Seniority Reversals and Endogenous Sudden Stops: Some Transfer Problem Dynamics

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Abstract

Sovereign debt restructuring often ends in abject failure, as analogies from corporate debt restructuring are applied without proper analysis of dynamic disincentives (Bulow and Rogoff, 1989). In this paper we analyze the dynamic incentive effects of debt restructuring and changes in seniority among rivalling debt elements in a stochastic endowment economy with a risk averse sovereign debtor. Away from the default zone, the debtor will prefer to hold senior debt to signal creditworthiness and to obtain a so-called good housekeeping seal of approval. After a major adverse shock and within the default zone, fresh money will only be granted if the debtor is allowed to issue senior debt, making legacy debt junior. This leads to a borrowing binge and is often followed by sudden stop and default episodes in which the junior debt is defaulted on first. We calibrate the model to interwar Germany under the Dawes Plan of 1924-29, where new debt was issued in large amounts. Our simulation results bear out the predictions of Keynes (1922, 1929) about the dim prospects of recovering reparations.

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1 Introduction

Between 1924 and 1931, Germany absorbed accumulated net capital imports equivalent to about 20% of its GDP (Deutsche Bundesbank, 1976, p. 328). Accumulated gross capital inflows, a metric that takes into the fact that German capital exports were largely to formerly neutral countries and remained sheltered from sanctions in the 1930s, amounted to 35% of Germany's GDP. How could that be? Having lost World War I, Germany was subjected to punitive reparations that according to Keynes (1919) far exceeded her capacity to pay. Even the rescheduled reparations under the Dawes Plan of 1924 amounted to more than 70% of German GDP in present value. Still, in the second half of the 1920s, Germany was able to build up foreign debt that came in 1930 to nearly a third of its national income (Ritschl, 2002).

The answer commonly given to this phenomenon is transfer protection of commercial investors, as advocated by Keynes (1922). Under the scheme, foreign investors would get privileged access to foreign exchange in case of a future German payment crisis. Investor protection in its various forms is generally associated with a country's higher integration in international capital markets and larger net and gross foreign asset positions (e.g., Cyrus et al., 2006). Recent research has turned to find lower default rates in environments with well-defined investors' rights (e.g., Fang et al., 2020). However, applying protection to only one group of creditors violates the *pari passu* principle, which became important in litigation of Argentinian debts in the early 2000s (Olivares-Caminal, 2013). Debtor countries commonly attempt to play off creditor groups against each other by discriminating against legacy debt in favor of fresh money. Prioritization of payments to friendly creditors helps maintain their access to new credit by willing political lenders (Hinrichsen, 2022).

This paper targets the dynamic incentives related to discrimination among creditor groups rigorously. To this end, we extend the benchmark Eaton-Gersovitz (1986) model of sovereign debt to include two types of debt that differ in their seniority. An opportunistic debtor would choose to make those debts junior where default is considered excusable in the sense of Grossman and van Huyck (1986). We implement this concept by assuming that the debtor country's output cost of default is lower for junior debt. Our principal finding is that two incentives operate against each other, as their relative strength is determined by the size of the macroeconomic shock experienced by the debtor country. The static, first-principles effect is the country's opportunistic preference for junior debt, because of its lower default cost. As markets price in the higher default risk of junior debt, there exists a counteracting virtue-signalling dynamic incentive: by concentrating its borrowing in senior debt instruments, the country signals its unwillingness to default. Debt in senior instruments thus acts as a good housekeeping seal of approval, expressed in low interest rate spreads over financial centers, favourable agency ratings, and low volatility of capital flows. We find for moderate debt to GDP ratios that the virtue signalling effect dominates. After a major adverse shock, incentives are reversed and the country has an incentive to discriminate against the legacy debt, making it junior. If successful, the country may engineer a renewed credit bonanza, driving out its legacy debt while enjoying another day in the sun with its new, privileged creditors. Such credit rushes are, however, typically short-lived. We obtain endogenous sudden stops and default zones, from which the country emerges only gradually.

Many European debtor countries had in fact experienced a reversal of capital flows, but Germany stood out in the amount of foreign capital it had received as well as the subsequent capital reversal. Table 1 presents net capital inflows to 13 European debtor countries for two periods: 1924-1930 and 1931-37.[1] The heavy capital importing countries were Germany, Austria, Italy, Romania, and Poland, which together accounted for about 89% of the net capital imports received by 13 debtor countries. Germany alone took 57%. Capital flows came predominantly from the U.S. In 1931-1937, capital flows reversed, and this group of countries actually became net capital exporters, as net capital inflows to them either dropped substantially or even turned from positive to negative. Again, Germany experienced the most severe reversal of capital flows among the European debtor countries. Even in terms of per capita net capital inflows, reported in the last two columns of Table 1, the German experience clearly stands out, only exceeded by Austria.[2] For Germany, private capital inflows also dominated official inflows during 1924–1930, and it was net private flows that reversed in 1931, with the peak-to-trough drop in net capital inflows at 5.6% of the country's GDP (Accominotti and Eichengreen, 2016, Figure 4; Ho and Yeh, 2019, Figure 2). These capital inflows and outflows were among the main driving forces of Germany's business cycle between 1925 and 1931 (Ritschl, 2012; Accominotti and Eichengreen, 2016; Ho and Yeh, 2019).

The dominant explanation for the surge and reversal of capital inflows to Germany is attributed to the *transfer protection clause* of the Dawes Plan (Ritschl, 1996; 1998; 2012; 2013).[3] To our best knowledge, there are so far no empirical studies on the above hypothesis of the transfer protection clause. The hypothesis treats the transfer protection clause as a key loophole in the Dawes Plan and theorizes the interaction between the

[1] The 13 European debtor countries include Austria, Bulgaria, Estonia, Finland, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Poland, Romania, and Yugoslavia.

[2] Since the National Socialists took power in 1933, the reported figures in Germany's net capital inflows in 1931-1937 also reflected a deliberate policy of the Nazi government to reduce foreign indebtedness (Feinstein and Watson, 1995). The Nazi regime had tight controls over current and capital account payments. Moreover, as early as June 8, 1933, Hitler's government, under the helm of Hjalmar Schacht, initiated default on Germany's long-term foreign debt (Tooze, 2006). For how the Nazi regime misled foreign governments and foreign creditors about its true intentions to service Germany's foreign debt, see De Broeck and James (2019).

[3] It should be noted that besides the transfer protection clause discussed here, the high discount rate of the Reichsbank, in an attempt to stabilize the German currency, was also a reason for the capital inflows to Germany (Knortz, 2021, p. 236).

reparation policies and the capital flows to Germany as an aspect that has been ignored even by participants of the Dawes Plan.[4] The hypothesis has been accepted by popular writing, for example Kleinlein (2019, p. 9), even though so far there is no formal analysis of the effects of the transfer protection clause. The argument is also widely accepted by the greater academic community, such as Accominotti et al. (2017, p. 5), Knortz (2021, p. 111), and Yee (2020).

By using a sovereign debt model calibrated to the interwar Germany, this research examines the effects of reparation arrangements on capital inflows into Germany. We extend the benchmark Eaton-Gersovitz model, the current workhorse for the study of sovereign debt and default, to explore the interaction between reparation policies and capital flows. The employment of such a model also emphasizes that the willingness to pay, which depends on the enforceability of debt contract, is more relevant than the ability to pay when discussing the German reparation problem and sovereign lending in general (Eaton et al., 1986; Hinrichsen, 2021). Appropriately set incentives to produce timely payment of reparations are essential (White, 2001). We examine two predictions of the hypothesis. The first prediction is that for low output levels and high reparations, it is optimal for the sovereign to choose the level of commercial debt so that reparations are in default. The second prediction is that reparations (junior debt) would default first when economic conditions worsen. We also examine whether the adoption of the transfer protection can quantitatively generate the dynamics of observed capital flows to Germany; namely, the surge of commercial debt borrowing. We find that the transfer protection clause can account for Germany's high level of foreign debt in the 1920s.

The transfer protection clause introduced by the Dawes Plan made reparations debt junior to commercial debt. If a default on only the junior debt incurs the same output loss as a default on the senior debt, then there is no reason that the foreign borrowing will favor the senior debt; that is, the commercial debt. Things will be different if default on the junior debt is an excusable default, as it incurs a lower output cost than default on the senior debt. Knowing that junior debt is less enforceable, creditors would require a higher risk premium to compensate for the default risk and would prefer to lend in commercial debt, which is senior. If the transfer protection clause is responsible for the

[4] For example, Carl Bergmann, Germany's representative during the reparation negotiations, suggested that the transfer protection of the Dawes Plan had never been put into operation (Bergmann, 1930). Foreign loans to Germany provided ample foreign currency that allowed the reparation transfer without any danger to Germany's foreign exchange. Bergmann's point of view was shared by many contemporaries who treated the transfer protection as trivial. In fact, the transfer protection of the Dawes Plan had been put into operation when the negotiation of Young's plan came to a deadlock in 1929. The Reichsbank was confronted with high foreign exchange outflows and was only able to stabilize its reserves again by raising the discount rate from 6.5% to 7.5% on April 25, 1929. After the French media reported about a criticism of the Transfer Committee on the German government and a counter-criticism of Schacht on the Transfer Committee, the Agent General for Reparation discovered that foreign exchange was hardly available for the next transfer according to the Dawes plan. Accordingly, he scaled back his foreign exchange purchases (Ritschl, 2016, pp. 589-90).

surge in commercial debt, it is because the clause makes default on junior debt excusable. The surge in commercial debt under the Dawes Plan reflects the rational response of the agents to the changed debt arrangements. For an economy initially restricted in floating reparations debt, such as Germany in 1924, the surge in commercial debt borrowing can be even more dramatic.

Our paper contributes to the modeling of sovereign debt. Wright (2012), Aguiar and Amador (2014), Aguiar et al. (2016), and Yue and Wei (2019) provide reviews on models of external sovereign debt and default. Panizza et al. (2009) and Tomz and Wright (2013) go over the empirical literature about sovereign debt and default. The Eaton-Gersovitz model à la Aguiar and Gopinath (2006), Arellano (2008), and Uribe and Schmitt-Grohe (2017) contains one type of sovereign debt. We extend the Eaton-Gersovitz model to include both junior debt and senior debt and explore how the seniority structure and the asymmetric output loss affect debt pricing and type of debt borrowing. The two debt instruments also differ in historical default frequency. Moreover, we explore the borrowing behavior of forward-looking sovereign when regime change triggers the reversal of debt seniority and its implication for the trade account. Our analysis compliments the literature that explores the seniority structure of sovereign debt. For example, Clasessens and Diwan (1990) discuss the cooperation between creditors and debtors that can be Pareto-improving in the presence of a debt overhang. Chamley and Pinto (2012) analyze the introduction of the seniority of new loans (such as official loans) relative to old loans in a two-period setting. Chatterjee and Eyigungor (2015) look into the positive and normative implications of including a seniority clause in debt contracts to mitigate the problem of debt dilution. For empirical work, Schlegl, Trebesch, and Wright (2019) examine external sovereign debt's de facto seniority structure. They find that IMF is the most senior creditor, followed by other multilateral creditors. In contrast, bilateral official loans are not senior to private creditors.

Our analysis strongly echoes Keynes's view of the German transfer problem (Keynes, 1922; 1929). To create the trade balance and to enable Germany to make the transfer, German wages must fall. However, the Dawes Plan made almost no contribution to bringing about the reduction of wages. The easiest method would be to allow the German mark to devalue by the amount necessary to produce the required exports. However, the transfer protection clause of the Dawes Plan precisely forbade exchange rate devaluation; nor was there any compulsory deflation when the transfer protection clause came into play. Our analysis shows that the Dawes Plan encouraged commercial debt borrowing, resulting in Germany making the transfer out of foreign borrowing without promoting the needed adjustments in domestic wages. The process of borrowing from abroad must come to an end someday, and that happened in 1930.

The rest of the paper is structured as follows. Section 2 describes the Dawes Plan in 1924 and the transfer protection clause. Section 3 presents the analytical model, the calibration of model parameters, and the extension of the model to include both reparations debt and commercial debt as well as debt seniority. Section 4 reports the empirical results. The final section concludes.

2 The Dawes Plan and the transfer protection clause

2.1 The Dawes Plan coming into being

The Paris Peace Conference was held on January 18, 1919 during which the Allies could not reach a consensus on the amount of reparations that Germany should pay. Therefore, the Versailles Peace Treaty signed on June 28, 1919 did not set the amount and time limit for the country's war reparations. Instead, it referred the issue to the Reparation Commission to process the issue before May 1, 1921.

Under the ultimatum and Allied threats to send troops to occupy the Ruhr industrial area, Germany accepted the plan proposed by the Reparation Commission on May 5, 1921, which is the London Schedule of Payments. The plan stipulated that Germany issue three types of bonds A, B, and C to pay reparations: Bond A (for war damages) was 12 billion gold marks with an interest of 5%; Bond B (for Inter-Allied debts) was 38 billion gold marks with an interest of 1%; AB bonds totaled 50 billion gold marks; Bond C (contingent on Germany's hypothetical economic recovery) was 82 billion gold mark without interest, but was considered for issuance only after AB bonds had settled. In fact, Bond C was only hypothetical in nature, and its purpose was to appease the turbulent taxpayers of the Allied countries. Under the aforementioned scheme, Germany had to pay 2 billion gold marks every year starting on May 1, 1921, plus a floating payment equal to 26% of the total value of German exports. Given Germany's export figures at that time, the annual payment was about 3 billion gold marks, to be paid quarterly. The payment period was estimated to be 30 to 35 years. The German GDP of 1913 was about 56 billion marks, and 1920 GDP was about 76% of 1913 GDP (Ritschl and Spoerer, 1997).

In the summer of 1921, Germany paid the first prescribed payment. Payments due in November 1921 were mostly payments in kind rather than cash. However, problems with payments began to emerge from December 1921. After August 1922, Germany no longer paid cash, and after January 1923 even the payment in kind stopped.

The Reparation Commission ruled that Germany deliberately refused to pay reparations on time, giving France and Belgium a legal basis to send troops to occupy the Ruhr area of Germany on January 11, 1923. Germany adopted a passive resistance policy, which only worsened the government's fiscal woes. Most of the fiscal deficits were financed through the printing of banknotes by the German Reichsbank, leading to hyperinflation. German Chancellor Wilhelm Cuno resigned due to the failure of his passive resistance policy. On September 26, 1923, the new Chancellor Gustav Stresemann announced an unconditional end to the passive resistance policy so as to avoid a total collapse of the German economy. As France itself was in a financial crisis, President Raymond Poincaré agreed on November 11, 1923 that the Reparation Commission should convene experts to renegotiate reparations. On November 30, 1923, the Allied Reparation Commission approved the Dawes Committee, which was given a task to balance the German government budget and to find a new plan for paying reparations. The result was the Dawes Plan in 1924.[5]

2.2 Explanation of the Dawes Plan

In its design the Dawes Plan conceived a two-step procedure to collect reparations from Germany. First, Germany's annual obligation was to be raised in domestic currency and paid into the bank of issue (the Reichsbank).[6] Second, Germany's creditors (the Allies) could spend this money in Germany or convert it into foreign currencies. In the latter case, should the remittances be excessive and endanger the exchange rate, then the Transfer Committee, presided by the Agent for Reparation Payments, would obviate the remittances. The aim was to secure maximum transfers to the Allies, without bringing about instability to the German currency. The sums not remitted accumulated in the Reichsbank, but with a limitation of amounts (5 billion marks). The design was intended to safeguard against such transfers of mark payments into foreign exchange that would destroy Germany's exchange rate stability.[7][8]

What were the considerations behind such a design? Strongly influenced by Keynes (1922)'s views of the German reparation problem, such a design primarily focuses on Germany's capacity to pay reparations. Moreover, it starts from the premise that Germany's capacity to pay taxes (for reparations) and Germany's ability to transfer its wealth abroad are two distinct though related questions.

To pay reparations, German government had to create a budget surplus through taxation. The amount of budget surplus that could be raised by taxes was not strictly but yet positively correlated with Germany's external position. On the other hand, the amount that could be paid to the Allies in foreign currencies could not exceed what Germany's balance of payments allowed. The design separates the two questions: the first deals with the question of the maximum budget surplus Germany can create, and then with the question of making payments (the sums thus collected) to the Allies.

