically. 'Gunboat diplomacy' or imposed fiscal control were often used to ensure repayment after default, with more than 40 percent of sovereign defaults between 1870 and 1913 resulting in sanctions (Mitchener and Weidenmier 2010). The incentive to pay was linked directly to control of economic and political sovereignty for the debtor. The enforcer

[3] Defaults occur when countries find debt service to be costlier than a default (e.g. Arellano 2008 or Bocola et al. 2019). Most papers specify a time-period where the country is excluded from capital markets.

[4] See e.g. Aguiar and Amador (2014) for a recent contribution. A recent example of a sovereign asset seizure was when the hedge fund Elliott seized an Argentine navy ship in Ghana in 2012 to collect on defaulted bonds from the 2001 restructuring (Cotterill 2012).

could either be other countries, or international banks who played a key role. They were able to set conditions on loans because they had legal and military remedies to enforce their claims, and thus acted as a lender of reputation to ensure payment (Flandreau and Flores 2012).[5]

The case of war reparations is an extreme version of gunboat diplomacy because countries were often occupied until the debt was paid. After the Napoleonic Wars ended in 1815, France had to pay not only war reparations, but also the cost of the occupation (Oosterlinck et al. 2014). The same was the case fifty years later with the Franco-Prussian War indemnity, where the withdrawal of Prussian troops from France was directly linked to repayment of the indemnity (Devereux and Smith 2007). Both payments were made in full ahead of time. German World War I reparations had to be enforced by occupation of the Ruhr in 1923, after no payments were forthcoming initially (Ritschl 2012a), while Finnish war reparations following World War II were paid because of its close relationship and dependency on the Soviet Union. These four reparations, shown in Table 1, were sizable both in terms of GDP and in annual cost. They were either repaid or attempted to be repaid (the case of Germany). Other war reparations were either relatively small and therefore insignificant in economic terms or paid out over many decades.[6]

	Debt stock before reparations	Reparations	Annual debt service and reparations cost	Reparations and interest costs (percent of government taxes)
1815-19: Napoleonic Wars	15	22	7	70
1871-73: Franco-Prussian War	55	25	9	72
1923-33: WWI (Germany)	72	100	13	44
1945-52: WWII (Finland)	61	20	3	15

Sources: Calculated from Oosterlinck et al. (2014); White (2001, p. 351); Ritschl (1996b, 2012a); and Pihkala (1999, p. 32-35). Note: Finnish reparations were paid in-kind but converted to money equivalent.

Table 1: Comparison of reparations (in percent of GDP).

[5] For a list of case studies during the period, see e.g. Tunçer (2015).

[6] The economically insignificant cases are Mexican-American War reparations and the other World War II reparations (Italy, Germany, and Japan). Haitian reparations after the Independence War, Chinese reparations following the Boxer Rebellion, and Iraqi reparations following the Gulf War were paid out over decades. Sino-Japanese War reparations and Greco-Turkish reparations in the late 19th century suffer from incomplete economic data.

The amounts paid were large, both in an absolute sense and relative to state capacity. The debt stock after each respective war was already sizeable before the imposed reparation, which required a transfer of resources on top. Yet, the results are very different. Was the difference simply that creditors could enforce sovereign debt contracts in some cases, but not in others? To answer, the first thing required is to understand if countries should have defaulted. An optimal policy of default is modelled, where the government is in control of both the decision to default and conducts optimal monetary policy. The latter ensures the government can devalue its currency, to lower real wages. The empirical combination of default and devaluation, as seen in many emerging markets during defaults (Reinhart 2002), is used as the optimal policy which war reparations defaults and non-defaults are measured against. The goal is to figure out if the cost of repaying sovereign debt was higher than the benefits, and if yes to understand why only the German case ended in default.

3. A model of optimal default

Would it have been optimal to default on reparations? Sovereign debt models can provide a framework in which the cost of servicing sovereign debt is quantified against the benefits of repayment. A default frees up domestic balance sheets, but results in an output loss and exclusion from capital markets and the ability to borrow.[7] If there were no costs associated with sovereign debt defaults, more countries would surely do it. In the model, the government chooses to default or repay sovereign debt, based on a value function. The nominal exchange rate is set unilaterally by the government, which can counteract any (potential) distortions from wage rigidities. The predictions of the model can then be used for both the 19th century with limited wage rigidities and the 20th century.[8] In the 19th century wages were flexible, while in the 20th century the nominal exchange rate adjusts real wages lower (see section 4.3 for a discussion of how this applies to Germany under the gold standard). Because of the adjustment

[7] As is standard in the literature and an empirical feature of sovereign debt defaults (see e.g. Borenztein and Panizza 2008, Furceri and Zdzienicka 2012, or Hébert and Schreger 2017).

[8] See Eichengreen (2008) for a general discussion of wage rigidities.

mechanism, if it makes sense to default in a floating exchange rates regime, it makes even more sense in a world of fixed exchange rates.[9]

The model is the optimal monetary policy version of Na et al. (2018). It is calibrated to the French economy in 1870-73, the German economy in 1930-33, and the Finnish economy in 1945-48. The point of the model is to observe certain stylised facts around sovereign defaults and compare optimal policy against the historical setting of war reparations. It helps answer if countries should have defaulted but were unable to because sovereign debt was enforced by occupation. The next few pages present the model.

3.1. Government

The model is of a small open economy where the government borrows on international debt markets. The economy consists of the government, homogeneous firms that are perfectly competitive, and households that have identical preferences. The government can either be in default or not. If the country is repaying its debt, $R_{t-1} = 1$, whereas if the country defaults at the start of the period then $R_t = 0$. Default implies that the country has lost all access to borrowing on international debt markets. The country exits a default period with probability θ, and starts with no debt after a default.[10] Default lasts a random number of periods, with $1 - \theta$ probability of market access restored at $t + 1$. The government budget constraint is equal to

$$g_t = d_{t+1} q_t^d \tau_t^d + (1 - R_t) d_t \tag{1}$$

where d_{t+1} is the level of debt at t to be repaid at $t + 1$, q_t^d is the price of one unit of face value debt; and τ_t^d is a tax collected on debt. The debt is denominated in tradable goods so that the effect can be measured in consumption. It follows the standard Eaton-Gersovitz allocation of

[9] To adjust the relative real wage and the price of non-traded goods in a fixed exchange rate system, unemployment would have to rise. A devaluation would adjust this via the exchange rate instead.

[10] It means there is no recovery value on defaulted bonds. Cruces and Trebesch (2013) show that higher haircuts lead to longer exclusion from capital markets, which can be captured by lowering the parameter θ.

debt with centralised borrowing and centralised default. Households take the country premium on borrowing as exogenously given, while the government internalises it into the country risk premium it pays on its external debt. If the country is in default, all private external debt repayments are stopped, which in the model has the effect of households receiving a lump-sum payment, F_t, which is expressed as $g_t = F_t/P_t^T$ in terms of tradable goods, where P_t^T is the nominal price of tradables, while P_t^N is the nominal price of nontradables. The price of debt must satisfy a risk-neutral foreign lender that wants to cover their opportunity cost of capital, i.e. lenders are expected to earn the same return abroad as at home

$$1 + r^* = \frac{P\{R_t = 1 | R_{t+1} = 1\}}{q_t} \tag{2}$$

Which means that the country spread is simply the probability of default in the next period.

3.2. Firms

Each firm will want to maximize profits, Π_t, and produce nontraded output according to

$$y_t^N = F(h_t) \tag{3}$$

where the function is concave and increasing. The input is simply labour h_t, provided by the households who are paid nominal wages, W_t. Firms maximise profits according to

$$\Pi_t = P_t^N F(h_t) - h_t W_t \tag{4}$$

which can be rewritten as

$$p_t F'(h_t) = w_t \tag{5}$$

with $w_t = W_t/P_t^T$ being the real wage in terms of tradable goods, and $p_t = P_t^N/P_t^T$ the relative price of nontradables in terms of tradables.

3.3. Households

Households are alike and make decisions based on information available to them at present time, with constant relative risk aversion. Their utility is maximised with respect to

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t) = \left(\frac{{c_t}^{(1-\sigma)}-1}{(1-\sigma)}\right) \quad (6)$$

with c_t being total consumption, the parameter $\beta \in (0,1)$ denotes the discount factor, and U is assumed to be concave and increasing. c_t is a composite of the two types of consumption: traded c_t^T, and non-traded c_t^N, and is given by its CES aggregator function

$$c_t = A(c_t^T, c_t^N) = \left[a{c_t^T}^{1-\frac{1}{\xi}} + (1-a){c_t^N}^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}} \quad (7)$$

where A is a linearly homogenous function that is concave and increasing, a is the percentage of tradables in the total consumption basket, and ξ is the elasticity of substitution between tradables and nontradables. The firms are owned by the households in a uniform manner, and they therefore receive the profits from said firms. The household budget constraint is given by

$$P_t^T c_t^T + P_t^N c_t^N + P_t^T d_t = h_t W_t + \Pi_t + F_t + \\ (1-\tau_t^d) P_t^T d_{t+1} q_t^d + P_t^T \tilde{y}_t^T \quad (8)$$

The left (top) side of the equation is each household's spending, which consists of consumption of tradable and nontradable goods, plus their debt. The right-hand side of the equation is each household's income from their labour, profits from firms they own, potential lump-sum payments from non-repayment of foreign debt, τ_t^d a tax on debt income received from the ownership of foreign debt, with $\tilde{y}_t^T$ being each household's endowment of traded goods, which is given and stochastic. In reality, τ_t^d can be thought of as a tax on capital flows, such as reserve requirements on banks or capital controls.