Practical reasons also require one to separate these two questions, and doing so also brings advantages. The budget depended on the decision of the German authorities. It

[5] Schuker (1976) provides a detailed description of the negotiation of the Dawes Plan with a focus on the Allied powers' military evacuation of the Ruhr area.

[6] The Reichsmark was tied to gold since mid-1924 and convertible.

[7] Online Appendix 1 gives the text of the transfer protection clause.

[8] The Dawes Plan included a stabilization loan that allowed Germany to return to the gold standard. For details of the Dawes stabilization loan, see Accominotti et al. (2017).

could be calculated and analyzed within a narrow limit of error.[9] In contrast, Germany's trade balance defies exact calculation, because it is subject to many factors that the government has no control. Here, a budget surplus sets a clear and objective framework to access Germany's capacity to pay. For the designers of the Dawes Plan, reparations must first be provided for as an item in the budget surplus rather than as an item in the trade balance.

The 1924 Dawes Plan provided for Germany's return to the gold standard, a stabilization loan, a payment schedule for reparations, and a transfer protection clause. The transfer to reparation creditors was entrusted to the Transfer Committee, which was composed of five Allied experts and headed by the Agent General for Reparations. The Dawes Plan explicitly provided that reparation transfer shall be made only if this did not damage the German gold standard. If such a danger arose, then the collected domestic currency shall be paid into the account of the Agent for Reparation Payments at the Reichsbank.[10]

The design created a wrong sense of safety that fulfilling the reparation payments did not require sacrifices on the part of the German people (see Online Appendix 1). In fact, what happened was worse than this: Germany was never able to achieve a budget surplus during the years of the Dawes Plan. Germany fudged its budget figures to create the appearance of a surplus when in fact none existed (James, 1985; Ritschl, 2002, Appendix *A*). Overly expansionary wages drove up consumption and lowered savings, and imports of capital were relied on for domestic capital formation (Borchardt, 1980). Seeing the same problems, the Agent General for Reparation publicly advocated for the revision of the Dawes Plan, which was replaced by the Young Plan adopted in 1930.[11]

2.3 The Young Plan that followed

The renegotiations leading to the Young Plan were a response to the incentive for roaring foreign borrowing created by the Dawes Plan. Knowing that Germany had systematically employed foreign borrowing to undermine reparation payments and to prevent Germany's further abuse of the Dawes Plan, reparation creditors pressed for a new arrangement under which Germany would pay out reparations under almost all contingencies (Ritschl,

[9] In his annual reports, the Agent General for Reparation criticized German attempts to obfuscate the budget figures and published his more pessimistic ones. Reconstructing the budget deficit from later official publications and internal documents, Ritschl (2002, Appendix *A*) can almost identically reproduce the Agent General's figures. It is likely he had access to leaked internal data.

[10] The Dawes Plan was drafted before the Reichsmark was created. According to the Dawes Plan, payments were to be made in gold marks. Effectively, payments were later made in Reichsmarks.

[11] S. Parker Gilbert, the Agent General for Reparation, publicly signaled the need for the revision of the Dawes Plan in the third annual report of December 10, 1927. Among other reasons, he suggested that the Dawes Plan, even though it opened up Germany's access to foreign credit markets, had resulted in unsustainable levels of borrowing. The Plan allowed Germany to pay reparations on credit instead of building the necessary foreign exchange through trade surpluses.

1998).[12] The Young Plan was reached in Paris on June 7, 1929 by experts of the participating nations and under the chairmanship of Owen D. Young. The Young Plan was accepted by the Reichstag on March 12, 1930 and was immediately ratified by Germany.

According to the Treaty of Versailles of 1919, reparations were senior to commercial claims. Article 248 of the Treaty of Versailles provided that reparation claims should have absolute priority of payment by Germany over commercial debt and all other government obligations. New credit, having junior rank, would be the first to default if Germany suspended payments, making it difficult for Germany to obtain credit.

The adoption of the Dawes Plan made all things different. Under the transfer protection clause, the Reichsbank would make foreign reserves available for reparation transfers only after the commercial claims on Germany had been first satisfied. This effectively reversed the ranking of reparations and commercial debt so that in the event of a shortage of foreign exchanges, commercial claims would be serviced at the cost of reparations.[13] This explains the puzzle why Germany could still attract so much foreign credit, given that it was already over-indebted in reparations. The argument finds a similar tone in Morgan (1931, p. 221), who suggests that "the factor of transfer protection tended to create a vague sense of safety in the minds of both borrowers and lenders and so encouraged the too free use of credit". Over time, it "became instead the screen behind which public spending and borrowing developed and flourished" (Morgan, 1931, p. 223). The high burdens of servicing the foreign debt likewise alarmed JP Morgan partner Russell Leffingwell enough to warn that the Dawes Plan had become a house of cards (Gomes, 2010, p. 166). Moreover, the clause created a perverse incentive for Germany to over-borrow strategically. As an internal memorandum of Germany's foreign ministry showed: "The more foreign credit we take in, the less we will have to pay out in reparations" (Ritschl, 2012, p. 952). It is even suggested that foreign policy under Gustav Stresemann was simply taking foreign creditors hostages to the reparation problem (Link, 1970; McNeil, 1986; Schuker, 1988).

Things changed when the Dawes Plan was replaced by the 1930 Young Plan. The aim of the Young Plan was the complete and final settlement of reparations. Its terms of payments were stricter than those of the Dawes Plan.[14] Most importantly, the Young Plan

[12] For a description of the negotiations over the Young Plan, see Lamont (1930). A detailed account is provided by Kent (1989), especially chapters 8 and 9.

[13] As Ritschl (2013, p. 114) puts it, "Transfer protection implied that at the central bank's foreign exchange window, transfers of dividends and interest on commercial loans would take precedence over transfers of reparations. This had the effect of making reparation recipients the residual claimants on German foreign exchange surpluses".

[14] One part of the annuity, to the amount of 612 million Reichsmarks, must in all circumstances be paid unconditionally. For the remaining and larger portion of annuity, the Germany government could delay the payments for two years at most. There was a clear connection between the Young Plan and the Allied debts. The 612 million Reichsmarks were supposed to compensate for the war losses of the Allies and were to be commercialized and mobilized as quickly as possible. The portion of annuity that could be postponed corresponded to the Allied debt payments to the United States.

of 1929 abolished the transfer protection clause. The removal of the transfer protection made reparation debt senior to commercial claims again. German bond issues abroad almost came to a standstill when the Young Plan was implemented. Foreign credits halted, and a foreign debt crisis quickly approached Germany.

3 Analytical model

3.1 The benchmark setting

We use a formal analytical framework to examine the effects of the transfer protection clause. Our analytical model is a version of the Eaton-Gersovitz model following the exposition of Aguiar and Gopinath (2006), Arellano (2008), and Na et al. (2018). The model and its extensions are the current workhorse for the analysis of sovereign debt and default.[15] We begin with a benchmark model to illustrate the analytical model's main features and for parameter calibration. We will extend the model in due course for counterfactual simulations.

Assume a small open economy has many identical individuals with the preferences of the individuals described by the utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t\right), \tag{1}$$

where E_0 denotes the expectations operator, c_t denotes consumption, $u\left(\cdot\right)$ is the period utility function, and $\beta \in (0,1)$ denotes the discount factor. We assume an endowment economy so that in each period the economy is endowed with y_t units of consumption goods. The endowment is assumed to be exogenous and follows an AR(2) process denoted by:

$$\ln y_t = \beta_1 \ln y_{t-1} + \beta_2 \ln y_{t-2} + \sigma_\epsilon \epsilon_t, \tag{2}$$

where ln denotes the natural logarithm, β_1, β_2 are model coefficients, σ_ϵ denotes the standard deviation of the innovations to the endowment process, and ϵ_t is a normally

[15] Hamann (2002) points out the main features of the Eaton-Gersovitz sovereign debt model: (a) default is more likely and also desirable when output is low and debt level is high; (b) a lower degree of relative risk aversion raises the probability of default; (c) a lower discount factor increases the probability of default; (d) a higher volatility of output reduces the probability of default; (e) greater persistence of output increases the probability of default; (f) a higher default risk-free rate raises the probability of default; and (g) in general, factors that raise the value of having access to financial markets reduce the probability of default and ease access to foreign credit. Wright (2012) and Tomz and Wright (2013) examine a number of important aspects of the Eaton-Gersovitz sovereign debt model that are at variance with the data.

distributed random variable that follows $\epsilon_t \sim \mathcal{N}(0,1)$.[16][17]

There is a single non-state-contingent asset. For each period, the economy may start either under good financial standing or bad financial standing. The economy acquires bad financial standing when it defaults on its financial obligations. If the economy is in bad financial standing, then it can regain access to financial markets with a constant probability of θ and be prevented from participating in financial markets with probability $(1-\theta)$. This implies that the average exclusion duration from financial markets is $\frac{1}{\theta}$ periods. A larger θ means that the economy will regain access to credit markets sooner. When $\theta = 0$, the economy is perpetually excluded from the international credit markets. Following the common assumption, the economy starts with zero external obligations when it regains access to financial markets.

It is further assumed that a default incurs a direct output cost that is exogenously given. Specifically, the endowment received by the economy is not y_t, but $\tilde{y}_t$, which is smaller than y_t and is defined as:

$$\tilde{y}_t = \begin{cases} y_t & \text{if} \quad \text{the economy is in good standing} \\ y_t - L(y_t) & \text{if} \quad \text{the economy is in bad standing,} \end{cases} \tag{3}$$

where $L(y_t)$ is the loss function (positive and non-decreasing in y_t) and has the following specification:

$$L(y_t) = \max\left\{0, a_0 + a_1 y_t + a_2 y_t^2\right\}. \tag{4}$$

The assumptions of finite exclusion period and output cost of default imply that upon default the economy is punished by the loss of access to international credit markets and the loss of part of its endowment. When excluded from the financial markets, the economy is forced into autarky, and consumption is equal to its endowment. The budget constraint under bad financial standing and exclusion from the financial markets is thus:

$$c_t = y_t - L(y_t). \tag{5}$$

An economy in good financial standing can choose to honor its debt or to default on its obligations. The economy immediately acquires bad financial standing if it chooses to default. If it chooses to honor its debt, then the economy maintains good financial standing until the beginning of the next period. For an economy in good financial standing that chooses to honor its debt, its budget constraint is given by:

[16] We have not used an AR(1) process, because it might misidentify the data-generation process and exhibit spurious volatility. That, in turn, would downward bias the default probabilities.

[17] By assuming an endowment economy, the model does not allow doom loops to develop in the model. For example, the perceived probability of default may affect the bond markets, which can spill over to private credit and, thus, economic activities. We thank James Fenske for this point.

$$c_t + d_t = y_t + q_t\left(d_{t+1}, y_t\right) d_{t+1}, \tag{6}$$

where d_t denotes the economy's debt due in the current period t, d_{t+1} is the debt acquired in the current period and due in the next period $t+1$, and $q_t\left(d_{t+1}, y_t\right)$ is the market price of the country's debt. The price of debt depends on the amount of debt acquired in the current period (and that due in the next period), as well as the current level of output. This is because the default decision in the next period depends on the amount of debt due then, and that the current level of output (y_t is assumed to be serially correlated) is informative about the future expected endowment level.

For an economy in good financial standing, the value function associated with choosing to honor its debt and thus continuing to participate in the financial markets is denoted by $v_t^c\left(d_t, y_t\right)$ and is given by:

$$v_t^c\left(d_t, y_t\right) = \max_{d_{t+1}} \left\{u\left(y_t + q_t\left(d_{t+1}, y_t\right) d_{t+1} - d_t\right) + \beta E_y v_{t+1}^g\left(d_{t+1}, y_{t+1}\right)\right\}, \tag{7}$$

where $v_t^g\left(d_t, y_t\right)$ denotes the value function of being in good financial standing, and E_y is the expectations operator conditional on y_t. The value function of being in bad financial standing is denoted by $v_t^b\left(y_t\right)$ and is given by:

$$v_t^b\left(y_t\right) = u\left(y_t - L\left(y_t\right)\right) + \beta\theta E_y v_{t+1}^g\left(0, y_{t+1}\right) + \beta\left(1-\theta\right) E_y v_{t+1}^b\left(y_{t+1}\right). \tag{8}$$

The value function of being in good financial standing is given by:

$$v_t^g\left(d_t, y_t\right) = \max\left\{v_t^c\left(d_t, y_t\right), v_t^b\left(y_t\right)\right\}. \tag{9}$$

The economy chooses to default when $v_t^b\left(y_t\right) > v_t^c\left(d_t, y_t\right)$. Default is more likely under a higher level of debt and lower current endowment. We denote the risk-free real interest rate by r^* and assume it to be constant. Assume that foreign lenders are risk neutral and perfectly competitive. Therefore, the expected rate of return on the economy's debt must be equal to r^*. The price of debt $q_t\left(d_{t+1}, y_t\right)$ can be obtained by equating the expected rate of return on the domestic debt to the risk-free world interest rate r^*:

$$\begin{aligned} q_t\left(d_{t+1}, y_t\right) &= \frac{\Pr_y\left\{v_{t+1}^c\left(d_{t+1}, y_{t+1}\right) \geq v_{t+1}^b\left(y_{t+1}\right)\right\}}{1+r^*} \\ &= \frac{1-\Pr_y\left\{v_{t+1}^c\left(d_{t+1}, y_{t+1}\right) < v_{t+1}^b\left(y_{t+1}\right)\right\}}{1+r^*}, \end{aligned} \tag{10}$$

where $\Pr_y$ denotes the probability conditional on y_t. The country interest rate r_t is given by the inverse of the price of debt minus one:

$$r_t \equiv \frac{1}{q_t\left(d_{t+1}, y_t\right)} - 1. \tag{11}$$

The country premium is defined as the difference between the country interest rate and the world interest rate:

$$\eta_t \equiv r_t - r^*. \tag{12}$$

The trade balance tb_t is given by:[18]

$$tb_t \equiv y_t - c_t = d_t - q_t\left(d_{t+1}, y_t\right) d_{t+1}. \tag{13}$$

3.2 Calibration

We assume that one period in the model corresponds to one quarter. To operate the model, we adopt a CRRA form for the period utility function:

$$u\left(c_t\right) = \frac{c_t^{1-\sigma} - 1}{1-\sigma}. \tag{14}$$

Following most of the literature, we set the inverse of the elasticity of intertemporal substitution σ at 2. From Ho and Yeh (2019), the world real interest rate r^* is calibrated to the average real U.S. long-term interest rate in 1925–1929, given that most of the capital flows received by Germany during this period were from the United States. In the calibration of the world interest rate, we make use of the U.S. consumer price index and U.S. long-term interest rate taken from the Jordà-Schularick-Taylor Macrohistory Database (Jordà et al., 2017). The value of r^* is equal to 3.4% per year, or 0.85% per quarter. For comparison, Na et al. (2018) set the world interest rate to 1% per quarter.

To calibrate the probability of re-entry into the financial markets θ, we visit the evidence on the average exclusion period of the Germany economy. We measure the exclusion period by the number of years a country is in default status. Germany experienced 3 episodes of external default and restructuring in the twentieth century. After unification in 1871 and before the beginning of World War I in 1914, Germany, being a net capital exporter, had never experienced any default. Germany then defaulted on its debt in 1922-23 when in November 1922 Germany defaulted on reparations payment as scheduled. The second default started in 1931 (standstill agreement) in which short-term debt was frozen while still being fully honored. From 1933 on, Germany gradually resumed service on short-term credits and payments of short-term debt to Great Britain resumed in 1933/34 (Ritschl, 2012). Thus, the second default lasted roughly 3 years. The Nazi default of 1933 is a third, separate event that lasted for 21 years to the 1953 London debt agreement (Reinhart and Rogoff, 2011, p. 81). We take into account all 3 episodes, and

[18] While in financial autarky the economy's trade balance is equal to zero.

thus on average Germany was in default status for 8.67 years. This yields a value of θ of 0.0288 at a quarterly frequency.[19] This value is slightly smaller than the value of θ used by Chatterjee and Eyigungor (2012) and Na et al. (2018) for the case of a modern emerging market: Argentina.[20][21]

We use data from interwar Germany to estimate the output process. We choose to proxy y_t by the Industrial Production Index taken from Wagemann (1935, p. 54, Reihe 21) from 1925:Q1 to 1932:Q4.[22] We obtain the cyclical component of output by the HP filter, setting the smoothing parameter to be equal to $1,600$. The OLS estimate of equation (2) is then:

$$\ln y_t = 1.4498 \ln y_{t-1} - 0.6240 \ln y_{t-2} + 0.0470\epsilon_t. \tag{15}$$

The estimated process is stationary. The implied unconditional standard deviation of output is about 13%, which is quite volatile.[23] Given the volatile output, domestic agents have a strong incentive to participate in the international markets to smooth consumption.

We adopt a one-parameter specification of the output loss function in equation (4) by setting $a_1 = 1$ and $a_2 = 0$. This specification implies during periods of bad financial standing that all output beyond a certain level is lost. This specification, following Arellano (2008), assumes that output loss from default is proportionally larger when the level of the endowment is high and is a setting used to support a higher equilibrium level of debt. To calibrate a_0 of the parameters of the output loss function as well as the discount factor β, we depend on two characteristics of the Germany economy as follows.

(i) Based on the international assets and foreign debt data taken from Deutsche Bundesbank (1976, p. 331) and the GDP data provided by Ritschl (2002), the foreign investments in Germany to GDP ratio between 1926 and 1932 is about 30.3%. The ratio of Germany's investments abroad to GDP between 1926 and 1930 is about 13.5%. To obtain Germany's net external debt over 1926-32, one cannot simply subtract German investments abroad from German foreign debt towards the formerly belligerent countries, because German investments abroad were in formerly neutral countries (such as Switzerland, Sweden, and the Netherlands) and their risk of sanctions were extremely low and perhaps close to zero. Assume for the moment that Germany's net external debt was 25%

[19] $\frac{1}{8.67\times 4} = 0.0288$.

[20] Both Chatterjee and Eyigungor (2012) and Na et al. (2018) set $\theta = 0.0385$, which gives an average period of exclusion of 6.5 years. To compute the exclusion period, one can also consider measuring the end of the exclusion period by the first year of issuance of new debt. Such information, however, is not available for Germany.

[21] If we exclude the default on reparations in the calculation of θ, then on average Germany was in default status for 12 years. This yields a value of θ of 0.0208 at a quarterly frequency.

[22] Wagemann (1935) is a publication by Institute für Konjunkturforschung, which was set up as a copy of the Burns and Mitchell NBER project to gather various disaggregate time series.

[23] $\sqrt{\frac{(1+0.6240)*0.0540^2}{(1-0.6240)(1-1.4498+0.6240)(1+1.4498+0.6240)}} \simeq 0.13$.

and the unsecured portion was 70%. In terms of the Eaton-Gersovitz model, this implies an annual debt-to-GDP ratio of 17.5%,[24] or a quarterly debt-to-GDP ratio of 70%.[25]

(ii) As mentioned above, Germany has 3 default events in the twentieth century. The frequency of default is about 3 times per century.[26]

We set β and a_0, together with the rest of the parameter values, to match the average debt-to-output ratio and the average default frequency observed in Germany. Some studies, such as Na et al. (2018), adopt a two-parameter specification of the output loss function to target one additional empirical statistic; that is, the average output loss per year during periods of bad financial standing. Practical reasoning prevents us from targeting this additional statistic.[27]

We set $\beta = 0.815$ and $a_0 = -0.840$. Together with the rest of the parameter values, the chosen values for (a_0, β) result in an average debt-to-GDP ratio of about 70% per quarter in periods of good financial standing, and the frequency of default is about 3 times per century. Table 2 summarizes the calibration of the model. Table 3 reports the selected first and second moments of the model.[28]

Following Uribe and Schmitt-Grohé (2017, pp. 520 − 541), we solve the model by using value-function iteration over a discretized state space to approximate the model's

[24] $\frac{25}{100} \times \frac{70}{100} = 17.5\%$.

[25] According to Guinnane (2014), the 1953 London Debt Agreement cut those debts incurred by the Germany government and private entities before 1945 by 55.2%. This suggests that 55.2% of Germany's external debt was unsecured. The figures of Guinnane (2014) do not account for the below-par buybacks of pre-Nazi debt, which were substantial. In addition, Nazi Germany's foreign borrowing, much of it forced, had been taken out of considerations beforehand.

[26] Alternatively, between 1870 and 2020 Germany experienced 3 times of foreign debt default. The frequency of default is about 2 times per century.

[27] Germany did go into partial default in July 1931. If we use the additional output loss to July 1932 as a candidate estimate for the output loss of default, the estimate is about 10% of real GDP (Ritschl, 2002, Table C.2). We would obtain odd results if we follow the method proposed by Zarazaga (2012) to calculate the average output loss per year conditional on being financial autarky. According to data provided by Ritschl (2002), the capital-to-output ratio $\frac{k_t}{y_t}$ increased from 22.22 in 1931:Q3 to 23.50 in 1932:Q3. Assume a production function of the form $y_t = k_t^{\alpha} h_t^{1-\alpha}$, where y_t denotes output, k_t denotes capital, h_t denotes employment, and $\alpha = 0.36$. The capital share in GDP is taken from the Historical Capital Shares Database constructed by Bengtsson and Waldenström (2018). We use the average capital share in GDP for Germany in 1925-29, which is equal to 0.36. The production function implies the relationship $\frac{y_t}{h_t} = \left(\frac{k_t}{y_t}\right)^{\frac{\alpha}{1-\alpha}}$. This means that output per worker would have increased by $\left[\left(\frac{23.50}{22.22}\right)^{\frac{0.36}{1-0.36}} - 1\right] \times 100$ percent, which is about 3.2%. Thus, on average, between 1931:Q3 and 1932:Q3, output per worker was 1.6% higher than it would have been had the capital to output ratio not risen. If we attributed all the increase in the capital to output ratio observed in this period to the sovereign default of July 1931, then one would conclude that the average annual output benefit (not cost) of the default was 1.6%. Estimating the output loss from later default is even trickier. We cannot use Germany's post-1933 default experience to calibrate output loss, because the economy subsequently recovered and also was affected by many compounding factors: the country's embrace of autarky, the Nazi rearmament, and public works programs financed via deficit spending. It is simply unreasonable to attribute all the output variation observed in this period to the sovereign default of 1933 and then to derive the average annual output cost of that default.

[28] Adopting $\theta = 0.0385$, the value some studies use for Argentina, would result in an average debt-to-GDP ratio of about 60%, and the default frequency is thus about four times per century.

equilibrium dynamics. We discretize the continuous AR(2) process for $\ln y_t$ using 200 equally-spaced points. The minimum and the maximum values of the grid for $\ln y_t$ are set to the unconditional mean plus ± 4.2 times the unconditional standard deviation of $\ln y_t$. Given the values of β_1, β_2 and σ_ϵ reported in equation (15), the first and the last grid points for $\ln y_t$ are ± 0.5607. We discretize the stock of net external debt d_t with a grid of 200 equally-spaced points that start from 0 and end at 2.0.

We next use the benchmark model to show that the model reproduces the standard feature that a higher output cost of default helps sustain a higher level of debt. Knowing this property helps us to interpret the results of later empirical analysis.

3.3 Output cost of default and the level of foreign debt

The ability of the creditors to enforce a larger output cost of default helps sustain a higher level of foreign debt. To see this, we compare the predictions of the model under two different values of a_0. We consider $a_0 = -0.840$ and $a_0 = -0.7560$. In the former case, which is our calibration reported in Table 2, the output level is capped at 0.840 after default, while in the latter case the output level is capped at 0.7560 (which is 10% lower than 0.840) after default. Figure 1 plots the output cost of default and shows that output suffers a larger loss under the parameterization that sets $a_0 = -0.7560$. A smaller absolute value of a_0 can be treated as a stronger ability of the foreign creditors to impose punishments on the debtor once the debtor chooses to default and therefore is a proxy for stronger enforcement. The other parameters of the model remain the same as in Table 2.

Table 4 shows with stronger enforcement that default frequency actually reduces from 3.0 to 1.7. The amount of debt to GDP ratio in good financial standing also increases from 69.0% to 151.5%, accompanied by a reduction in the mean risk premium from 4.4% to 2.2%. The volatility of risk premium also decreases from 4.6 to 2.6. This exercise shows that punishments in terms of output losses, as an instrument of enforcement, actually discourage default and therefore tend to increase the amount of debt sustainable in equilibrium. They also reduce the risk premium, which creates better terms of debt contract for the debtor. Moreover, they discourage default in good states of nature and therefore deals with the potential problem that the debtor might claim default when it actually was in a good state and able to pay the debts.

Table 4 also reports a case when enforceability is weakened, represented by setting the parameter a_0 equal to -0.9240 (the absolute value of which is 10% higher than 0.840). With weakened enforcement, the default frequency increases to 4.3, the sustainable debt to GDP ratio decreases to only 28.7%, and the mean risk premium rises to 7.6%.

3.4 Modeling the Dawes Plan and the Young Plan

The model presented so far (the benchmark model) assumes only one type of debt. To study the effects of reparation arrangements on capital flows, we extend the model to include two types of debt: reparations and commercial debt. The two types of debt differ in their seniority, depending on the reparation arrangements in place. We assume for tractability that both reparations and commercial debt are short-term debts. We use d_t^{rep} to denote reparations debt and d_t^{com} to denote commercial debt. Total debt d_t is the sum of reparations debt and commercial debt: $d_t = d_t^{rep} + d_t^{com}$. Below we present first the model in which the Dawes Plan is the reparation arrangement (henceforth, the Dawes-Plan model) and then the model in which the Young Plan is the reparation arrangement (henceforth, the Young-Plan model).

The transfer protection clause is present in the Dawes-Plan model, implying that reparations debt is junior while commercial debt is senior. The sovereign can default on the junior debt and keep the senior debt intact or default on both types of debt. By definition, the sovereign cannot default on senior debt while continuing to service the junior debt. A default on both types of debt incurs an output cost identical to equation (4). A default on only the reparations debt, which is junior, incurs an output loss $L_{Dawes}(y_t)$.

$$L_{Dawes}(y_t) = \max\left\{0, b_0 + b_1 y_t + b_2 y_t^2\right\} \tag{16}$$

An economy in good financial standing that chooses to honor its debt has the budget constraint:

$$c_t + d_t^{rep} + d_t^{com} = y_t + q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{rep} + q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{com} \tag{17}$$

where $q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right)$ and $q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right)$ are the market prices of reparations debt and commercial debt, respectively. The price of debt depends on the amount of each type of debt acquired in the current period (and that due in the next period), as well as the current level of output.

We now need to find optimal levels and prices for each type of debt *as if* the debtor country was free to choose its debt composition and see the levels of debt that were incentive compatible with creditors. Once these equilibria are found, we can further closely examine the debt levels and compositions that are not incentive compatible; i.e., of the default zones.

3.4.1 Incentive-compatible reparations and commercial debt levels

In the following, we counter-intuitively deal with reparations as a problem of debt choice by the debtor country. The equilibria we find are those where reparation creditors “lend”, commercial creditors lend, and the country accepts reparations and commercial debt in varying compositions and up to certain levels.

We assume therefore the economy decides on its optimal borrowing for each type of debt. The value function associated with choosing to honor its debt and thus continuing to participate in the financial markets is given by:

$$v_t^c\left(d_t^{rep}, d_t^{com}, y_t\right) = \max_{d_{t+1}^{rep}, d_{t+1}^{com}} \left\{u\left(c_t\right) + \beta E_y v_{t+1}^g\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right)\right\} \tag{18}$$

The Dawes-Plan model differs from the benchmark model in that default on only junior debt (reparations debt) is possible. Senior debt (commercial debt) is still honored. The budget constraint under the default on only reparations debt is:

$$c_t + d_t^{com0} = y_t - L_{Dawes}\left(y_t\right) + q_t^{com0}\left(\cdot, d_{t+1}^{com0}, y_t\right) d_{t+1}^{com0} \tag{19}$$

The economy incurs an output loss $L_{Dawes}\left(y_t\right)$, but is not excluded from the commercial debt markets. Note that we make a distinction between d_t^{com0} and d_t^{com}, because for the former case, reparations debt is in default and not available when the sovereign decides the optimal level of commercial debt. For the same reason, we make a distinction between q_t^{com0} and q_t^{com}. Let $v_t^{b,rep}$ denote the value function of default on only reparations debt. It follows that $v_t^{b,rep}$ is expressed as:

$$v_t^{b,rep}\left(d_t^{com0}, y_t\right) = \max_{d_{t+1}^{com0}} \left\{u\left(c_t\right) + \beta\theta E_y v_{t+1}^g\left(0, d_{t+1}^{com0}, y_{t+1}\right) + \beta\left(1-\theta\right) E_y v_{t+1}^{g,rep}\left(d_{t+1}^{com0}, y_{t+1}\right)\right\} \tag{20}$$

$$v_t^{g,rep}\left(d_t^{com0}, y_t\right) = \max\left\{v_t^{b,rep}\left(d_t^{com0}, y_t\right), v_t^b\left(y_t\right)\right\} \tag{21}$$

Equation (20) means that the economy can regain access to reparations debt with probability θ. With probability $(1-\theta)$, the economy will be prevented from access to reparations debt. Equation (21) means when prevented from access to such debt that the economy decides whether to default on only junior debt or default on both types of debt.

An economy that defaults on both reparations debt and commercial debt has a budget constraint identical to equation (5). Let v_t^b denote the value function of default on both types of debt. It follows that v_t^b is expressed as:

$$v_t^b\left(y_t\right) = u\left(c_t\right) + \beta\theta E_y v_{t+1}^g\left(0, 0, y_{t+1}\right) + \beta\left(1-\theta\right) E_y v_{t+1}^b\left(y_{t+1}\right) \tag{22}$$

Equation (22) shows that the economy returns to a state of no default on both types of debt with probability θ. The value function of being in good financial standing is:

$$v_t^g\left(d_t^{rep}, d_t^{com}, y_t\right) = \max\left\{v_t^c\left(d_t^{rep}, d_t^{com}, y_t\right), v_t^{b,rep}\left(d_t^{com}, y_t\right), v_t^b\left(y_t\right)\right\} \tag{23}$$

The price of debt, as before, is obtained by equating the expected rate of return on the debt to the risk-free world interest rate. Junior debt (reparations debt) has a non-zero price only if the economy honors both types of debt. The price of reparations debt is thus given by equation (24). Senior debt (commercial debt) has a non-zero price as long as the economy does not default on both types of debt. The price of commercial debt is thus given by equation (25). The price of senior debt (commercial debt) when junior debt (reparations debt) is in default is given by equation (26), which shows that commercial debt has a non-zero price, either because the economy regains access to reparations debt (with probability θ) and does not default on both types of debt, or because the economy is prevented from access to reparations debt (with probability $(1-\theta)$), but nevertheless continues to honor commercial debt.

$$q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) = \frac{1}{1+r^*} \Pr_y \left\{ \begin{array}{c} v_{t+1}^{c}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ \geq \max\left\{v_{t+1}^{b}\left(y_{t+1}\right), v_{t+1}^{b,rep}\left(d_{t+1}^{com}, y_{t+1}\right)\right\} \end{array} \right\} \tag{24}$$

$$q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) = \frac{1}{1+r^*} \left\{ 1 - \Pr_y \left[\begin{array}{c} v_{t+1}^{b}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{c}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right), v_{t+1}^{b,rep}\left(d_{t+1}^{com}, y_{t+1}\right)\right) \end{array} \right] \right\} \tag{25}$$

$$q_t^{com0}\left(\cdot, d_{t+1}^{com0}, y_t\right) = \frac{1}{1+r^*} \left\{ \begin{array}{c} (1-\theta)\left(1 - \Pr_y\left[v_{t+1}^{b,rep}\left(d_{t+1}^{com0}, y_{t+1}\right) < v_{t+1}^{b}\left(y_{t+1}\right)\right]\right) \\ +(\theta)\left(1 - \Pr_y \left[\begin{array}{c} v_{t+1}^{b}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{c}\left(0, d_{t+1}^{com0}, y_{t+1}\right), v_{t+1}^{b,rep}\left(d_{t+1}^{com0}, y_{t+1}\right)\right) \end{array} \right]\right) \end{array} \right\} \tag{26}$$

It is easy to show that $q_t^{com} > q_t^{com0}$ and $q_t^{com} > q_t^{rep}$. Appendix 1 lists all the equations that constitute the Dawes-Plan model.