People in this economy are subject to no-Ponzi conditions. The relative price of nontradables, p_t, can be written as

$$p_t = \frac{A_2(c_t^T, c_t^N)}{A_1(c_t^T, c_t^N)} \quad (9)$$

$$\Upsilon_t = U'(c_t) A_1(c_t^T, c_t^N) \quad (10)$$

$$\beta E_t \Upsilon_{t+1} = (1-\tau_t^d) q_t^d \Upsilon_t \quad (11)$$

The household budget constraint therefore uses the Lagrange multiplier, Υ_t/P_t^T. Households supply inelastic labour $\bar{h}$ and it is assumed that $\bar{h} = h_t$, meaning the economy is at full employment. The assumption here is that the central bank stands ready to counteract any distortions from nominal wage rigidities by devaluing the exchange rate, to ensure that the real wage is lowered.

3.4. Equilibrium

Households optimise their utility subject to their budget constraints and choose the composition of their consumption basket and borrowing. In equilibrium, the market for nontradables clears

$$c_t^N = y_t^N \tag{12}$$

Each period, the country receives y_t^T endowment per household, stochastically and exogenously decided. To ensure there is a cost associated with default, it is assumed that $L(y_t^T)$ is a loss-function that is positive and increasing, so that

$$(1 - R_t)L(y_t^T) = max\{0, \delta_1 y_t^T + \delta_2 (y_t^T)^2\}$$

If the country is not in default, output is simply equal to the endowment y_t^T. The loss-function also dissuades countries from defaulting during boom-times. The natural logarithm of tradable output y_t^T, follows the law of motion and is given by

$$ln(y_t^T) = \rho\ ln(y_{t-1}^T) + \eta\ \mu_t \tag{13}$$

where µ is an independent random variable with mean equal to zero and standard deviation η, while ρ is a positive parameter with a value between zero and one governing the autocorrelation of output. The total consumption of tradables is chosen according to

$$c_t^T = y_t^T - (1 - R_t)L(y_t^T) + R_t[q_t d_{t+1} - d_t] \tag{14}$$

When the country is not in default, the price of the its debt q_t^d, must equal what is offered by foreign lenders q_t, otherwise nobody would be willing to offer credit, so that

$$R_t(q_t^d - q_t) = 0 \tag{15}$$

It follows that the law of one price also holds for actual prices, like with the price of money, so that

$$P_t^T = P_t^{T*}\varepsilon_t$$

where ε_t is the nominal exchange rate from last period to t.[11] The price of foreign traded goods is normalised to one for simplicity. Finally

$$(1 - R_t)\tau_t^d = 0 \tag{16}$$

$$(1 - R_t)d_{t+1} = 0 \tag{17}$$

$$R_t\left[q_t - \frac{E_t R_{t+1}}{1+r^*}\right] = 0 \tag{18}$$

$$\frac{A_2\left(c_t^T, F(h_t)\right)}{A_1\left(c_t^T, F(h_t)\right)} = \frac{w_t}{F\prime(h_t)} \tag{19}$$

Given the assumption of optimal monetary policy, the government can set the exchange rate and the level of the debt tax. Then the stochastic processes of consumption c_t^T, labour h_t, debt in the next period d_{t+1}, and the price of debt q_t, are given by processes of traded output y_t^T and the choice of default R_t, and initial condition of debt d_0.

3.5. Default

The government only engages in default when it is economically beneficial to do so. Default occurs when the loss of output by repayment v^r, is bigger than default v^d, or

$$v^r(y_t^T, d_t) < v^d(y_t^T) \tag{20}$$

The left-hand side of the equation is the value of being able to access international capital markets, and the right-hand side is the value of being in default. Continued repayment, $R_t = 1$, has a value of

$$v^r(y_t^T, d_t) = \max_{\{d_{t+1}, h_t, c_t^T\}} \left\{U\left(A\left(c_t^T, F(h_t)\right)\right) + \beta E_t v^g(y_{t+1}^T, d_{t+1})\right\} \tag{21}$$

[11] When ε_t goes up, the currency for the donor country depreciates.

Where the last expression is the value of continued markets access, the optimal level of $h_t = \bar{h}$, and it is subject to

$c_t^T + d_t = y_t^T + q(y_t^T, d_{t+1})d_{t+1}$

The value of default (v^d) and the value of having access to capital markets (v^g) are

$$v^d(y_t^T) = \max_{h_t} \left\{ \begin{array}{c} U\left(A\left(y_t^T - L(y_t^T), F(h_t)\right)\right) + \\ \beta E_t\left(\theta v^g(y_{t+1}^T, 0) + (1-\ \theta)v^d(y_{t+1}^T)\right) \end{array} \right\} \tag{22}$$

$$v^g(y_t^T, d_t) = max\{v^r(y_t^T, d_t), v^d(y_t^T)\} \tag{23}$$

The default set is then given in terms of tradable-output levels of d_t

$$D(d_t) = [y_t^T : v^r(y_y^T, d_t) < v^d(y_t^T)] \tag{24}$$

Equation (24) can be thought of as the optimal policy reaction of when to default, given the government's wish to maximise the full-employment real wage

$$\mathrm{w^f(c_t^T) = \frac{A_2\left(c_t^T, F(\bar{h})\right)}{A_1\left(c_t^T, F(\bar{h})\right)} F'(\bar{h})}$$

The probability of default in the next period if the country is repaying is

$$P\{R_{t+1} = 0 | R_t = 1\} = P\{y_{t+1}^T \in D(d_{t+1})\} \tag{25}$$

and the price of the country's debt as a function of tradable output and the debt level is

$$q(y_t^T, d_{t+1}) = \frac{1 - P\{y_{t+1}^T \in D(d_{t+1}) | y_t^T\}}{1 + r^*} \tag{26}$$

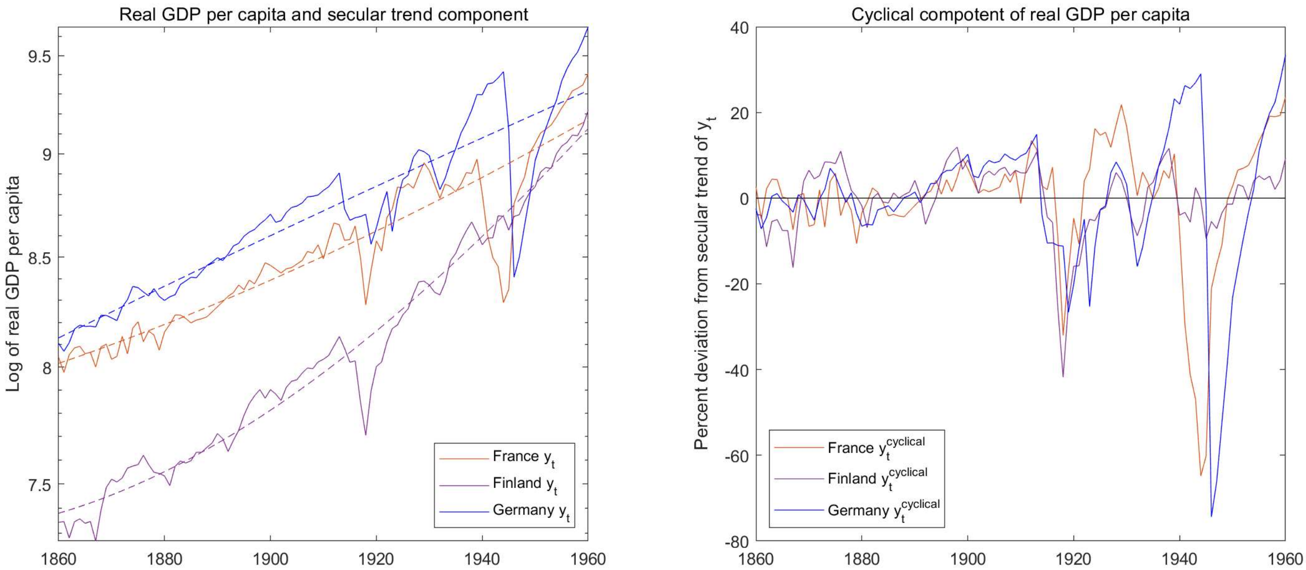
It is therefore possible to give the optimal size of the devaluation by, specified by the policy rule that stabilises nominal wages

$$\varepsilon_t = \frac{w_{t-1}}{w^f(c_t^T)} \tag{27}$$

As shown by Na et al. (2018), the value functions under the assumption of optimal monetary policy are similar to Arellano (2008).