3.4.2 Pathways into and out of default

In the benchmark model the economy starts either from good or bad financial standing. An economy that starts from good financial standing may continue to participate in the financial markets or choose to default. An economy that starts from bad financial standing may reenter the financial markets or remain in autarky.

The economy's routes in the Dawes-Plan model are more than the benchmark model. The economy may start from (i) no default, (ii) default on only junior debt (reparations debt), or (iii) default on both types of debt. An economy that starts from no default may continue to honor both types of debt, default on only junior debt (reparations debt), or default on both kinds of debt. An economy that starts from default on only junior debt (reparations debt) may regain access to both types of debt or only have access to senior debt (commercial debt). In the latter case, the economy may default on only reparations debt or default on both types of debt. An economy that starts from a default on both types of debt may regain access to or still not have access to both kinds of debt. Figure 2 summarizes the economy's decision routes in the Dawes-Plan model. The simulations of the model we conduct below follow these decision routes.

Transfer protection clause is not present in the Young-Plan model, implying that reparations debt is senior while commercial debt is junior. The Young-Plan model is analogous to the Dawes-Plan model, only in that reparations debt and commercial debt reverse their seniority. For example, the sovereign can default on commercial debt (now junior debt) and keep reparations debt (now senior debt) intact or default on both types of debt. The sovereign cannot default on senior debt while continuing to service junior debt. To save space, we will not describe in detail the Young-Plan model. Appendix 2 lists all the equations that constitute the Young-Plan model. Figure 3 summarizes the economy's decision routes in the Young-Plan model.

4 Empirical analysis

4.1 Model properties

In the following, we present and analyze the properties of the model characterized above.[29] The strategy is to allow more considerable deviations successively from the benchmark model of just one debt element.

We begin with the case in which the output loss of partial default is equal to the benchmark model. As explained above, we allow for two components of debt: d_t^{rep} and d_t^{com}. We assume (without loss of generality) that d_t^{com} is senior. This means under partial default that d_t^{rep} would be defaulted first. Figure 4 shows the price of both elements of debt for constant levels of d_t^{rep}. In Figure 4 the prices of the two debts, shown in the upper-left and the upper-right panels respectively, are identical. As seen from the lower panel of Figure 4, the price of commercial debt under partial default in reparations debt is non-zero, but relatively small. Under the assumption of full default cost, the option of partial default does not matter very much. The debtor country has an incentive to either avoid the cost of default or to go full default with default cost baked in. The simple reason is that the penalty is not affected by the size of the default.

Things change when defaulting on only junior debt (reparations debt) incurs a less significant output loss than the benchmark case. Partial default on reparations debt can be less costly, because it does not damage private creditors; banks in reparation creditor

[29] Due to computational limitation, we use a grid of 60 equally-spaced points for $\ln y_t$, d_t^{rep}, and d_t^{com} to solve the Dawes-Plan model and the Young-Plan model.

countries may also lobby to prevent sanctions. The sovereign's incentive to default on only the reparations debt increases. In Figure 5 we set $b_0 = 1.20a_0$, implying that the output loss from a default on only the reparations debt is 20% smaller than the benchmark case. Figure 5 shows that the price of reparations debt (upper-left panel) decreases and the price of commercial debt (upper-right panel) increases, making the price of reparations debt smaller than the price of commercial debt. At the same time, the price of commercial debt when reparations debt is in default (lower panel) increases substantially. It is straightforward to show that as the output loss from default on only reparations debt decreases further, the price of commercial debt when reparations debt is in default will approach toward and finally be equal to the price of commercial debt.

To understand the sovereign's borrowing under the Dawes-Plan mode, we simulate the model for 1 million periods with $100,000$ burn-in periods. We first go back to the case of identical default cost in Figure 6 and then show the effects of asymmetric default cost in Figure 7. It is helpful to notice in advance why d_t^{rep} and d_t^{com} under the assumption of symmetric default cost are almost the same in Figures 4 and 6, but not entirely so. The reason is prior knowledge of default frequency, which per our calibration, is slightly higher for reparations than for commercial debt. In the parlance of the sovereign debt literature, reparations are more odious than commercial debt, though not much more so.

Figure 6 plots the distribution of debt to GDP ratio obtained by the simulation and indicates that the sovereign borrows more junior debt (reparations debt) than senior debt (commercial debt). The average reparations debt to GDP ratio is 61.62%, with the mean and standard deviation of the risk premium being 4.72% and 5.15%, respectively. The average commercial debt to GDP ratio is 5.96%, with the mean and standard deviation of the risk premium being 0.18% and 1.30%, respectively. The sovereign defaults on reparations debt about 3.13 times per hundred years and defaults on the commercial debt about 3.05 times per hundred years. The average total debt to GDP ratio, 67.58%, is almost identical to the benchmark model's calibrated debt to GDP ratio.

This first exercise highlights the role of symmetric default cost and is also informative about the historical case. With the default frequency the only characteristic that differs between the two debt instruments, a pretty high average ratio of reparations debt to output is supported, while commercial borrowing abroad remains mostly very low. This would suggest that talk of softening the terms of payment as in the Dawes Plan of 1924 may have been a mistake. In terms of reparation levels considered to be sustainable, and taking the 1913 output of Germany (50 billion gold marks) as a benchmark estimate of the steady state, Figure 6 would suggest a sustainable reparations burden averaging 30 billion gold marks. This is close to the suggestions of Keynes and to the numbers proposed by the Germans in unofficial negotiations at the time. It is somewhat smaller than the net present value of the Dawes Plan, although the latter is still well within two standard errors from the mean in Figure 6.

We conduct the same simulation, but let the output loss from a default on only junior debt (reparations debt) be 20% smaller than the benchmark case. Figure 7 shows that the sovereign will borrow overwhelmingly senior debt (commercial debt) rather than junior debt (reparations debt). The average reparations debt to GDP ratio now falls to 4.03%, with the mean and standard deviation of the risk premium becoming 10.33% and 23.83%, respectively. The average commercial debt to GDP ratio jumps to 64.23%, with the mean and standard deviation of the risk premium being 4.30% and 4.83%, respectively. The sovereign defaults on reparations debt about 4.70 times per hundred years, and it defaults on commercial debt about 3.08 times per hundred years. The average total debt to GDP ratio of 68.27% is almost identical to the benchmark model's calibrated debt to GDP ratio.

This second exercise suggests that allowing the debtor to issue senior debt on top of reparations reverses the debt structure to the detriment of the latter. Reparations being junior is consistent with the historical evidence on transfer protection of international credit to Germany under the Dawes Plan. We see that the debtor country now holds roughly as much total debt as in the previous exercise. However, commercial debt has crowded out reparations almost entirely. This is an echo of concerns during the Dawes Plan period that Germany was borrowing at high rates on international markets in order to drive out reparations. Figure 7 suggests that if commercial debt is senior to reparations, the desired share of reparation debt is reduced to a mere 4% of output. The equilibrium default rate on commercial debt is still lower than on reparations, which makes lending to the debtor country incentive compatible for international agents. We also notice that a significant risk premium over the international interest rate still obtains, which is consistent with historical observations.

These first results imply that giving transfer protection to commercial debt in the Dawes Plan was self-defeating. Rather than helping the country to phase in reparations gradually, it sets into motion a major crowding out effect. Capacity to pay is not the principal issue, the incentive structure created by the inverse seniority of reparations and commercial debt is. In the simple world of Figures 6 or 7, had there been no transfer protection there would have been no transfer problem.

Why does the sovereign borrow mostly junior debt (reparations debt) when defaulting on only junior debt incurs identical output cost as the benchmark case? The situation is like an implicit contract. If we present the debtor country with a choice between shouldering reparations debt or commercializing debt like France in 1871, then under equal default cost the country prefers reparations debt and so do the creditors. An incentive-compatible contract is supported by the common knowledge of relative default probabilities (assuming it is higher for reparations debt). Under asymmetric default cost, the country prefers commercializing debt, not reparations debt, and so do the creditors. Ex-ante (and if there is a choice), we have either equilibrium, depending on the default cost. Creditors provide the selection (for given default probabilities) among equilibria by setting relative default cost.

The above discussion suggests that the Dawes-Plan model supports the hypothesis of the transfer protection clause in the sense that commercial debt is encouraged. Nevertheless, it is important to emphasize the preconditions that lead to such a result. First, default on junior debt (reparations debt) is an excusable default, as it incurs a lower output cost than default on both junior debt and senior debt. Second, the sovereign's borrowing twists towards senior debt (commercial debt), because the creditors, fully understanding the sovereign's incentive, perceive junior debt as highly risky and prefer to lend in senior debt.

The properties of the Young-Plan model are analogous to that of the Dawes-Plan model, but now reparations debt is senior and commercial debt is junior. Figures analogous to Figures 4-7, but for the Young-Plan model, are available in Online Appendix 2. The prices of the two debts are identical when output loss from a default on only junior debt (commercial debt) is identical to the benchmark case. Commercial debt is preferable to reparations debt. The price of reparations debt increases and the price of commercial debt decreases when defaulting on only commercial debt incurs a less significant output loss than the benchmark case. Reparations debt becomes preferable to commercial debt.

4.2 Partial default with and without transfer protection: results

With the above models, we now test two predictions that the hypothesis of the transfer protection clause suggests. The first prediction is that given low output levels and high reparations, it is optimal for the sovereign to choose the level of commercial debt so that reparations are in default. There are two reasons that the model bears out this prediction. First, default on reparations (junior debt) is excusable, and it is simply not optimal for the sovereign to continue servicing high reparations debt. Second, holding reparations debt when output levels are low is not feasible.

We simulate the Dawes-Plan model (in which the transfer protection clause is present) for 1 million periods to test that prediction. Define Γ_A as the 25% quantile of output level and Γ_B as the 75% quantile of reparations from the 1 million simulated periods. We search for periods that satisfy the following initial conditions: output level is below Γ_A, and reparations are above Γ_B. For those periods that satisfy the above initial conditions, we trace out their subsequent 24 periods (quarters) and summarize the relevant statistics. The exercise answers how an economy that starts from low outputs and high reparations will evolve and provides a direct test of the first prediction. For the simulation, we assume that the output loss of default on only the junior debt (reparations debt) is 20% lower than the benchmark case.

Figure 8 reports the average value of the simulation and shows that starting from low outputs and high reparations, both the default on reparations debt and the default on commercial debt increase in the next period. For the first few periods, the frequencies of defaulting on reparations debt and defaulting on commercial debt are almost identical. However, starting from the 6th quarter, default frequency on reparations debt increases substantially, while default frequency on the commercial debt remains roughly the same.[30] The prediction that the sovereign tends to default in reparations debt, but refrains from defaulting on commercial debt, does find support. Consistent with the prediction, the quantities of commercial debt (in level and relative to GDP) are unaffected; actually, commercial debt sees a slightly rising trend. Reparations debt price and commercial debt price decline over time. The price of commercial debt is higher than the price of reparations debt, and they diverge over time: the difference can be as significant as 10%. Notice that as commercial debt increases, the probability of default rises and suppresses the price of commercial debt. The marginal effect of debt increment on the price of debt is more significant when the quantity of debt is high (Arellano, 2008).[31]

The second prediction is that commercial debt (senior debt) would work out fine under good conditions. Bad conditions would lead to a default on only reparations (junior debt), and even worse conditions would result in a default on both types of debt. In other words, as output declines and default becomes unavoidable, the sovereign will default on the reparations debt first, because it is the lesser evil of the two. We examine the default distribution over output levels using the time series we obtain from simulating the Dawes-Plan model to test the prediction.

Figure 9 reports the results. For each panel, frequency on the y-axis is calculated as the number of defaults per hundred years, against the output level on the x-axis. The left panel of Figure 9 reports the default frequencies of routes 2, 3, and 6, respectively. As Figure 2 shows, starting from good financial standing, the sovereign can honor both types of debt (route 1), default on only the junior debt (reparations debt, route 2), or default on both junior and senior debts (route 3). Figure 9 shows that when the output is high, there is no default. As the output declines, junior debt (reparations debt) first comes into default. As the output falls further, both types of debt come into default. Figure 9 also reports route 6, which is the frequency of sovereign defaulting on senior debt (commercial debt) when it has already defaulted on junior debt (reparations debt). That frequency is zero when output is high, but as output lowers it begins to increase in step with the default on both types of debt. In general, the results in the left panel of Figure 9 are consistent with the prediction.

[30] In the simulation, the risk premium for reparations debt starts to jump up from the sixth quarter. The model's risk premium is proportional to the probability of default (Uribe and Schmitt-Grohé, 2017, p. 528). This explains the increase in the default frequency.

[31] The average and the median values of the simulation are similar. A plot showing the 68% confidence band of the simulation is available from the authors.

The right panel of Figure 9 reports the frequencies of defaulting on commercial debt, on reparations debt, and either type of debt. As output declines, the frequency of defaulting on junior debt (reparations debt) increases sharply, and the frequency of defaulting on senior debt (commercial debt) rises only mildly. Only when output falls further does the frequency of defaulting on commercial debt rise significantly. Note that the frequency of defaulting on commercial debt is the sum of routes 3 and 6 reported in the left panel. It makes the frequency of defaulting on commercial debt look higher than that of defaulting on reparations debt. If we exclude route 6 from the calculation, then the two frequencies will be identical after output falls below 0.90, because now commercial debt and reparations debt will simultaneously default. In sum, Figure 9 is consistent with what the second prediction that the hypothesis of the transfer protection clause suggests.

4.3 Seniority reversal

To test the hypothesis we move a step further to examine whether the model fits the data. According to the hypothesis of the transfer protection clause, it was the changes in reparations arrangements with their implications for debt seniority that triggered first the pileup and then the drop of Germany's commercial borrowing. Specifically, the 1924 Dawes Plan (commercial debt being senior relative to reparations) led to capital inflows, and the 1930 Young's plan (commercial debt being junior to reparations) then led to capital outflows. We earlier model the Dawes Plan and the Young Plan, but now examine whether this seniority reversal could have accounted for Germany's observed pattern of capital flows.

Assume with probability $(1-p)$ that reparations debt switches from junior to senior debt in every period. Once reparations debt is senior, it switches from senior to junior debt with probability p in every period. In other words, the transition matrix that describes the transition between the Dawes Plan and the Young Plan is given by:

$$\begin{bmatrix} p_{DD} & p_{DY} \\ p_{YD} & p_{YY} \end{bmatrix} = \begin{bmatrix} p & 1-p \\ p & 1-p \end{bmatrix}$$

where D denotes Dawes Plan, Y denotes Young Plan, and p_{DY} denotes the transition probability from the Dawes Plan to the Young Plan. The transition matrix implies a case of independent switching. Each period, there is a probability p that the state is the Dawes Plan and a probability $(1-p)$ that the state is the Young Plan, regardless of the state of the previous period.

We conduct simulations, drawing from the two states following the switching regression literature. To let the simulation start with the Young Plan (the non-existence of the transfer protection clause), we begin with $p = 0.2$. With stochastic simulation, the Dawes Plan may turn out to be the state, even though the Young Plan has a greater chance to be the state. If we let $p = 0$, implying that the Young Plan is entirely credible, then it will be the state obtained from every simulation. The simulation begins with the Young Plan, because we want the model economy to start from the periods in which the transfer protection clause is non-existent. In the simulation we assume that default on junior debt is an excusable default; namely, it incurs a lower output cost in that $b_0 = 1.20a_0$.