3.6. Calibration

The model is calibrated to France in the 1870s (the Franco-Prussian Wars indemnity); Germany in the 1930s (World War I reparations); and Finland in the 1940s (World War II reparations). The output process of (13) is estimated using ordinary least squares for each of the episodes. Figure 1 shows real GDP per capita from 1860 to 1960 for the countries studied, with the log of output and the structural trend on the left, and the cyclical component obtained by log-quadratic detrending on the right.[12]



Source: Bolt et al. (2018) data for output. Note: log-quadratic detrending used to obtain cyclical trend. The dashed line is the secular trend (left-hand). Replication file, *lqtrend_p2.m.*

Figure 1: Secular and cyclical components of real GDP (1860-1960).

The autocorrelation and standard deviation of the cyclical trend used in the model are estimated from 1860 to 1930 before the German default. It therefore avoids the volatile period of WWII in the standard deviation parameter.[13] The output process yields the following for the three countries

[12] The choice is motivated by the fact that a log-quadratic approach explains a lot more of the cyclical deviations than a log-linear approach. Appendix A shows that a log-linear and HP(100) filter approach does not alter the results.

[13] Autocorrelations of the cyclical component of real GDP are 0.958 (France), 0.941 (Germany), and 0.907 (Finland) for annual data. To avoid unrealistic distributional assumptions in making the number into quarterly

$$ln(y_t^T)_{France} = 0.932\ ln(y_{t-1}^T) + 0.037\mu_t$$
$$ln(y_t^T)_{Germany} = 0.932\ ln(y_{t-1}^T) + 0.039\mu_t$$
$$ln(y_t^T)_{Finland} = 0.932\ ln(y_{t-1}^T) + 0.043\mu_t$$

In addition to the autocorrelation of output, several parameters are used across the three episodes. All are standard in the literature and follow Na et al. (2018). The inverse of elasticity of intertemporal substitution of consumption is set at $\sigma = 2$, while the elasticity of consumption between traded goods and nontraded goods is $1/\sigma = 0.5$. The share of tradables in consumption is $a = 0.26$. Steady state traded output y^T and the labour endowment $\bar{h}$ are both set at unity. The value of the subjective discount factor $\beta = 0.85$, which might seem low but higher values of β worsens the overall fit of the model.[14] The range for traded output is set between 0.7 and 1.5.[15] The debt range for France and Finland is set between 0 and 1.5, while for Germany the upper range is 2. Appendix B shows the debt density graphically for the two debt ranges, which are well outside each country's actual minimum and maximum debt levels, as per Table 1 earlier. The time unit of the model is in quarters of a year.

			France (1870-73)	Germany (1930-33)	Finland (1945-48)
Episode specific	α	Labour share in the non-traded sector	0.64	0.60	0.75
	r^*	Risk free return (quarterly)	0.0092	0.0035	0.0024
	θ	Probability of escaping default	0.0385	0.0312	0.0385
	δ_1	Loss-function	-0.35	-0.32	-0.31
	δ_2	Loss-function	0.44	0.42	0.40
	η	Standard deviation of μ	0.037	0.039	0.43
Standard parameters (same across)	ρ	Autocorrelation of output		0.932	
	σ	Inverse of elasticity of substitution in consumption		2	
	ξ	Elasticity of substitution between traded and non-traded		0.5	
	a	Share of tradables		0.26	
	y^T	Steady-state traded output		1	
	$\bar{h}$	Labour endowment		1	
	β	Discount factor		0.85	
Discretization of state space		Debt range	0 to 1.5	0 to 2	0 to 1.5
		Traded output range		0.7 to 1.5	
		Grid points for output		200	
		Grid points for debt		200	

Table 2: Model parameters.

to fit the model, the standard parameter in the literature is used for ρ. The standard deviations would be 0.072, 0.083, and 0.042 if the full period to 1960 was used.

[14] Appendix C shows the sensitivity of output for various values of β.

[15] Following Na et al. (2018), 200 grid points are assumed for both output and debt. Their simulation approach for computing the transition probability matrix for tradable output is used.

The rest of the model parameters are episode specific. For the calibration of the French economy between 1870 and 1873, I follow Devereux and Smith (2007). The labour share of the non-traded sector is $\alpha = 0.64$, which is slightly lower than the literature. It is justified by a larger share of profits and rents to fixed factors than is the case in more recent studies. The annual world risk-free interest rate at the time was 3.7 percent. The time-unit of the model is a quarter, so $r^* = 0.0092$. It is the average interest rate of U.K. prime bank bills between 1870 and 1873, which was the largest bond market at the time.[16] Because France did not default, the parameter setting the length of default is $\theta = 0.0385$ following Chatterjee and Eyigungor (2012). The value implies that the country is in default on average for around 6.5 years.[17] The first loss-function parameter, δ_1, is calibrated to -0.35 while the second is estimated, $\delta_2 = \frac{(1-\delta_1)}{2}/max(y^T)$. Taken together with $\beta = 0.85$, it implies a steady state debt-to-GDP ratio around 55 percent for France when it is not in default, as was the case in 1871 before the indemnity was announced.

For the German 1930-33 calibration, labour's share of income is set at $\alpha = 0.60$ as the aggregate labour share of national income was close to 0.6 leading up to the default (Ritschl 2002, table b.5). Imputed wages would have to be calculated in trade and agriculture but given the lack of data and a low degree of mechanization in these sectors, it is assumed they are close to the aggregate. The average annual risk-free rate on U.S. 3-month Treasury bills was 1.4 percent, so that $r^* = 0.0035$. $\theta = 0.0312$, which implies a length of default of around eight years. Germany first defaulted on reparations in 1932 and was in default until the end of World War II but forcibly regained access to borrowing in 1940 (Klug 1993, p. 9-12). The loss-function parameters $\delta_1 = -0.32$ and $\delta_2 = 0.42$ are calibrated for a debt-to-GDP ratio of 90 percent, as German debt-to-GDP averaged 89 percent between 1929 and 1931 (Papadia and Schioppa 2015, p. 6).

[16] Chiţu et al. (2014) show the U.S. dollar overtook Sterling as the dominant currency for bond issuance around the Great Depression. Accordingly, the U.S. is used as the risk-free rate for Germany and Finland.

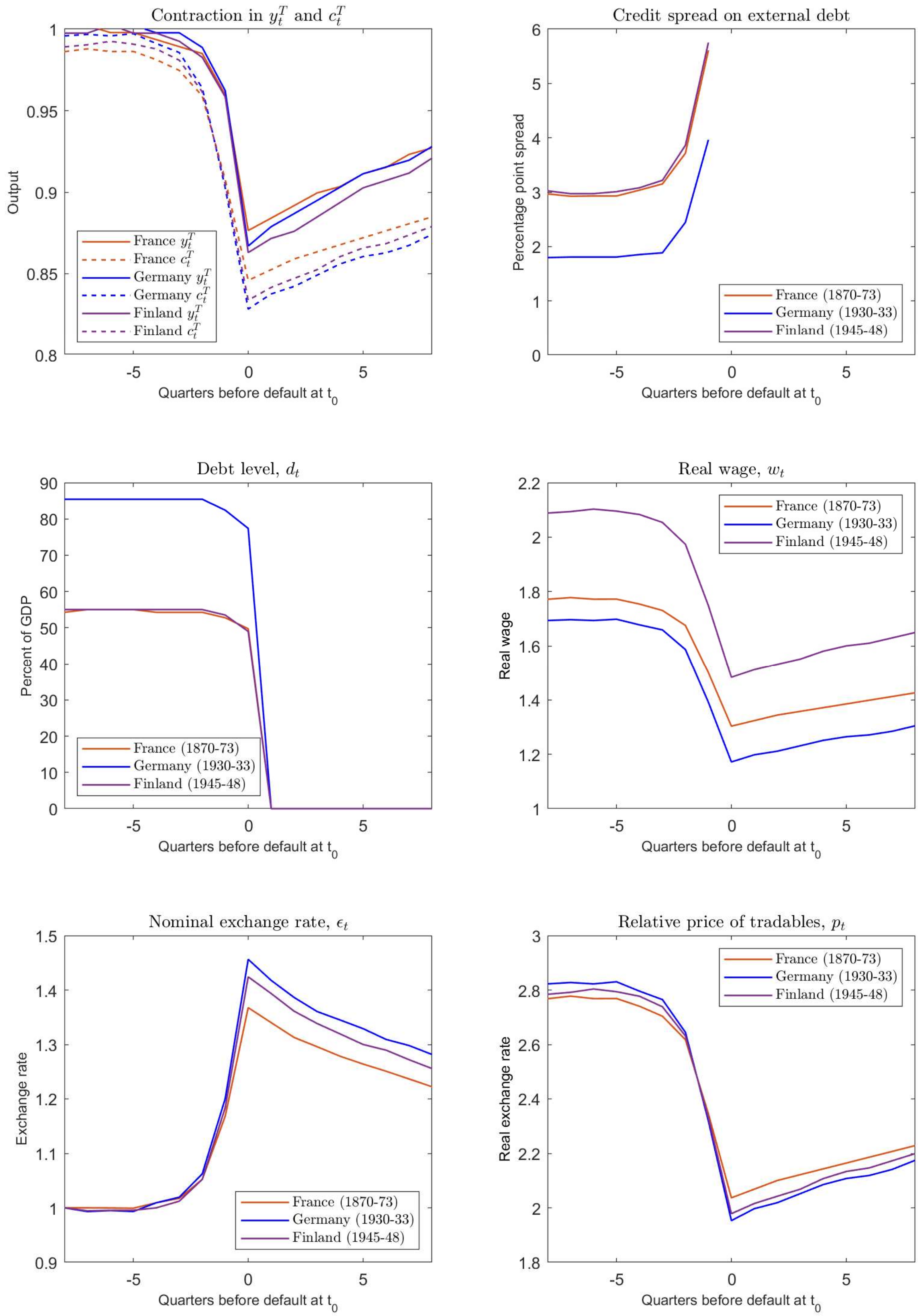
[17] A default of 6.5 years is around the average for 100 systemic crises (Reinhart and Rogoff 2014, p. 50).

For the calibration of the Finnish economy from 1945-48, $\alpha = 0.75$ which is standard in the literature. The world risk-free rate is still the U.S. 3-month Treasury bill, rate which averaged 1.0 percent, so that $r^* = 0.0024$. Like in France, given no default $\theta = 0.0385$. The loss-function parameters $\delta_1 = -0.31$ and $\delta_2 = 0.40$ are calibrated for a debt-to-GDP ratio of close to 60 percent.

3.7. Stylised macroeconomic facts about sovereign debt defaults

The model allows for the characterisation of certain stylised facts that typically accompany a sovereign debt default. It is simulated under optimal monetary policy across 1.1 million quarters for each of the three calibrations, where the first 0.1 million simulations are discarded.[18] The median values are calculated for y_t^T, c_t^T, d_t, w_t, ϵ_t, p_t, and the credit spread on external debt. The time of default is then normalised at t_0. Figure 2 shows the median of each macroeconomic indicator in the two years before and two years after default at t_0, for the French (orange), German (blue), and Finnish (purple) calibration. The time scale is in quarters of a year.

[18] The approach follows Na et al. (2018).



Note: Replication file, *plot_model.m.*

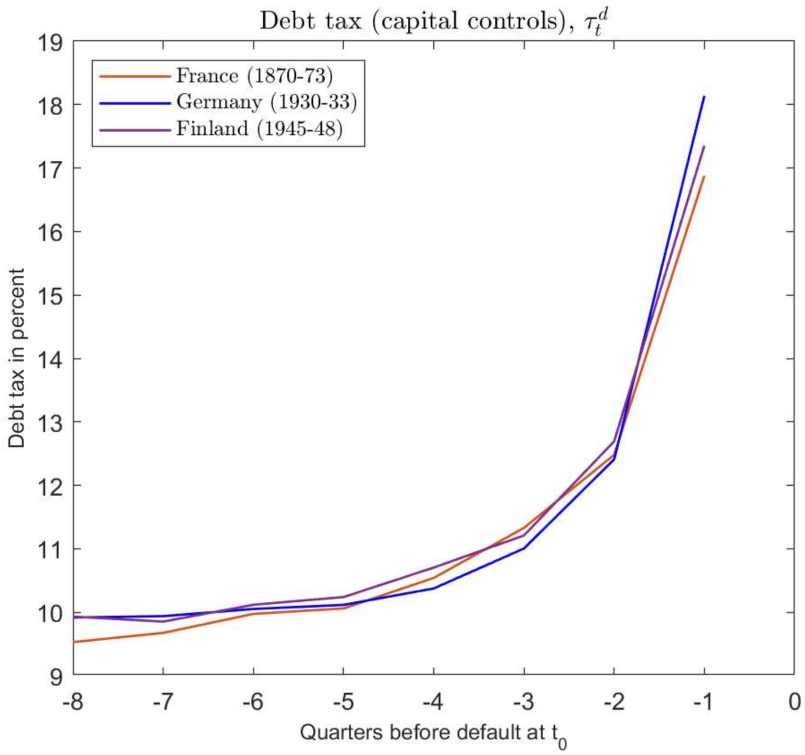
Figure 2: Stylised reaction around sovereign debt defaults.

Three stylised facts can be observed: first, like in most models of sovereign debt, a default occurs after a continuous contraction in tradable output across a short period of time. y_t^T falls 12 percent (France), 13 percent (Germany), and 14 percent (Finland) in less than one year before the government defaults at t_0 which triggers the loss-function $L(y_t^T)$.[19] The government chooses to default when the cost of debt service is higher than the benefits of continued ability to borrow, as specified by the value functions (20) to (24). As the risk of default increases, the risk premium on external debt goes up. Higher interest rates discourage borrowing so that the consumption of tradables c_t^T falls more than y_t^T. Second, default is accompanied by a large devaluation of both the nominal exchange rate ϵ_t, and the real exchange rate, shown by the relative price of tradables p_t. The devaluation is not followed by a bout of inflation as nominal prices remain stable. Third, the reason there is no inflation is that the real wage w_t declines, which lowers the real labour costs of firms. The three stylised facts are all characterised in equilibrium.

The output contraction that leads to default is mostly a function of subjective discount factor β and the volatility of the economy η. With a higher level of β, households will be more patient and ready to forego current for future consumption. The cost of default goes up with a higher β which makes countries default less often. Fewer defaults decrease the country risk premium and increase the level of sustainable debt. Appendix C shows the effect of increasing β. An increase in the level of volatility in the economy η has the reverse effect. A higher permanent volatility of output drives up the default frequency because there are more large negative income shocks, which increases the risk premium on external debt. The level of desired savings increases to protect against the volatility which lowers the level of debt. The level of real wages and the relative price level are affected by a and α, but the direction of the adjustment before a default is not. The loss-function parameters (δ_1, δ_2) are calibrated to ensure the model matches the level of debt-to-GDP as observed.

[19] It squares with the real observations around defaults, as noted by Sosa-Padilla (2018).

The central bank can set the nominal exchange rate ϵ_t, which ensures that the external crisis does not spread to the nontraded sector. The government can also set the level of taxes on external debt τ_t^d, which in a historical setting is best interpreted as the introduction of capital controls. Using the same estimation for τ_t^d as for the other macroeconomic indicators, Figure 3 shows the median level of capital controls in the two years before a default. The model thus captures the introduction of capital controls in the years leading up to a sovereign default, as was the case in Germany in the 1930s.



Note: Replication file, *plot_tau.m.*

Figure 3: Estimate of capital controls.

The model as outlined above assumes optimal policy from the government with respect to the default decision and in setting the exchange rate. As we will see in the next section, this has not always been the case historically. Countries might not have the option to default or devalue their exchange rate. Why not add in these rigidities? It is certainly possible to include wage and currency rigidities, alongside explicit financial sanctions. But the point of the analysis is to explain *optimal* sovereign debt policy and compare it to reparations policy.

4. When default is optimal

The stylised facts of sovereign default presented in section 3.7 can help analyse the special case of war reparations. To apply to historical cases, the following three sections provide the context around which the reparations, as outlined in Table 1, were paid. The model output is compared to historical data, which I collected for GDP, credit spreads, debt levels, real wages, nominal exchange rates, and real exchange rates for the three cases.[20]

To apply the model to historical data, the reparation is interpreted as an unexpected increase in the state variable d_0. At t_0 the country learns that it must pay the reparation, which is captured by a decrease in net output by the term $y_0 - d_0$. It is then possible to see where the level of net output lies in the default set, given historical data for the other macroeconomic variables. It will allow us to understand the costs of paying reparations and whether the optimal policy would have been to default. Sections 4.1 and 4.2 compare the model to the two non-defaults of France and Finland, while section 4.3 discusses Germany's default in the 1930s. The difference and the issue of enforcement is discussed in section 4.4.