We simulate the Young Plan model for 1 million periods and then choose those periods in which the sovereign has a reparations debt greater than 70% of the admissible debt range. We also set that the initial GDP to be higher than 70% of the admissible GDP range, indicating a low probability of default. By doing so, we purposely and directly let the economy have an initial condition of high reparations debt and high GDP. We now take each of these periods as the starting point, assume a Young-Plan regime for one period, run the regime switch to the Dawes Plan (fully credible), simulate the model for 32 periods, and summarize the statistics.

Figure 10 reports the simulation results. It is consistent with our expectation. The simulation shows in the non-default zone that the sovereign has an incentive to aggressively substitute reparations debt with commercial debt. With the total debt to GDP ratio remaining roughly constant, the reparations debt to GDP ratio declines from about 70% to less than 20%. The commercial debt to GDP ratio rises from 20% to 80%. The simulation depicts the "French solution": the aggressive substitution of reparations debt by commercial debt, all the non-default zone.

The following simulation depicts the Dawes solution: initial low GDP and no room for reparations debt. We first let the initial reparations debt to be higher than the 70% of the admissible debt range. Then, we find the border of GDP that can support such a high reparations debt. We find that the border line is 69% of the admissible GDP range. In other words, GDP level has to be at least at high as 69% of the admissible GDP range to support such a high reparations debt.

Next, we again let the economy start from high reparations debt that is above 70% of the admissible debt range, and immediately an adverse GDP shock occurs in the first period. To model that adverse GDP shock, we directly impose that the GDP level in the first period is equal to 30% of the admissible GDP range. Starting in the second period, the GDP level evolves again according to the calibrated AR (2) process.

Figure 11 presents the simulation results. Here we report the routes that the sovereign honors both types of debt. The figure shows that with low GDP that the reparations debt immediately becomes almost zero and remains almost zero even after switching to the Dawes regime. Commercial debt builds up gradually under the Dawes regime, because GDP needs time to recover. In Figure 10 where the economy starts from a high GDP level, commercial debt substitutes the reparations debt aggressively. Here we find no substitution between reparations debt and commercial debt but only gradual buildup of commercial debt. We also experiment with a scenario that starting from the second period, the shocks to GDP are milder, so that the GDP level always (randomly) stays between 30% and 70% of the admissible GDP range. The results (not reported) are similar, but only the buildup of commercial debt under the Dawes regime occurs more slowly. The simulation indicates that with low initial GDP, as Germany was in 1924, the Dawes Plan was never meant to be an effective plan for reparations.

We next examine what would happen if a country with an initially low level of debt were suddenly open to commercial borrowing under the Dawes Plan. The country would quickly build up its borrowing in commercial debt markets and run a trade deficit immediately after the opening. For the exercise, we simulate the Young Plan model for 1 million periods and then choose those periods in which the sovereign defaults on both types of debt; namely, routes 3, 6, and 8 of Figure 3. By doing so, we purposely and directly limit the amount of debt the economy has at the initial period. We now take each of these periods as the starting point, assume a Young-Plan regime for one period, run the regime switch to the Dawes Plan (fully credible), simulate the model for 32 periods, and summarize the statistics.

Figure 12 reports the results (average values over $268,009$ simulations that satisfy the initial condition). Free from the restriction on debt, the sovereign will start to borrow in reparations debt under the Young-Plan regime and build up a trade deficit. Notice that the reparations debt to GDP ratio is about 33%, or substantially lower than the steady-state value of 70%. The switch to the Dawes Plan pushes the total debt higher. Commercial debt rises sharply while reparations debt falls, and the rise in commercial debt more than offsets the fall in reparations debt. The switch (period 2 of Figure 12) pushes the total debt to GDP ratio to increase from less than 40% to over 60%, accompanied by a widening trade deficit of about 20%. The trade balance gradually returns to zero as the total debt to GDP ratio approaches its steady-state value. The prediction is consistent with Germany's experience. The start of the Dawes Plan was accompanied by a drop in Germany's trade balance that fell from \$315 million in 1923 to −\$216 million in 1924 (Tooze, 2008, Table 2). The change in the trade balance was about 5.5% of 1919 GDP.[32]

Our discussion so far is for the seniority reversal in 1924, namely, the introduction of the Dawes Plan. Now let's turn to the seniority reversal in 1929, namely, the introduction of the Young Plan.[33]

[32] In one experiment, we follow the same simulation procedure as Figure 12, but with one change: we purposely impose that the GDP level in the first period (which is under the Young Plan) is drawn randomly from the $[30\%, 70\%]$ interval of the admissible GDP range. We find that the reparations debt to GDP ratio in the first period is now 28.5%, which is smaller than the 33% reported in Figure 12, and is also substantially lower than the steady-state value of 70%.

[33] We conduct three simulations following the identical procedure of Figure 10, but for the seniority reversal in 1929. We start with the Dawes Plan. The sovereign's reparations and commercial debt are less than 50% of the permissible debt range. We also set the initial GDP to be higher than 70% of the permissible GDP range, indicating a low probability of default. We then let the regime change to the Young Plan for the following periods. We find that in the non-default zone, the sovereign is incentivized to substitute commercial debt with reparations debt aggressively. The results are near isomorphic to

We simulate the sovereign's debt decision for 32 periods, after which we set $p = 0.8$ to let the simulation continue with the Dawes Plan. The sovereign's debt decision follows the policy functions of the Dawes-Plan model and the Young-Plan model, which we have solved earlier. We run the simulation for another 32 periods, and after that we set $p = 0.2$ to let the simulation go on with the Young Plan again and then continue the simulation for another 32 periods. The choice of 32 periods (quarters) intends to match the study period from 1924 to 1931. We conduct $10,000$ simulations and take the average value of the simulated time series.

Figure 13 reports the simulation results.[34] If the hypothesis of the transfer protection clause is correct, then one would observe commercial debt to increase during the period when the Dawes Plan is dominant; namely, from 33rd to 64th periods. The simulation results do indeed support this conjecture. The commercial debt to GDP ratio increases from about 8% to 55%, or an increase of 47 percentage points. In contrast, the reparations debt to GDP ratio drops from about 52% to 8%, or a fall of 44 percentage points. The total debt to GDP ratio is roughly constant and sees a slight increase from 60% to 64%, accompanied by a worsened trade balance from about -3% to -11%. By equation (13), trade balance and total debt are negatively correlated. Please note in some simulations that total debt can decline, accompanied by an improved trade balance. The point here is that Figure 13 demonstrates clearly that commercial debt replaces reparations debt as the main source of foreign borrowing.

In the next exercise we make the conditions of the simulation even closer to post-WWI Germany. We restrict the reparation debt in all periods not to exceed the 5% quantile of the allowable debt range. Germany had difficulties floating reparations debt before the 1924 Dawes Plan. Restricting the reparations debt in all periods makes the simulation closer to Germany's situation in the 1920s.

Figure 14 reports the simulation results. In the first 32 periods, reparations debt is suppressed (about 10% of GDP). The same is true for commercial debt (about 18% of GDP). The total debt to GDP ratio is about 28%. For the subsequent 33rd to 64th periods, when the transfer protection clause is present, reparations debt is depressed further (about 6% of GDP), but commercial debt surges (about 61% of GDP). The

Figure 10, only that the role of reparations and commercial debt is exchanged. The second simulation has the same setting, but now immediately, an adverse GDP shock occurs in the first period. To model that negative GDP shock, we directly impose that the GDP level in the first period equals 30% of the permissible GDP range. The GDP level evolves again from the second period according to the calibrated AR (2) process. We find that the results are near isomorphic to Figure 11. Commercial debt immediately becomes almost zero and remains almost zero even after switching to the Young regime. Reparations debt builds up gradually under the Young regime. The third simulation restricts the reparation debt in all periods to be, at most, the 5% quantile of the allowable debt range. We find that reparations debt is suppressed (about 6.5% of GDP), but commercial debt (about 2.4% of GDP) is even suppressed further.

[34] In the current simulation, we assume that the transition from one regime to another occurs in one step. We also consider the case in which the regime change takes place gradually over four quarters. The simulated results are qualitatively the same.

increase in commercial debt more than compensates for the decline in reparations debt, driving up the total debt to GDP ratio from 28% to 67%. These periods witness a dramatic buildup of total debt, mainly due to commercial debt borrowing.

For the following 32 periods, when the transfer protection clause is not present again, both reparations debt (about 8% of GDP) and commercial debt (about 16% of GDP) fall back to the previous levels. The total debt to GDP ratio drops to 24%. The model produces a withdrawal of foreign lending, about 39% of GDP, and is consistent with the reversal of capital flows that Germany experienced when the Young Plan came into force. We could have restricted the reparation debt in all periods to be zero. The resulting increase in commercial debt would be more obvious, but the result is qualitatively the same.

Figure 14 confirms that reparation arrangements explain well the capital flow reversal that Germany experienced in the 1920s. Notice in Figure 14 that the total debt to GDP ratio and the trade balance to GDP ratio are negatively correlated (-0.21). The trade balance deteriorates when the Dawes Plan becomes dominant. When the Young Plan kicks in, the trade balance improves, even though dramatic.

To recap, suppose the sovereign starts from restricted borrowing in reparations and is suddenly open to borrowing in the commercial debt markets. In the presence of transfer protection, whatever junior debt (reparations) the sovereign has incurred so far is ignored, and there is even no such market for reparations. It is like the sovereign gets a fresh start in the commercial debt markets. Two forces are at work here. First, seniority reversal implies that from now, borrowing will occur primarily in commercial debt markets. Second, the existing reparations will default if needed, because the costs of default are low, and so the existing reparations are treated as inconsequential and have no effects on the borrowing of the country. That is what happened in 1924. Suppose we have high commercial debt and regime changes to the Young Plan. The sovereign will default on commercial debt and return to borrowing in reparations debt. If floating reparations debt is limited, then we are back to a low debt level. That is what happened in 1929-30.

The simulations indicate that the debtor tries to get out of the reparations debt under the Dawes Plan. If the initial reparations debt level exceeds a certain threshold that can be supported by the output level, then the debtor is even willing to incur the cost of default on reparations debt.

Germany did default on its reparations debt during 1922-1923. According to our model, given Germany's miserable economic situation in the early 1920s, the reparations debt that Germany would incentive-comparably incur is nearly zero. There is no way that Germany would take up reparations debt, even if the reparations debt is senior. Immediate reparations debt default is the rational course of action. Thus, the model is consistent with the initial historical conditions.

We can state this another way. The Dawes Plan that started in 1924 did not really solve the reparations debt problem. The Plan led to an increase in commercial debt, which was incentive comparable, but it did not increase the reparations debt that Germany would incentive-comparably incur. Historically speaking, this gives credence to the misgivings by Parker Gilbert and others about Germany's intentions and to Keynes' Cassandra-like warnings about the lack of feasibility of further reparations. The simulations find that reparations were "dead on arrival" in 1924 and indeed even in 1922. Everything else was a political Kabuki dance around the inevitable. Our analysis echoes the early contribution of Mantoux (1946), who criticized Keynes for having considerably underestimated the capacity to pay, and at the same time, insisted on a willingness-to-pay approach to the reparations question. Our own analysis suggests that while the 1924 Dawes Plan did not deal with Germany's willingness to pay but, at most, deferred that problem.

An alternative to the Dawes Plan aiming to address willingness to pay would have had to close the borrowing loophole of transfer protection, thus keeping reparations senior. Alternatively, it would have needed to impose foreign credit control until the economy had recovered enough to make higher levels of debt service – i.e., reparation payments – incentive compatible to the debtor country.[35]

4.4 Seniority reversal under rational expectation

In the simulation so far, we assume that the agents of the model (the sovereign and investors) learn the state of the economy period by period. The transition between the Dawes Plan and the Young Plan follows a constant probability. If the Dawes Plan (Young Plan) turns out to be the state, then the agents will behave optimally according to the policy functions solved for the Dawes-Plan (Young-Plan) model. This approach does not allow the agents to respond to the possibility of regime changes in a forward-looking manner, even though they know that a regime switch will occur with a given probability.

Rational agents under the Dawes Plan will consider the possibility that the state of the next period may switch to the Young Plan. Agents' optimal decision thus depends on the Dawes-Plan model and the Young-Plan model. The same is valid for rational agents' decision rules under the Young Plan. In other words, the policy functions of the Dawes-Plan model and that of the Young-Plan model are linked. We formulate a regime-switching default model to tackle this issue, where the regime switches between the Dawes Plan and the Young Plan, and agents respond to that change in forming their optimal policy. We use this model as a robustness test.

We report the regime-switching default model in Appendix 3. The model consists of two parts. One part describes the equilibrium conditions under the Dawes Plan, and the

[35] International capital controls were imposed on Austria as part of a League of Nations' stabilization loan package in 1923. This largely successful arrangement constituted a model case for IMF and World Bank interventions after World War II (Marcus, 2020).

other part the equilibrium conditions under the Young Plan. The two sets of equilibrium conditions are linked. For example, the value function associated with choosing to honor its debt and thus continuing to participate in the financial markets under the Dawes Plan v_t^{Dc} is given by:

$$v_t^{Dc}\left(d_t^{rep}, d_t^{com}, y_t\right) = \max_{d_{t+1}^{rep}, d_{t+1}^{com}} \left\{ \begin{array}{c} u\left(c_t\right) \\ +\beta \cdot p_D \cdot E_y v_{t+1}^{Dg}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ +\beta \cdot p_Y \cdot E_y v_{t+1}^{Yg}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \end{array} \right\}, \tag{27}$$

where p_D is the probability that the economy will stay in the Dawes Plan in the next period, $p_Y = 1 - p_D$ is the probability that the economy will switch to the Young Plan in the next period, and v_t^{Dg} and v_t^{Yg} denote the value function of being in good financial standing under the Dawes Plan and the Young Plan, respectively. Each period the economy will be in either the Dawes Plan or the Young Plan. Compared to equation (18), the value function of the Young Plan v_{t+1}^{Yg} now enters the value function of the Dawes Plan v_t^{Dc}, because the agents take the possibility of a regime switch into account and respond accordingly. Analogously, the pricing of debts depends not only on the default decisions under the Dawes Plan, but also on those under the Young Plan. The basic idea is to combine the two parts of the model to obtain an extended model and solve the model equations simultaneously. Our way of formulating the model is similar to the literature on regime-switching DSGE models (see Bianchi, 2013). We use value function iteration to solve the regime-switching sovereign debt model. Specifically, we solve the model's complete set of policy functions using value function iteration.[36]

With the policy functions thus obtained, we then simulate the scenario of seniority reversal. We let the economy start with $p_Y = 0.8$ and $p_D = 0.2$ for 64 periods (32 periods are burn-in periods), assuming that the Young Plan is the dominant state. For the following 32 periods, we let $p_Y = 0.2$ and $p_D = 0.8$, assuming that the Dawes Plane is the dominant state. Finally, for the last 32 periods, we let $p_Y = 0.8$ and $p_D = 0.2$ again. We conduct $10,000$ simulations and report the average value of the variables of interest. The results (not reported) show that taking rational expectation into account, the sovereign's tendency to borrow in senior debt is further strengthened when default on junior debt incurs a minor output loss. The total debt to GDP ratio increases, and like Figure 13 the commercial debt replaces reparations debt as the primary source of foreign borrowing.

Following what we have done in Figure 14, we restrict the reparation debt in all periods not to exceed the 5% quantile of the allowable debt range. Figure 15 reports the results. By construction, the amount of reparations debt is low throughout the simulation. Total debt relative to GDP increases by 79% once the transfer protection

[36] The sovereign's decision routes for the regime-switching default model, reported in Online Appendix 3, are more complex than those depicted in Figures 2 and 3.

clause kicks in. The surge in total debt is primarily due to commercial debt. Allowing agents to respond to the possibility of regime changes is like introducing a risk-sharing mechanism in the model. Since reparations debt is restricted, expecting this the agents turn to unrestricted commercial debt, driving the risk premium of commercial debt to an extremely high value under the Young regime. As senior debt, the risk premium of commercial debt falls substantially under the Dawes Plan, further stimulating commercial debt borrowing. Consequently, total debt increases. Even in the absence of the transfer protection clause, the commercial debt to GDP ratio is already as high as about 61%. Commercial debt borrowing was almost non-existent in pre-1924 Germany. It implies that with great probability the agents had not foreseen the changes in reparation arrangements (the Dawes Plan). The correlation between total debt and trade balance is negative at -0.16. In sum, we find evidence supporting the claim that the Dawes Plan led to an expansion of commercial debt.