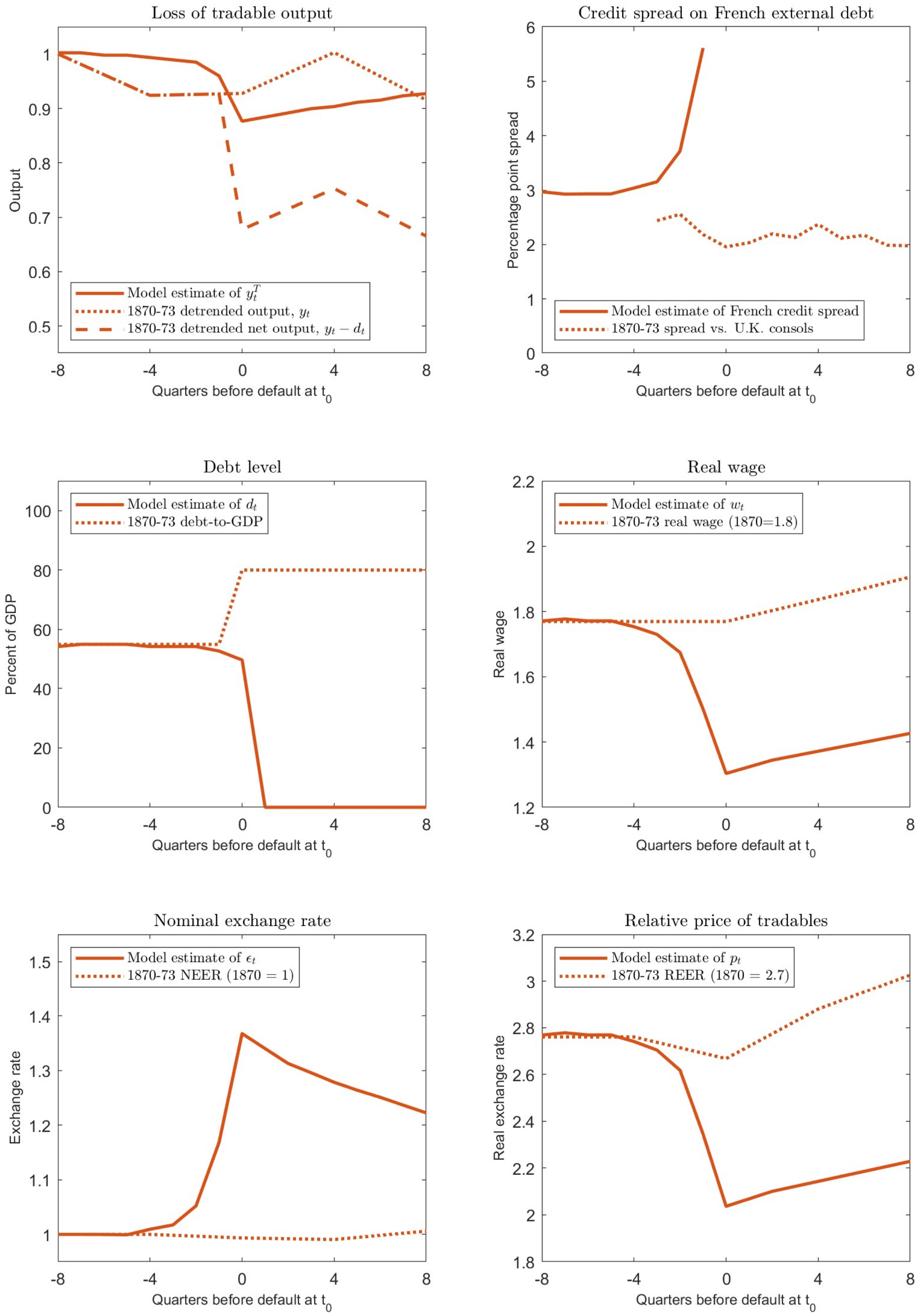
4.1. Non-default: The Franco-Prussian War indemnity

France was forced to pay reparations twice in the 19th century. First, after the Napoleonic Wars in 1815, then again after losing the Franco-Prussian War in 1871. Bismarck imposed an indemnity of five billion francs starting in 1871, payable over three years and amounting to around 25 percent of French output (Monroe 1919, p. 269). At the time, it was considered too big to be payable (Gavin 1992, p. 175). As shown in Table 1, it was larger in terms of output and taxes collected than the Napoleonic Wars reparations, with annual costs relating to debt service and reparations amounting to nine percent a year. The French indemnity payment was made in three years, financed by borrowing internationally and via the sale of foreign assets (Kindleberger 1993, p. 241-50). France had a stock of foreign assets that could be liquidated,

[20] Because of the lack of sectoral GDP for the period, tradable output is proxied by detrended real GDP per capita, available yearly.

and market access was never an issue. France issued external debt and repaid reparations quickly. Devereux and Smith (2007, p. 2392) show that the French terms of trade deteriorated during the repayment from 1871 to 1873 but conclude that the ability to borrow the money meant the impact on consumption was muted.

Figure 4 compares the macroeconomic predictions by the model to historical data, collected for the years 1870-73. The figure shows historical data two years prior to the announcement of reparations at t_0 and two years after. The two years prior to a hypothetical default coincides with the end of the war. Detrended output falls during the war but expands after, with GDP increasing by 10 percent from 1871 to 1872 back to 1870 levels. In the upper left of the figure is the level of output. The default set contraction is a fall of 12 percent, and outright growth fell less than predicted for a default. But the fall in net output $y_0 - d_0$ is significantly bigger. The level of debt in the model before default is close to the historical level of 55 percent debt-to-GDP in 1871. Net of reparations it is significantly higher at 80 percent debt-to-GDP, with the entire reparation funded by debt.



Sources: Bolt et al. (2018) for output; Ljungberg (2019) for nominal and real exchange rates; Insee and Bank of England for bond yields; see Table 1 for debt. Data on real wages is an estimate based on BL (1898, p. 668) for Paris wages. A similar trend is found in Bowley (1898, p. 488). Replication file, *plot_france.m.*

Figure 4: Model estimate and French historical data (1870-73).

Unlike in the model, the credit spread on French government bonds during the period were static, trading between five and six percent from 1870 to 1873. France was able to raise large amounts of loans, with no increase in borrowing costs. The level of real wages in the 19th century was generally flexible, but for the period 1870-73 both nominal and real wages were stable. Finally, the nominal exchange rate is stable as France was on the bimetallic standard (Flandreau 1996). As a result, the real exchange rate fell relatively little.

Alas, France did not default, despite the contraction in net output being in the default set. One explanation is that wages were in fact more flexible than observed in Figure 4 and that the economy adjusted by lowering the level of real wages. Another explanation is, simply, that France had no choice but to pay, despite a sovereign default being the optimal policy. As debt increases in 1871, a large share of the economy goes toward debt service, but the probability of default does not increase because that is not an option. Low interest rates allow for consumption smoothing, unlike in the model. The lower level of net output suggests there was a real transfer of resources from France to Germany, with no adjustment through lower levels of real wages. Instead, there was a binding enforcement mechanism that meant default was never really an option.

4.2. Non-default: Finnish World War II reparations

Finland was on the losing side of World War II and had to pay reparations to the Allied forces, as agreed at the 1945 Potsdam Conference. The Peace Treaties of Paris (1947) set up the Allied Control Commission and the War Reparations Commission allocated the Finnish accumulated debt to the Soviets. In addition to incurring the cost of the Commission, Finland faced significant reparations and lost territory to the Soviets.[21] Reparations were to be paid entirely in kind, at an estimated cost of 3 percent of output per year between 1945 and 1952 (Pihkala 1999, p. 26-37). The total size of the reparation in terms national output was almost

[21] The Marshall Plan helped rebuild Europe but was politically offensive to the Soviets and Finland was pressured not to participate by the Soviet, an added indirect cost.

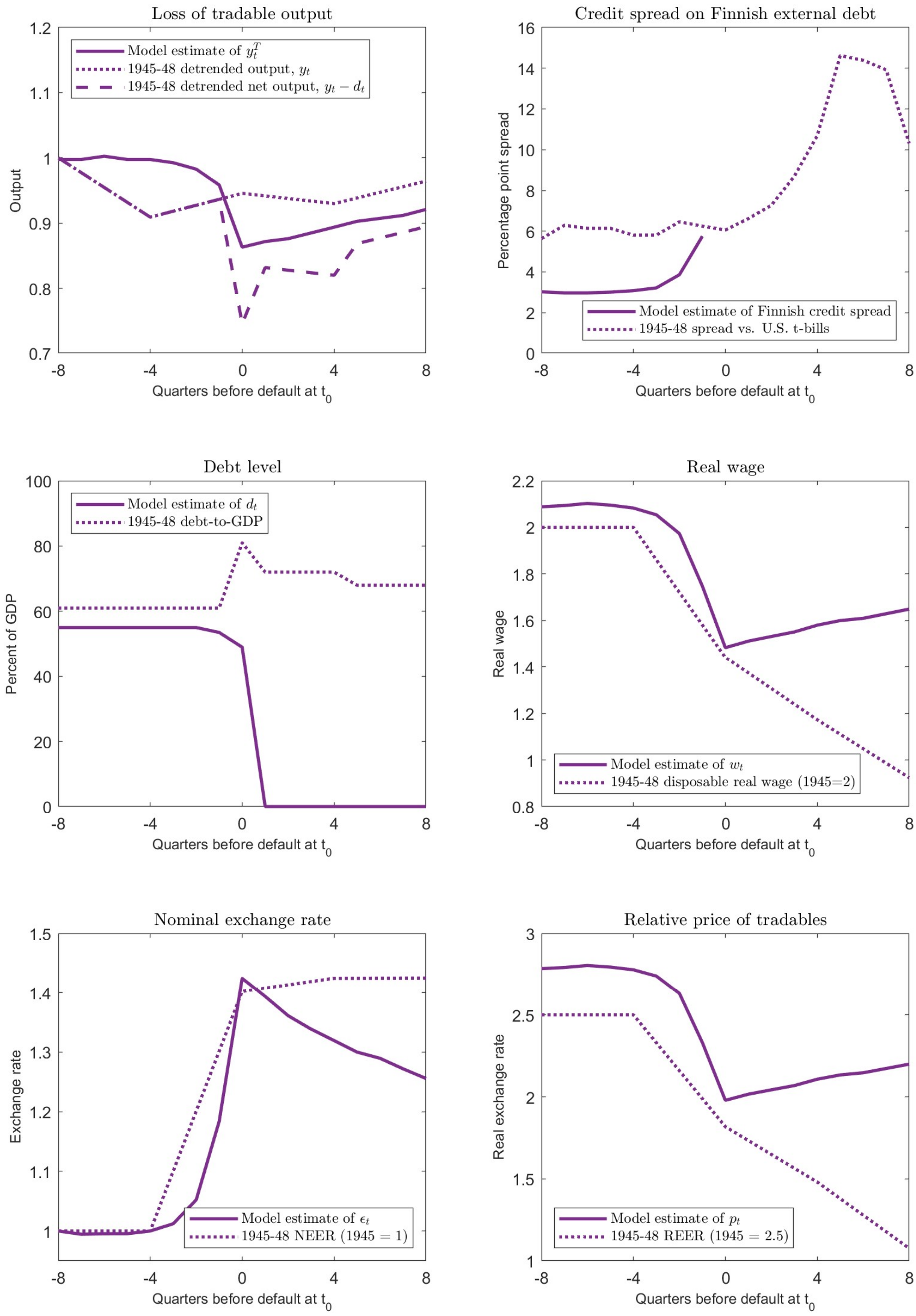
on par with the Franco-Prussian indemnity. The uncertainty around pre-war GDP and GDP levels during the first repayment means that the reparations-to-GDP can only be estimated at somewhere between 17 and 30 percent, of which the most reliable number (20 percent) is used.