5 Conclusion

Allowing a sovereign debtor to issue fresh debt that is senior to legacy debt may lead to borrowing binges and default. Measures by creditors to restore the seniority of legacy debt may generate endogenous sudden stops and again lead to debt default. This paper presented simulations of seniority reversals in an Eaton-Gersovitz model that we extended to include two assets. We find that the sovereign's willingness to pay is governed by two counteracting dynamic incentives. In or near the default zone, the sovereign will suspend payments either fully - in line with the standard one-asset model - or partly, defaulting on junior debt first. Outside the default zone, the sovereign has an incentive to substitute junior with senior debt. This makes the share of senior debt in the sovereign's total debt a near-sufficient statistic for the debtor's willingness to pay.

We calibrate and apply the model to the Dawes Plan of the 1920s, which protected foreign commercial investors from rivalry with reparation claims against Germany. Transfer protection in the Dawes Plan was adopted in response to the warnings of Keynes (1919, 1922) against Germany's limited capacity to pay. Our principal historical contribution is to rationalize the German response to transfer protection as a license to issue senior debt. Results suggests that Germany in 1924 was in the default zone, giving it an incentive to issue fresh debt without reducing legacy debt, i.e. reparations. Our model predicts a borrowing binge combined with default on reparations, which is what creditors suspected that Germany had in mind. Our second historical contribution is to examine a reversal of seniority as happened in the Young Plan of 1929, i.e. after the borrowing binge. Outside of the default zone, there is an incentive for Germany a move away from foreign debt and to accept higher reparations. In the default zone, the model predicts either default on the now junior commercial debt, or total default on both reparations and commercial debt.

This is what happened between 1931 and 1933. We find this outcome to be consistent with Keynes' (1919, 1929) warnings of deflation, default, and political de-stabilization should Germany be made to pay reparations out of trade balance surpluses.

Our research supports the widely accepted hypothesis that the transfer protection clause of the Dawes Plan accounted for Germany's high level of foreign debts in the 1920s. It also confirms Keynes' warnings that imposing reparations as a first charge would not work - although with a qualification, as the revised reparation amounts under the Young Plan were by themselves not high enough to cause a sovereign debt crisis.

Extending the above arguments, the account we provide here emphasizes the importance of debt contract enforcement. The equilibrium level of foreign debt depends on how vigorous the enforcement is. If a default on junior debt is excusable, then it is easy for the sovereign to walk away from junior debt, and junior debt becomes less enforceable. Creditors know this and will require a higher risk premium for junior debt and be more willing to lend in the senior debt market, which is more enforceable. Senior debt replaces junior debt, not because the creditors are short-sighted, nor because there is asymmetric information between the creditors and the debtors. It is the optimal behavior of the agents in response to the changed debt arrangements. The transfer protection clause of the Dawes Plan made reparations debt junior to commercial debt. It twisted the incentives of both the creditors and the debtors, making foreign borrowing end up in commercial debt. But not all reparations are unenforceable even if commercial debt is senior. Our third historical contribution is that outside of the default zone, the debtor has an incentive to aggressively pay off reparations and substitute them with commercial borrowing, as did France in 1871 with it reparations to Prussia.

Appendix 1: A summary of the Dawes Plan

Here is a summary of all the equations that constitute the Dawes Plan scenario.

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t\right)$$

$$\ln y_t = \beta_1 \ln y_{t-1} + \beta_2 \ln y_{t-2} + \sigma_\epsilon \epsilon_t$$

$$\tilde{y}_t = \begin{cases} y_t & \text{if} \quad \text{the economy is in good standing} \\ y_t - L_{Dawes}\left(y_t\right) & \text{if} \quad \text{the economy is in bad standing, default on reparations debt} \\ y_t - L\left(y_t\right) & \text{if} \quad \text{the economy is in bad standing, default on both types of debt} \end{cases}$$

$$L\left(y_t\right) = \max\left\{0, a_0 + a_1 y_t + a_2 y_t^2\right\}$$

$$L_{Dawes}\left(y_t\right) = \max\left\{0, b_0 + b_1 y_t + b_2 y_t^2\right\}$$

$$v_t^c\left(d_t^{rep}, d_t^{com}, y_t\right) = \max_{d_{t+1}^{rep}, d_{t+1}^{com}} \left\{u\left(c_t\right) + \beta E_y v_{t+1}^g\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right)\right\}$$

$$c_t = y_t + q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{rep} - d_t^{rep} + q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{com} - d_t^{com}$$

$$v_t^{b,rep}\left(d_t^{com0}, y_t\right) = \max_{d_{t+1}^{com0}} \left\{u\left(c_t\right) + \beta\theta E_y v_{t+1}^g\left(0, d_{t+1}^{com0}, y_{t+1}\right) + \beta\left(1-\theta\right) E_y v_{t+1}^{g,rep}\left(d_{t+1}^{com0}, y_{t+1}\right)\right\}$$

$$v_t^{g,rep}\left(d_t^{com0}, y_t\right) = \max\left\{v_t^{b,rep}\left(d_t^{com0}, y_t\right), v_t^b\left(y_t\right)\right\}$$

$$c_t = y_t - L_{Dawes}\left(y_t\right) + q_t^{com0}\left(\cdot, d_{t+1}^{com0}, y_t\right) d_{t+1}^{com0} - d_t^{com0}$$

$$v_t^b\left(y_t\right) = u\left(c_t\right) + \beta\theta E_y v_{t+1}^g\left(0, 0, y_{t+1}\right) + \beta\left(1-\theta\right) E_y v_{t+1}^b\left(y_{t+1}\right)$$

$$c_t = y_t - L\left(y_t\right)$$

$$v_t^g\left(d_t^{rep}, d_t^{com}, y_t\right) = \max\left\{v_t^c\left(d_t^{rep}, d_t^{com}, y_t\right), v_t^{b,rep}\left(d_t^{com}, y_t\right), v_t^b\left(y_t\right)\right\}$$

$$q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) = \frac{1}{1+r^*}\left\{1 - \Pr_y\left[\begin{array}{c} v_{t+1}^{b}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{c}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right), v_{t+1}^{b,rep}\left(d_{t+1}^{com}, y_{t+1}\right)\right) \end{array}\right]\right\}$$

$$q_t^{com0}\left(\cdot, d_{t+1}^{com0}, y_t\right) = \frac{1}{1+r^*}\left\{\begin{array}{c} (1-\theta)\left(1 - \Pr_y\left[v_{t+1}^{b,rep}\left(d_{t+1}^{com0}, y_{t+1}\right) < v_{t+1}^{b}\left(y_{t+1}\right)\right]\right) \\ +(\theta)\left(1 - \Pr_y\left[\begin{array}{c} v_{t+1}^{b}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{c}\left(0, d_{t+1}^{com0}, y_{t+1}\right), v_{t+1}^{b,rep}\left(d_{t+1}^{com0}, y_{t+1}\right)\right) \end{array}\right]\right) \end{array}\right\}$$

$$q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) = \frac{1}{1+r^*}\Pr_y\left\{\begin{array}{c} v_{t+1}^{c}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ \geq \max\left\{v_{t+1}^{b}\left(y_{t+1}\right), v_{t+1}^{b,rep}\left(d_{t+1}^{com}, y_{t+1}\right)\right\} \end{array}\right\}$$

$$r_t^{rep} \equiv \frac{1}{q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right)} - 1$$

$$r_t^{com} \equiv \frac{1}{q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right)} - 1$$

$$r_t^{com0} \equiv \frac{1}{q_t^{com0}\left(\cdot, d_{t+1}^{com0}, y_t\right)} - 1$$

$$\eta_t^{rep} \equiv r_t^{rep} - r^*$$

$$\eta_t^{com} \equiv r_t^{com} - r^*$$

$$\eta_t^{com0} \equiv r_t^{com0} - r^*$$

$$tb_t \equiv y_t - c_t = d_t^{rep} - q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right)d_{t+1}^{rep} + d_t^{com} - q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right)d_{t+1}^{com}$$

$$tb_t \equiv y_t - c_t = d_t^{com0} - q_t^{com0}\left(\cdot, d_{t+1}^{com0}, y_t\right)d_{t+1}^{com0}$$

We make a distinction between d_t^{com0} and d_t^{com}, because for the former case, reparations debt is in default and not available when the sovereign decides the optimal level of commercial debt. For the same reason, we make a distinction between q_t^{com0} and q_t^{com}. For the Dawes Plan, it is easy to show that $q_t^{com} > q_t^{com0}$ and $q_t^{com} > q_t^{rep}$.

Appendix 2: A summary of the Young Plan

Here is a summary of all the equations that constitute the Young Plan scenario.

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

$$\ln y_t = \beta_1 \ln y_{t-1} + \beta_2 \ln y_{t-2} + \sigma_\epsilon \epsilon_t$$

$$\tilde{y}_t = \begin{cases} y_t & \text{if} \quad \text{the economy is in good standing} \\ y_t - L_{Young}(y_t) & \text{if} \quad \text{the economy is in bad standing, default on commercial debt} \\ y_t - L(y_t) & \text{if} \quad \text{the economy is in bad standing, default on both types of debt} \end{cases}$$

$$L(y_t) = \max\left\{0, a_0 + a_1 y_t + a_2 y_t^2\right\}$$

$$L_{Young}(y_t) = \max\left\{0, b_0 + b_1 y_t + b_2 y_t^2\right\}$$

$$v_t^c\left(d_t^{rep}, d_t^{com}, y_t\right) = \max_{d_{t+1}^{rep}, d_{t+1}^{com}} \left\{u(c_t) + \beta E_y v_{t+1}^g\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right)\right\}$$

$$c_t = y_t + q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{rep} - d_t^{rep} + q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{com} - d_t^{com}$$

$$v_t^{b,com}\left(d_t^{rep0}, y_t\right) = \max_{d_{t+1}^{rep0}} \left\{u(c_t) + \beta\theta E_y v_{t+1}^g\left(d_{t+1}^{rep0}, 0, y_{t+1}\right) + \beta(1-\theta) E_y v_{t+1}^{g,com}\left(d_{t+1}^{rep0}, y_{t+1}\right)\right\}$$

$$v_t^{g,com}\left(d_t^{rep0}, y_t\right) = \max\left\{v_t^{b,com}\left(d_t^{rep0}, y_t\right), v_t^b(y_t)\right\}$$

$$c_t = y_t - L_{Young}(y_t) + q_t^{rep0}\left(d_{t+1}^{rep0}, \cdot, y_t\right) d_{t+1}^{rep0} - d_t^{rep0}$$

$$v_t^b(y_t) = u(c_t) + \beta\theta E_y v_{t+1}^g(0, 0, y_{t+1}) + \beta(1-\theta) E_y v_{t+1}^b(y_{t+1})$$

$$c_t = y_t - L(y_t)$$

$$v_t^g\left(d_t^{rep}, d_t^{com}, y_t\right) = \max\left\{v_t^c\left(d_t^{rep}, d_t^{com}, y_t\right), v_t^{b,com}\left(d_t^{rep}, y_t\right), v_t^b(y_t)\right\}$$

$$q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) = \frac{1}{1+r^*}\left\{1 - \Pr_y\left[\begin{array}{c} v_{t+1}^{b}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{c}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right), v_{t+1}^{b,com}\left(d_{t+1}^{rep}, y_{t+1}\right)\right) \end{array}\right]\right\}$$

$$q_t^{rep0}\left(d_{t+1}^{rep0}, \cdot, y_t\right) = \frac{1}{1+r^*}\left\{\begin{array}{c} (1-\theta)\left(1 - \Pr_y\left[v_{t+1}^{b,com}\left(d_{t+1}^{rep0}, y_{t+1}\right) < v_{t+1}^{b}\left(y_{t+1}\right)\right]\right) \\ +(\theta)\left(1 - \Pr_y\left[\begin{array}{c} v_{t+1}^{b}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{c}\left(d_{t+1}^{rep0}, 0, y_{t+1}\right), v_{t+1}^{b,com}\left(d_{t+1}^{rep0}, y_{t+1}\right)\right) \end{array}\right]\right) \end{array}\right\}$$

$$q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) = \frac{\Pr_y\left\{\begin{array}{c} v_{t+1}^{c}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ \geq \max\left\{v_{t+1}^{b}\left(y_{t+1}\right), v_{t+1}^{b,com}\left(d_{t+1}^{rep}, y_{t+1}\right)\right\} \end{array}\right\}}{1+r^*}$$

$$r_t^{rep} \equiv \frac{1}{q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right)} - 1$$

$$r_t^{com} \equiv \frac{1}{q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right)} - 1$$

$$r_t^{rep0} \equiv \frac{1}{q_t^{rep0}\left(d_{t+1}^{rep0}, \cdot, y_t\right)} - 1$$

$$\eta_t^{rep} \equiv r_t^{rep} - r^*$$

$$\eta_t^{com} \equiv r_t^{com} - r^*$$

$$\eta_t^{rep0} \equiv r_t^{rep0} - r^*$$

$$tb_t \equiv y_t - c_t = d_t^{rep} - q_t^{rep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{rep} + d_t^{com} - q_t^{com}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{com}$$

$$tb_t \equiv y_t - c_t = d_t^{rep0} - q_t^{rep0}\left(d_{t+1}^{rep0}, \cdot, y_t\right) d_{t+1}^{rep0}$$

We make a distinction between d_t^{rep0} and d_t^{rep}, because for the former case, commercial debt is in default and not available when the sovereign decides the optimal level of reparations debt. For the same reason, we make a distinction between q_t^{rep0} and q_t^{rep}. For the Young Plan, it is easy to show that $q_t^{rep} > q_t^{rep0}$ and $q_t^{rep} > q_t^{com}$.

Appendix 3: The regime-switching default model

The model consists of two parts. Part 1 describes the agents' decision problems under the Dawes Plan, while part 2 describes the agents' decision problems under the Young Plan. The two parts are linked, because agents' optimal decision under the Dawes Plan depends on the Young Plan and vice versa. Note that d^{rep} denotes reparations debt, d^{com} denotes commercial debt, and $d = d^{rep} + d^{com}$ is total debt. We use p_D and p_Y to denote transition probabilities and $p_D + p_Y = 1$.