From 1944 to 1947, Finland received loans from the U.S. worth 126 million U.S. dollar while paying out the equivalent of 232 million in reparations.[22] Pihkala (1999, p. 32) estimates that the required dollar funding—had Finland bought only American goods—would have been between 546 and 570 million dollar. It corresponds to around a third of total industrial production in 1945, though by 1952 it had fallen to four percent as the economy had grown. Finnish reparations were mostly funded by loans and foreign debt increasing from 229 million dollar in 1945 to 661 million dollars in 1951 (ibid, p. 46).

Finland paid its sovereign debt despite exhibiting all the characteristics of a sovereign default as explained in the model. Figure 5 plots the model predictions against Finnish historical macroeconomic data collected from 1945 to 1948. The largest output loss came in 1945 at the end of the war, falling 9 percent. Net output $y_0 - d_0$ decreased 25 percent as initial reparations were announced in 1945, before recovering slowly from 1946 onwards. Until the end of 1946, interest rates did not move much, hovering between six and seven percent, using Helsingfors municipal bonds as a proxy. But in 1947 the price of the five percent government bond maturing in 1961 dropped, increasing interest rates. The level of Finnish debt was 60 percent of GDP before the announcement of reparations, jumping to 80 percent of GDP in 1945, significantly above the level of $\boldsymbol{d_0}$ in the model. Real wages fell by 50 percent from 1945 to 1948 and Finland devalued their currency the *markka* three times in 1945. Like the real wage, the real exchange rate (bottom right) overshoots the prediction of the model significantly. A reason could be that Finland did not default, which meant that increased levels of domestic resources went to debt service.

[22] The Treaty had specified 300 million U.S. dollar in reparations.

On the face of it, the empirical investigation in Figure 5 exhibits all the stylised facts of sovereign debt defaults. Except that Finland did not default but did experience domestic inflation. The inflationary spiral lasted from 1945 to 1949 and the devaluation was in response to an initial bout of inflation. The net output contraction that occurred between early 1945 and 1946 clearly falls within the default set, with a 25 percent contraction and an initial level of debt slightly higher than the model d_0. It suggests that Finland paid for other than purely economic reasons, as the optimal policy would have been to default. Instead, the political economy realities of its close relationship with the Soviet Union meant that reparations debt was enforceable and default on its debt to the U.S. was impossible.



Sources: Bolt et al. (2018) for output; Ljungberg (2019) for exchange rates; Federal Reserve for bond yields; Pihkala (1999) for wages and debt. Replication file, *plot_finland.m.*

Figure 5: Model estimate and Finnish historical data (1945-48).

4.3. Default: German World War I reparations

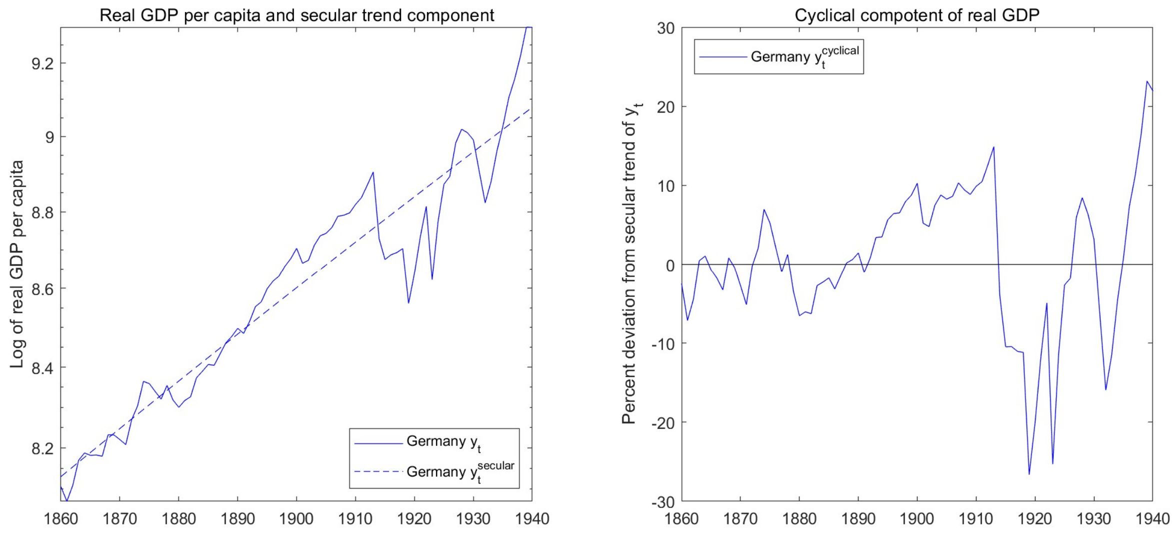
Unlike the French and Finnish reparations, Germany defaulted on its reparations in 1932. The Treaty of Versailles (1919) stipulated that Germany pay reparations for World War I, at a time when German external debt was already more than 70 percent of output. The size of reparations was to be negotiated later, but the Germans expected 30 billion to be an upper limit.[23] In 1920 news leaked of a larger-than-expected reparations bill of around 80 billion. It sent shockwaves through the German public, resulting in tax "boycotts" (Ritschl 2012a, p. 950). To make up for lower tax revenues, the central bank had to print money, which started the inflation spiral. Domestic political instability and hyperinflation followed (Ritschl 1996a, p. 3). The result was a collapse in real growth of almost 20 percent, and a fall in net output $y_0 - d_0$ well in the default set. Figure 6 shows German real GDP.[24]

In 1921, the London Schedule of Payments set the total reparations bill at 132 billion gold marks. It would be payable in three tranches: A-bonds (for war damages) worth 12 billion or around 25 percent of 1913 GDP; B-bonds (for inter-Allied war debt) worth 38 billion or around 75 percent of GDP; and C-bonds, the majority, at 82 billion totalling 150 percent of GDP. The implicit understanding was that the C-bonds would not need to be repaid (Ritschl 2012a, p. 945). The total size of the A-bonds (the reparation) and the German debt level was equivalent to the indemnity of 1871 in terms of GDP. Adding in the B-bonds for inter-Allied war debts took German debt levels well above historical precedents, but total debt level was close to that of Britain and France after World War I. By late 1922, the Germans refused to pay what they considered an intolerable and odious debt but was forced back to the negotiation table in January 1923 when the Allied occupied the Ruhr to enforce payment of reparations. Following the invasion of the Ruhr, Germany's creditors were able to enforce reparations and repayment resumed. In 1924, the Dawes Plan settled the reparations question and ended Allied

[23] See Ritschl (2012a) for the history. This section follows from there.

[24] Figure 6 is an enhanced version of Figure 1 showing only Germany. Again, the choice of detrending method does not alter the results in the paper. See Appendix A.

occupation of the Ruhr (Lutz 1930, p. 41-48; Yee 2020). The amounts agreed in the Dawes Plan were significantly less than agreed in 1921 and were arguably within the limits of what Germany could have paid without the onset of the Great Depression.



Source: Bolt et al. (2018). Replication file, *lqtrend_p2a.m*.

Figure 6: German secular and cyclical real output per capita (1860-1940).

Reparations transferred 2.5 percent of national income every year from 1925 to 1932, peaking at 3.5 percent in 1929 (Machlup 1964, p. 374-95). The amount was considered unpayable by many at the time.[25] Yet capital inflows to finance reparations were aplenty. Ritschl (1996a; 2002, 193-217) showed how the Dawes Plan embedded investor protections into reparations and stipulated that reparations remained junior to corporate debt claims in the central bank's foreign exchange window. Foreign lenders had an enforcement mechanism not usually available: seniority claim on the foreign exchange reserves at the Reichsbank (Ritschl 2012a, p. 952-55; Yee 2020).

From 1924 to 1929, Germany issued bonds across Europe and private foreign credit flowed into Germany (Accominotti and Eichengreen 2016, p. 476-78). In 1929 it proved unsustainable and the Young Plan was put in place to tighten payment terms and reverse the seniority. It

[25] For example, central bank president Schacht. Fleisig (1976) argued Germany would have defaulted even without a global depression while Neto (1986) on the other hand argued the German government never tried to raise taxes or cut spending to produce the required primary surplus.

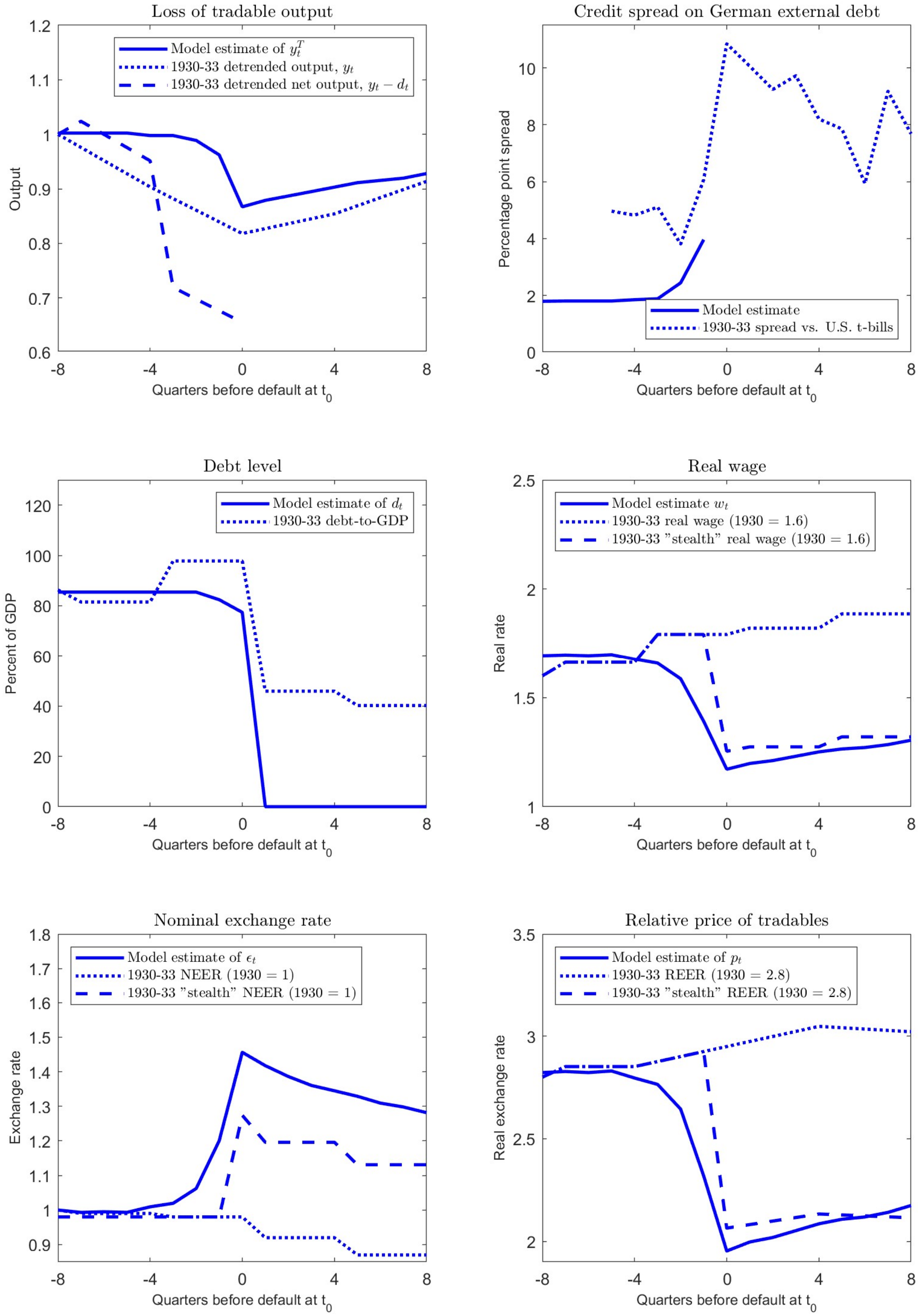
effectively cut off the flow of credit and Germany saw capital outflows. The level of debt-to-GDP increased from 75 percent in 1928 to just under 100 percent in 1931 (Papadia and Schioppa 2015, p. 6). Until the reversal of capital flows, high real wages in Germany had not affected unemployment negatively but after 1929 they did. The Young Plan ruled out a devaluation and made Germany unable to alleviate the pressure from too high real wages, which translated into a sharp output contraction, as first outlined by Borchardt (1984, 1990).

Nominal wages did fall but inflation fell more, and real wages rose despite mass unemployment. Even though the government was unable to pursue an outright devaluation of its currency, it nonetheless did so by stealth method. Klug (1930, p. 18) estimates that exports subsidies meant German exports could be purchased abroad at a 30 to 60 percent discount. *De facto* German currency policy is therefore in line with equation (27). The stylised facts accompanying sovereign defaults are therefore all present in Germany in 1932, as shown in Figure 7. The figure shows model output and historical German data from 1930 to 1933, with the sovereign debt default occurring in 1932 at t_0.

The German default on reparations in 1932 lies in the default set. German output y_t collapsed 18 percent between 1930 and 1932, while net output $y_0 - d_0$ was 35 percent lower. The level of debt at the time of default was 97 percent of GDP, including reparations which unlike the other episodes was not a surprise at the time of default. The middle-left figure in Figure 7 shows that the German debt stock after the default fell to 45 percent in 1932 and then to 40 percent in 1934. By 1938, its debt stock was down to 14 percent of GDP. The real wage, the nominal exchange rate, and the real exchange rate are plotted with their actual values and with the stealth devaluation.

The credit premium on Germans bonds over U.S. treasuries more than doubled in the year before the default, as the probability of default rose. After the Young Plan of 1929, Germany had issued external debt across Europe and New York to pay reparations. The increase in credit spreads in 1931 coincided with the financial meltdown in Europe, and the collapse in German output. It forced Germany to borrow 100 million U.S. dollar from a consortium of central banks as private credit flows reversed (Clement 2004, p. 36).[26] Figure 8 plots German external bonds yields from 1931 to 1935, the period in which it defaulted. It shows how one needs to be careful with a direct translation of historical data, as Germany defaulted over several years.

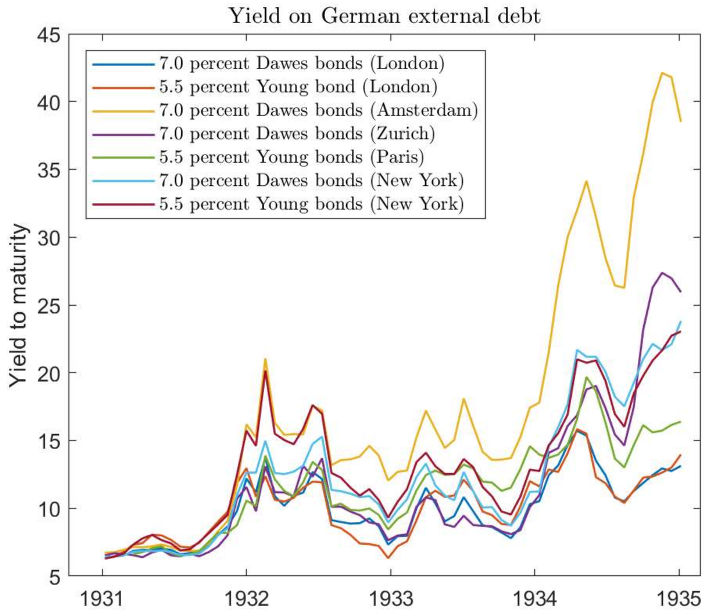
[26] The New York Federal Reserve, the Bank of England, the Banque de France, and the Bank of International Settlements.



Sources: Bolt et al. (2018) for output; Ljungberg (2019) for exchange rates; Ritschl (2012b, p. 40) for wages; Papadia and Schioppa (2015, p. 15) for debt and German bond yields; the Federal Reserve for U.S. yields; and Klug (1993, p. 18) for the estimate of the stealth devaluation, where the lower part of the range (30 percent) is used. Replication file, *plot_germany.m.*

Figure 7: Model estimate and German historical data (1930-33).

The default on reparations in early 1932 caused a rally on other bonds, as cash was perceived available, but it was short-lived. Additional defaults occurred in 1933 as Germany revoked the Gold Clause and announced it would only honour the nominal value of its debt (Clement 2004, p. 37-38). In 1934, a full moratorium on debt payments was announced alongside capital controls (Schuker 1988, p. 47-82). In 1934, another spike in interest rates occurred in the lead up to the full default in 1934 (Ritschl 2001, p. 329-30). The various reparations plans, seniority, and multiplicity of debt instruments means there is not a single default date for Germany.