Decision problems under the Dawes Plan

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

$$\ln y_t = \beta_1 \ln y_{t-1} + \beta_2 \ln y_{t-2} + \sigma_\epsilon \epsilon_t$$

$$\tilde{y}_t = \begin{cases} y_t & \text{if} \quad \text{the economy is in good standing} \\ y_t - L_{Dawes}(y_t) & \text{if} \quad \text{the economy is in bad standing, default on reparations debt} \\ y_t - L(y_t) & \text{if} \quad \text{the economy is in bad standing, default on both types of debt} \end{cases}$$

$$L(y_t) = \max\left\{0, a_0 + a_1 y_t + a_2 y_t^2\right\}$$

$$L_{Dawes}(y_t) = \max\left\{0, c_0 + c_1 y_t + c_2 y_t^2\right\}$$

$$v_t^{Dc}\left(d_t^{rep}, d_t^{com}, y_t\right) = \max_{d_{t+1}^{rep}, d_{t+1}^{com}} \left\{ \begin{array}{c} u(c_t) \\ +\beta \cdot p_D \cdot E_y v_{t+1}^{Dg}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ +\beta \cdot p_Y \cdot E_y v_{t+1}^{Yg}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \end{array} \right\}$$

$$\begin{aligned} c_t = \; & y_t \\ & + q_t^{Drep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{rep} - d_t^{rep} \\ & + q_t^{Dcom}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{com} - d_t^{com} \end{aligned}$$

$$v_t^{Db,rep}\left(d_t^{com0}, y_t\right) = \max_{d_{t+1}^{com0}} \left\{ \begin{array}{c} u(c_t) \\ +\beta\theta \cdot p_D \cdot E_y v_{t+1}^{Dg}\left(0, d_{t+1}^{com0}, y_{t+1}\right) + \beta\theta \cdot p_Y \cdot E_y v_{t+1}^{Yg}\left(0, d_{t+1}^{com0}, y_{t+1}\right) \\ +\beta(1-\theta) \cdot p_D \cdot E_y v_{t+1}^{Dg,rep}\left(d_{t+1}^{com0}, y_{t+1}\right) \\ +\beta(1-\theta) \cdot p_Y \cdot E_y v_{t+1}^{Yg,com}\left(0, y_{t+1}\right) \end{array} \right\}$$

$$v_t^{Dg,rep}\left(d_t^{com0}, y_t\right) = \max\left\{v_t^{Db,rep}\left(d_t^{com0}, y_t\right), v_t^{Db}\left(y_t\right)\right\}$$

$$v_t^{Yg,com}\left(0, y_t\right) = \max\left\{v_t^{Yb,com}\left(0, y_t\right), v_t^{Yb}\left(y_t\right)\right\} \tag{AUX01}$$

$$c_t = y_t - L_{Dawes}\left(y_t\right) + q_t^{Dcom0}\left(\cdot, d_{t+1}^{com0}, y_t\right) d_{t+1}^{com0} - d_t^{com0}$$

$$\begin{aligned} v_t^{Db}\left(y_t\right) &= u\left(c_t\right) \\ &\quad +\beta\theta \cdot p_D \cdot E_y v_{t+1}^{Dg}\left(0, 0, y_{t+1}\right) + \beta\theta \cdot p_Y \cdot E_y v_{t+1}^{Yg}\left(0, 0, y_{t+1}\right) \\ &\quad +\beta\left(1-\theta\right) \cdot p_D \cdot E_y v_{t+1}^{Db}\left(y_{t+1}\right) + \beta\left(1-\theta\right) \cdot p_Y \cdot E_y v_{t+1}^{Yb}\left(y_{t+1}\right) \end{aligned}$$

$$c_t = y_t - L\left(y_t\right)$$

$$v_t^{Dg}\left(d_t^{rep}, d_t^{com}, y_t\right) = \max\left\{v_t^{Dc}\left(d_t^{rep}, d_t^{com}, y_t\right), v_t^{Db,rep}\left(d_t^{com}, y_t\right), v_t^{Db}\left(y_t\right)\right\}$$

$$\begin{aligned} & q_t^{Dcom}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) \\ = \; & \frac{1}{1+r^*} \cdot p_D \cdot \left\{1 - \Pr_y\left[\begin{array}{c} v_{t+1}^{Db}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{Dc}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right), v_{t+1}^{Db,rep}\left(d_{t+1}^{com}, y_{t+1}\right)\right) \end{array}\right]\right\} \\ & + \frac{1}{1+r^*} \cdot p_Y \cdot \Pr_y\left\{\begin{array}{c} v_{t+1}^{Yc}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ \geq \max\left\{v_{t+1}^{Yb}\left(y_{t+1}\right), v_{t+1}^{Yb,com}\left(d_{t+1}^{rep}, y_{t+1}\right)\right\} \end{array}\right\} \end{aligned}$$

$$\begin{aligned} & q_t^{Dcom0}\left(\cdot, d_{t+1}^{com0}, y_t\right) \\ = \; & \frac{1}{1+r^*}\left\{\begin{array}{c} \left(1-\theta\right) \cdot p_D \cdot \left(1 - \Pr_y\left[v_{t+1}^{Db,rep}\left(d_{t+1}^{com0}, y_{t+1}\right) < v_{t+1}^{Db}\left(y_{t+1}\right)\right]\right) \\ + \left(1-\theta\right) \cdot p_Y \cdot \left(1 - \Pr_y\left[v_{t+1}^{Yb,com}\left(0, y_{t+1}\right) < v_{t+1}^{Yb}\left(y_{t+1}\right)\right]\right) \\ + \left(\theta\right) \cdot p_D \cdot \left(1 - \Pr_y\left[\begin{array}{c} v_{t+1}^{Db}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{Dc}\left(0, d_{t+1}^{com0}, y_{t+1}\right), v_{t+1}^{Db,rep}\left(d_{t+1}^{com0}, y_{t+1}\right)\right) \end{array}\right]\right) \\ + \left(\theta\right) \cdot p_Y \cdot \Pr_y\left\{\begin{array}{c} v_{t+1}^{Yc}\left(0, d_{t+1}^{com}, y_{t+1}\right) \\ \geq \max\left\{v_{t+1}^{Yb}\left(y_{t+1}\right), v_{t+1}^{Yb,com}\left(0, y_{t+1}\right)\right\} \end{array}\right\} \end{array}\right\} \end{aligned}$$

$$
\begin{aligned}
& q_t^{Drep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) \\
= & \frac{1}{1+r^*}\cdot p_D \cdot \Pr_y \left\{ \begin{array}{c} v_{t+1}^{Dc}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ \geq \max\left\{v_{t+1}^{Db}\left(y_{t+1}\right), v_{t+1}^{Db,rep}\left(d_{t+1}^{com}, y_{t+1}\right)\right\} \end{array} \right\} \\
& + \frac{1}{1+r^*}\cdot p_Y \cdot \left\{ 1 - \Pr_y \left[\begin{array}{c} v_{t+1}^{Yb}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{Yc}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right), v_{t+1}^{Yb,com}\left(d_{t+1}^{rep}, y_{t+1}\right)\right) \end{array} \right] \right\}
\end{aligned}
$$

Decision problems under the Young Plan

$$
E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t\right)
$$

$$
\ln y_t = \beta_1 \ln y_{t-1} + \beta_2 \ln y_{t-2} + \sigma_\epsilon \epsilon_t
$$

$$
\tilde{y}_t = \left\{ \begin{array}{ccc} y_t & \text{if} & \text{the economy is in good standing} \\ y_t - L_{Young}\left(y_t\right) & \text{if} & \text{the economy is in bad standing, default on commercial debt} \\ y_t - L\left(y_t\right) & \text{if} & \text{the economy is in bad standing, default on both types of debt} \end{array} \right.
$$

$$
L\left(y_t\right) = \max\left\{0, a_0 + a_1 y_t + a_2 y_t^2\right\}
$$

$$
L_{Young}\left(y_t\right) = \max\left\{0, b_0 + b_1 y_t + b_2 y_t^2\right\}
$$

$$
v_t^{Yc}\left(d_t^{rep}, d_t^{com}, y_t\right) = \max_{d_{t+1}^{rep}, d_{t+1}^{com}} \left\{ \begin{array}{c} u\left(c_t\right) \\ +\beta\cdot p_Y \cdot E_y v_{t+1}^{Yg}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ +\beta\cdot p_D \cdot E_y v_{t+1}^{Dg}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \end{array} \right\}
$$

$$
\begin{aligned}
c_t = & \; y_t \\
& + q_t^{Yrep}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{rep} - d_t^{rep} \\
& + q_t^{Ycom}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) d_{t+1}^{com} - d_t^{com}
\end{aligned}
$$

$$
v_t^{Yb,com}\left(d_t^{rep0}, y_t\right) = \max_{d_{t+1}^{rep0}} \left\{ \begin{array}{c} u\left(c_t\right) \\ +\beta\theta\cdot p_Y \cdot E_y v_{t+1}^{Yg}\left(d_{t+1}^{rep0}, 0, y_{t+1}\right) + \beta\theta \cdot p_D \cdot E_y v_{t+1}^{Dg}\left(d_{t+1}^{rep0}, 0, y_{t+1}\right) \\ +\beta\left(1-\theta\right)\cdot p_Y \cdot E_y v_{t+1}^{Yg,com}\left(d_{t+1}^{rep0}, y_{t+1}\right) \\ +\beta\left(1-\theta\right)\cdot p_D \cdot E_y v_{t+1}^{Dg,rep}\left(0, y_{t+1}\right) \end{array} \right\}
$$

$$v_t^{Yg,com}\left(d_t^{rep0},y_t\right)=\max\left\{v_t^{Yb,com}\left(d_t^{rep0},y_t\right),v_t^{Yb}\left(y_t\right)\right\}$$

$$v_t^{Dg,rep}\left(0,y_t\right)=\max\left\{v_t^{Db,rep}\left(0,y_t\right),v_t^{Db}\left(y_t\right)\right\} \tag{AUX02}$$

$$c_t=y_t-L_{Young}\left(y_t\right)+q_t^{Yrep0}\left(d_{t+1}^{rep0},\cdot,y_t\right)d_{t+1}^{rep0}-d_t^{rep0}$$

$$\begin{aligned}v_t^{Yb}\left(y_t\right) &= u\left(c_t\right)+\beta\theta\cdot p_Y\cdot E_y v_{t+1}^{Yg}\left(0,0,y_{t+1}\right)+\beta\theta\cdot p_D\cdot E_y v_{t+1}^{Dg}\left(0,0,y_{t+1}\right)\\ &\quad+\beta\left(1-\theta\right)\cdot p_Y\cdot E_y v_{t+1}^{Yb}\left(y_{t+1}\right)+\beta\left(1-\theta\right)\cdot p_D\cdot E_y v_{t+1}^{Db}\left(y_{t+1}\right)\end{aligned}$$

$$c_t=y_t-L\left(y_t\right)$$

$$v_t^{Yg}\left(d_t^{rep},d_t^{com},y_t\right)=\max\left\{v_t^{Yc}\left(d_t^{rep},d_t^{com},y_t\right),v_t^{Yb,com}\left(d_t^{rep},y_t\right),v_t^{Yb}\left(y_t\right)\right\}$$

$$\begin{aligned}&q_t^{Yrep}\left(d_{t+1}^{rep},d_{t+1}^{com},y_t\right)\\ =&\frac{1}{1+r^*}\cdot p_Y\cdot\left\{1-\Pr_y\left[\begin{array}{c}v_{t+1}^{Yb}\left(y_{t+1}\right)\\ >\max\left(v_{t+1}^{Yc}\left(d_{t+1}^{rep},d_{t+1}^{com},y_{t+1}\right),v_{t+1}^{Yb,com}\left(d_{t+1}^{rep},y_{t+1}\right)\right)\end{array}\right]\right\}\\ &+\frac{1}{1+r^*}\cdot p_D\cdot\Pr_y\left\{\begin{array}{c}v_{t+1}^{Dc}\left(d_{t+1}^{rep},d_{t+1}^{com},y_{t+1}\right)\\ \geq\max\left\{v_{t+1}^{Db}\left(y_{t+1}\right),v_{t+1}^{Db,rep}\left(d_{t+1}^{com},y_{t+1}\right)\right\}\end{array}\right\}\end{aligned}$$

$$\begin{aligned}&q_t^{Yrep0}\left(d_{t+1}^{rep0},\cdot,y_t\right)\\ =&\frac{1}{1+r^*}\left\{\begin{array}{c}\left(1-\theta\right)\cdot p_Y\cdot\left(1-\Pr_y\left[v_{t+1}^{Yb,com}\left(d_{t+1}^{rep0},y_{t+1}\right)<v_{t+1}^{Yb}\left(y_{t+1}\right)\right]\right)\\ +\left(1-\theta\right)\cdot p_D\cdot\left(1-\Pr_y\left[v_{t+1}^{Db,rep}\left(0,y_{t+1}\right)<v_{t+1}^{Db}\left(y_{t+1}\right)\right]\right)\\ +\left(\theta\right)\cdot p_Y\cdot\left(1-\Pr_y\left[\begin{array}{c}v_{t+1}^{Yb}\left(y_{t+1}\right)\\ >\max\left(v_{t+1}^{Yc}\left(d_{t+1}^{rep0},0,y_{t+1}\right),v_{t+1}^{Yb,com}\left(d_{t+1}^{rep0},y_{t+1}\right)\right)\end{array}\right]\right)\\ +\left(\theta\right)\cdot p_D\cdot\Pr_y\left\{\begin{array}{c}v_{t+1}^{Dc}\left(d_{t+1}^{rep},0,y_{t+1}\right)\\ \geq\max\left\{v_{t+1}^{Db}\left(y_{t+1}\right),v_{t+1}^{Db,rep}\left(0,y_{t+1}\right)\right\}\end{array}\right\}\end{array}\right\}\end{aligned}$$

$$
\begin{aligned}
& q_t^{Ycom}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_t\right) \\
= \quad & \frac{p_Y \cdot \Pr_y \left\{ \begin{array}{c} v_{t+1}^{Yc}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right) \\ \geq \max\left\{ v_{t+1}^{Yb}\left(y_{t+1}\right), v_{t+1}^{Yb,com}\left(d_{t+1}^{rep}, y_{t+1}\right) \right\} \end{array} \right\}}{1+r^*} \\
& + \frac{p_D \cdot \left\{ 1 - \Pr_y \left[\begin{array}{c} v_{t+1}^{Db}\left(y_{t+1}\right) \\ > \max\left(v_{t+1}^{Dc}\left(d_{t+1}^{rep}, d_{t+1}^{com}, y_{t+1}\right), v_{t+1}^{Db,rep}\left(d_{t+1}^{com}, y_{t+1}\right) \right) \end{array} \right] \right\}}{1+r^*}
\end{aligned}
$$