Source: Papadia and Schioppa (2015, p. 15). Note: Bonds converted to yields, using stated coupon, maturities in 1949 for the Dawes and 1965 for the Young bonds (Clement 2004, p. 47). Replication file, *plot_gdr.m.*

Figure 8: Yields on German external bonds (1931-35).

With the introduction of full-scale capital controls, and once the exchange rates and real wages have been adjusted for the de facto devaluation, the German sovereign debt default of 1932 has all the characteristics as suggested by the model.

4.4. Enforcement of war reparations

The stylised facts that accompany sovereign defaults are remarkably close to what happened during periods of reparations. Even though the optimal policy in all three cases is shown to be default, only Germany defaulted on its sovereign debt. The collapse in net output across all historical cases is larger than the typical default, with an initial level of debt already high coming out of war.

The main difference is one of enforcement of sovereign debt contracts. France had no choice but to repay in 1871 to maintain its sovereignty. Enforcement was not a matter of financial sanctions, but one of military occupation. It was not an option to default and lose financial assets: default meant the loss of sovereignty. It therefore makes sense that credit spreads did not increase following the announcements of reparations, as the probability of default did not increase as debt contracts were enforceable by military force.[27] Finland following World War II was in a similar case, as political dividing lines were being drawn between the U.S. and the Soviet Union. There was no choice but to pay, despite significant domestic costs. For both France and Finland, the trough in net output was marked by the announcement of the reparation and the repayment was relatively quick. There was not a choice to extend payments into the future because the enforceability was directly linked to the transfers.

German debt enforceability is a bit messier. The invasion of the Ruhr was akin to the occupation of France in 1871, which forced Germany to pay. The payment schedule worked when there was a binding enforcement mechanism, alongside capital inflows. Once the 1930s came around, the enforcement mechanism was gone. Unlike in the early 1920s, the military threat had diminished, and the optimal economic policy was no longer impossible to implement.

[27] It is similar to the effect, shown by Accominotti et al. (2011), of the British empire was to remove the default risk of its colonies.

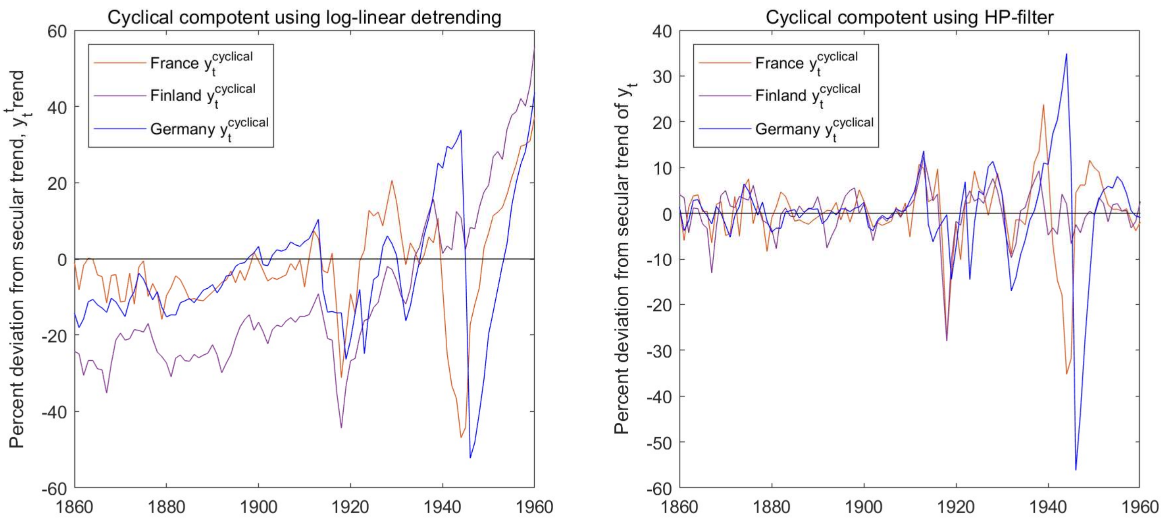
5. Conclusion

The literature on sovereign debt mostly focuses on recent examples of defaults. This paper situates the German default of the 1930s within the quantitative literature. I find it is well-explained by a sovereign debt model where default is accompanied by a devaluation of the currency.

The paper shows that the difference between the German default on World War I reparations and the repayment of other reparations was enforcement of debt contracts, not economic factors. The economies of France in 1871, Germany in 1932, and Finland in 1945 are all shown to exhibit macroeconomic characteristics that typically are seen during sovereign defaults, but economic reality took a backseat to political and military power. Once Germany's creditors were too weak to militarily enforce reparations, it defaulted.

Appendix A: Different detrending methods for real GDP

The results of the paper do not depend on the choice of detrending method. Figure 9a shows the cyclical components of output using log-linear detrending method to the left (King et al. 1988), and HP(100) filtering to the right. There are substantial differences in the length of the suggested business cycles, but the contraction in cyclical output in the years after reparations transfers is similar. As an example, for France from 1870-73 the deviation from the secular trend changes by less than one percent across all methods. The other episodes are similar. Quadratic detrending is therefore used throughout the paper.

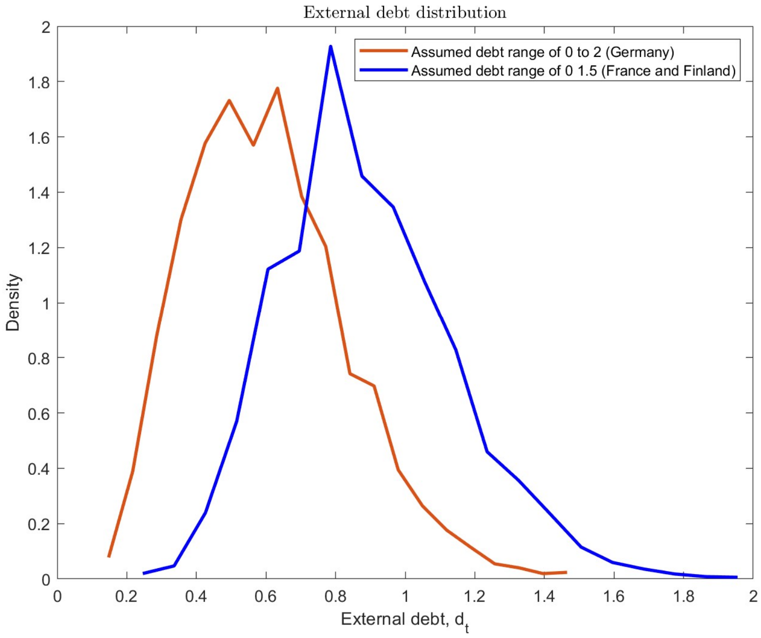


Source: Bolt et al. (2018). Replication file, *alt_trends.m*.

Figure 9a: Log-linear detrending and HP-filter of real GDP (1860-1960).

Appendix B: Distribution of external debt

Figure 10a shows the density distribution of external debt for the calibrations. Germany's debt level is assumed to fall between zero and 200 percent of tradable output, while France and Finland have an upper limit of 150 percent.

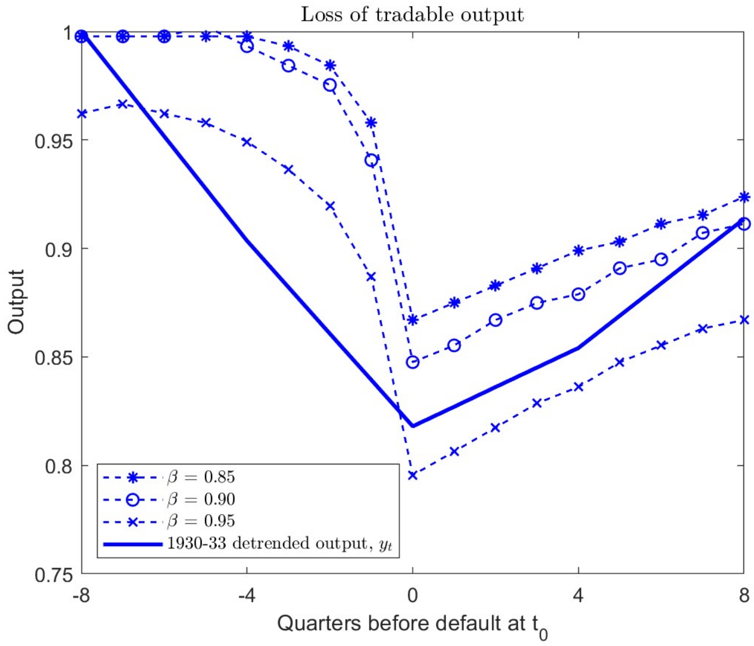


Note: Depending on the country being in good financial standing. Replication file, *debt_dist.m.*

Figure 10a: Distribution of external debt.

Appendix C: Varying the discount factor β

Figure 11a shows the model estimates for different values the subjective discount factor β for the German calibration. As the discount rate is lowered (higher β) the present cost of default goes up. For $\beta = 0.95$, the median output loss before default increases to over 20 percent. A higher value of β worsens the fit of the structural credit spread across episodes.



Source: Bolt et al. (2018). Replication file, *plot_b.m.*

Figure 11a: German model output for different values of β.

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