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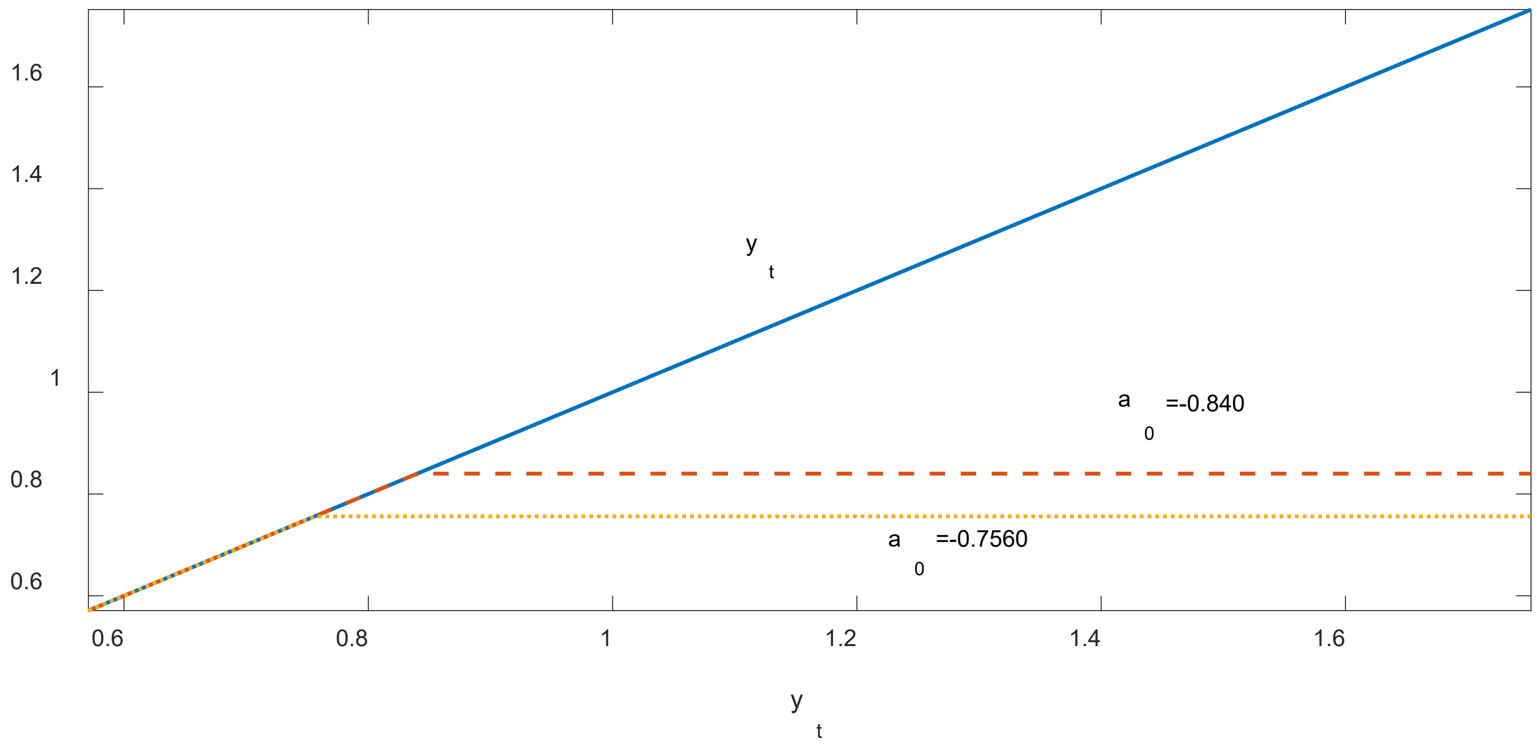
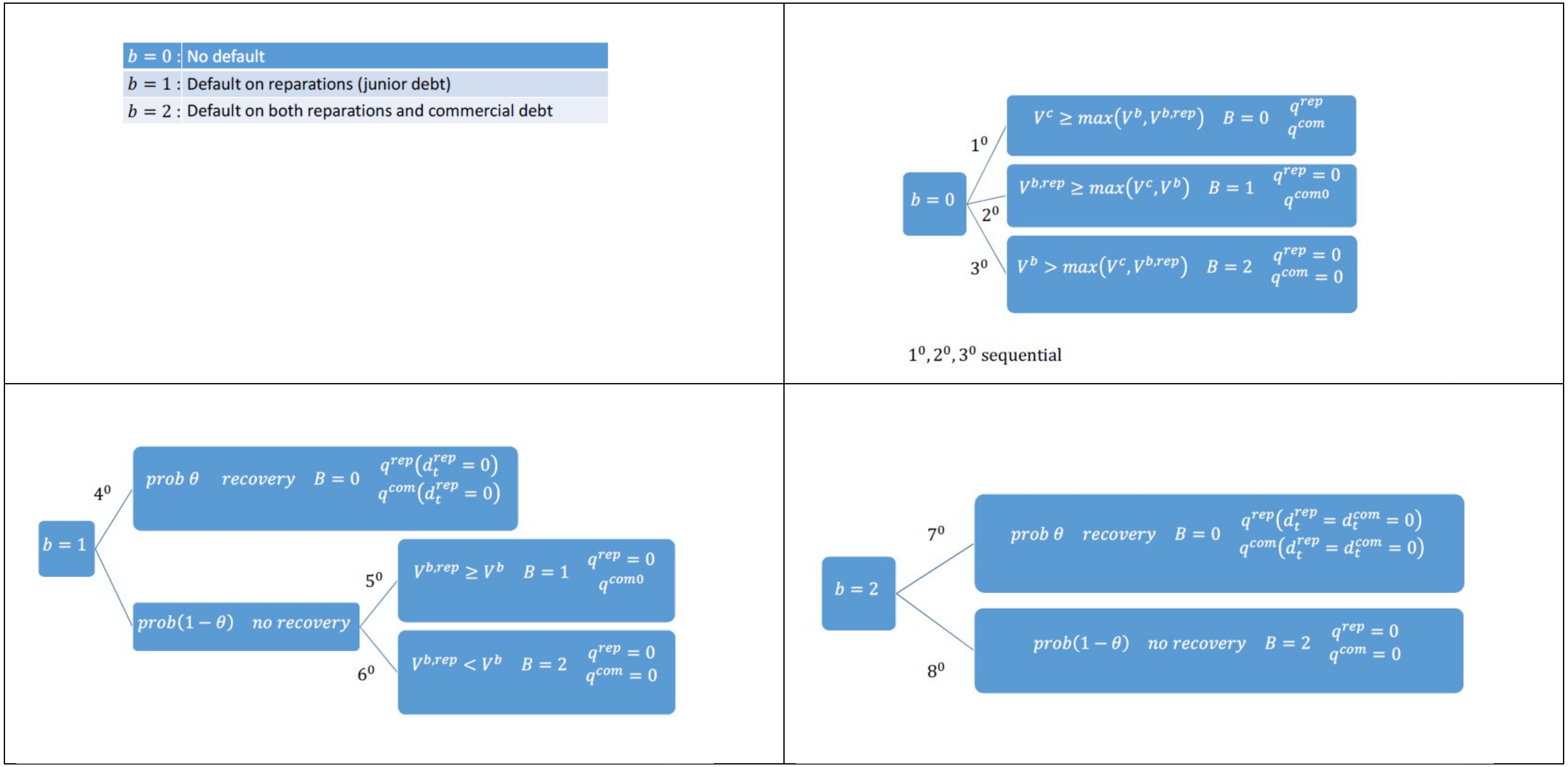
Figure 1: Output Cost of Default



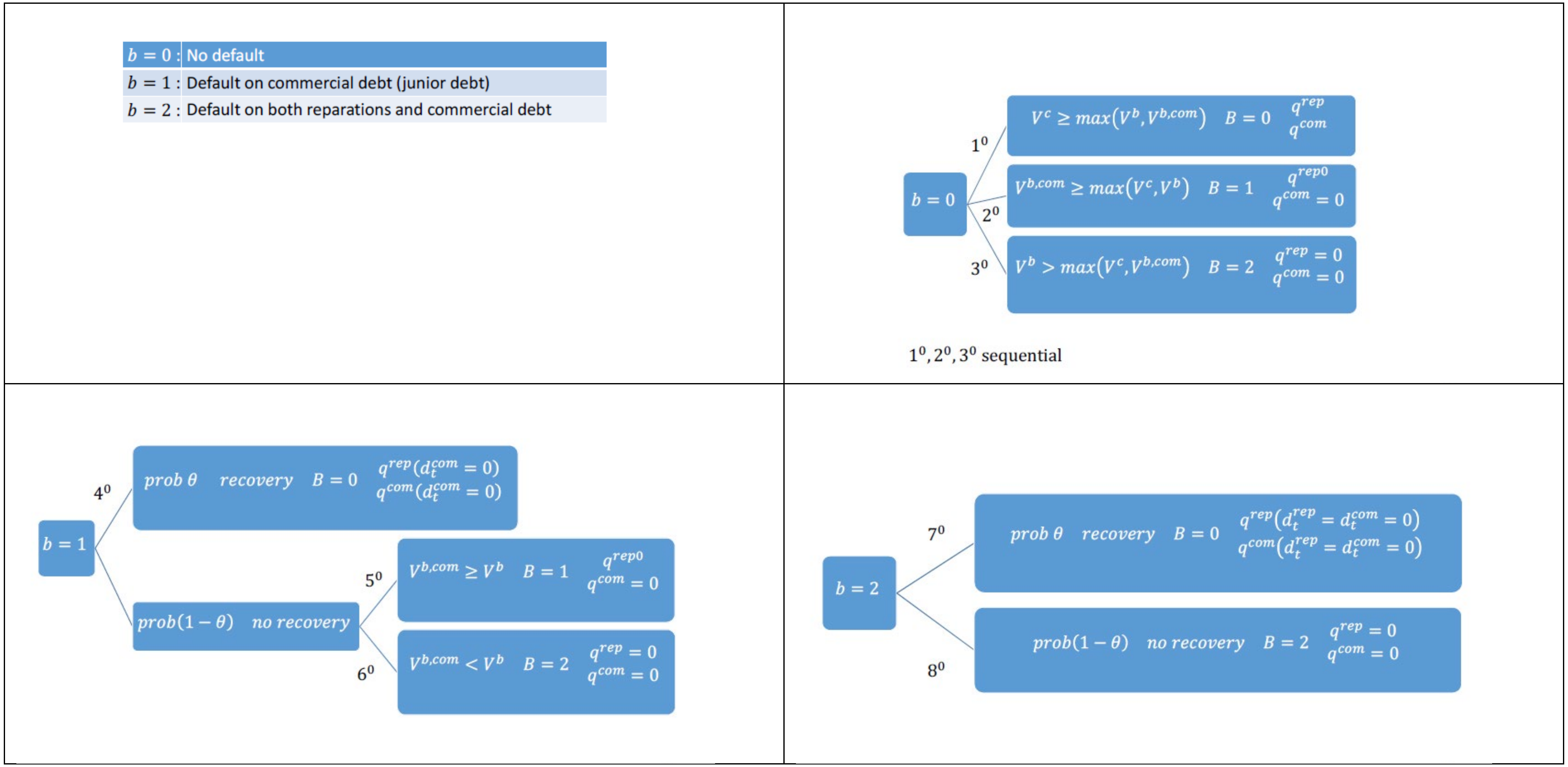
Source: Authors' Drawing.

Figure 2: Sovereign's Decision Routes in the Dawes-Plan Model



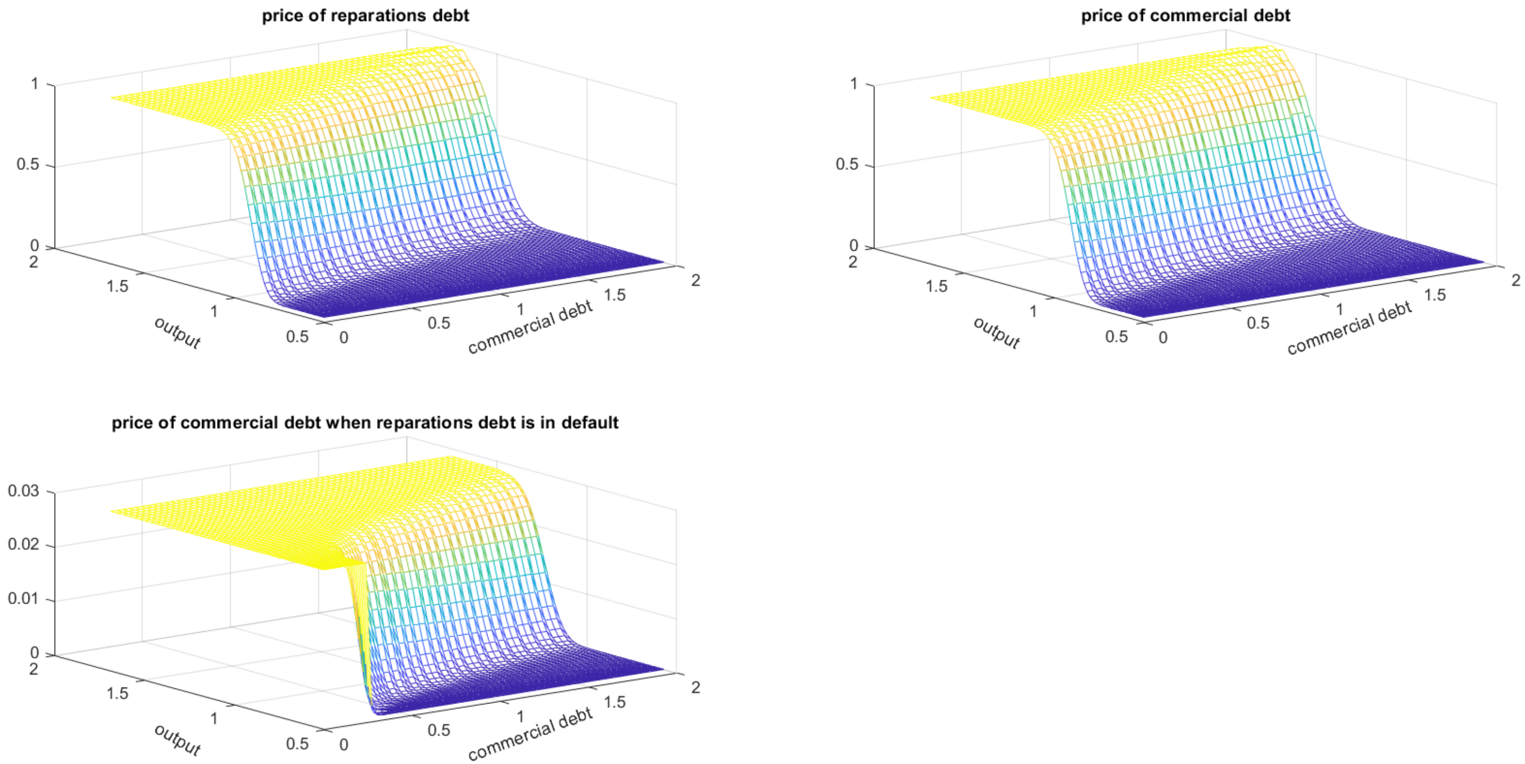
Note: We use b and B to denote the state of the sovereign at the end of the previous period and the end of current period, respectively.

Figure 3: Sovereign's Decision Routes in the Young-Plan Model



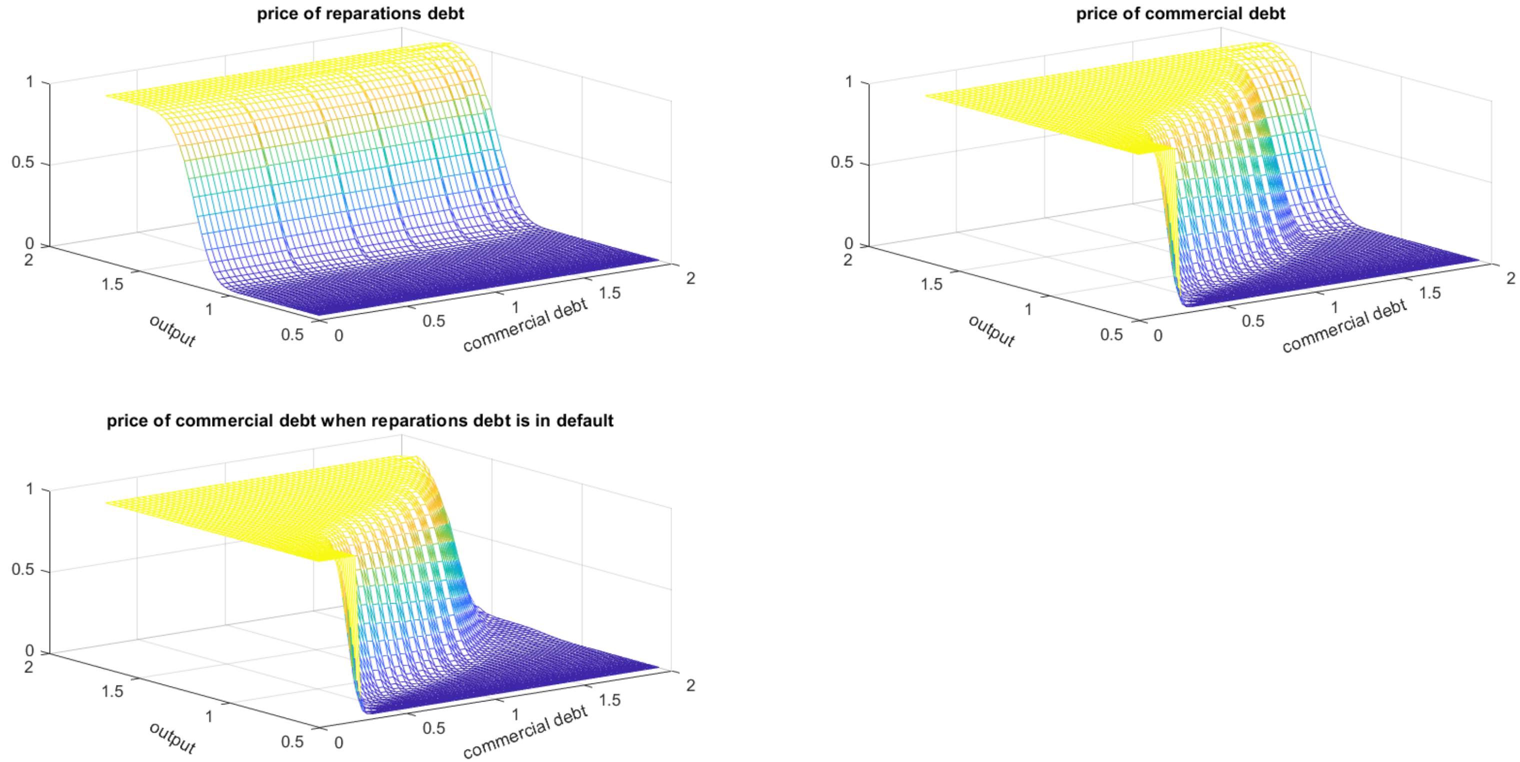
Note: We use b and B to denote the state of the sovereign at the end of the previous period and the end of current period, respectively.

Figure 4: Prices of Debts under the Dawes-Plan Model



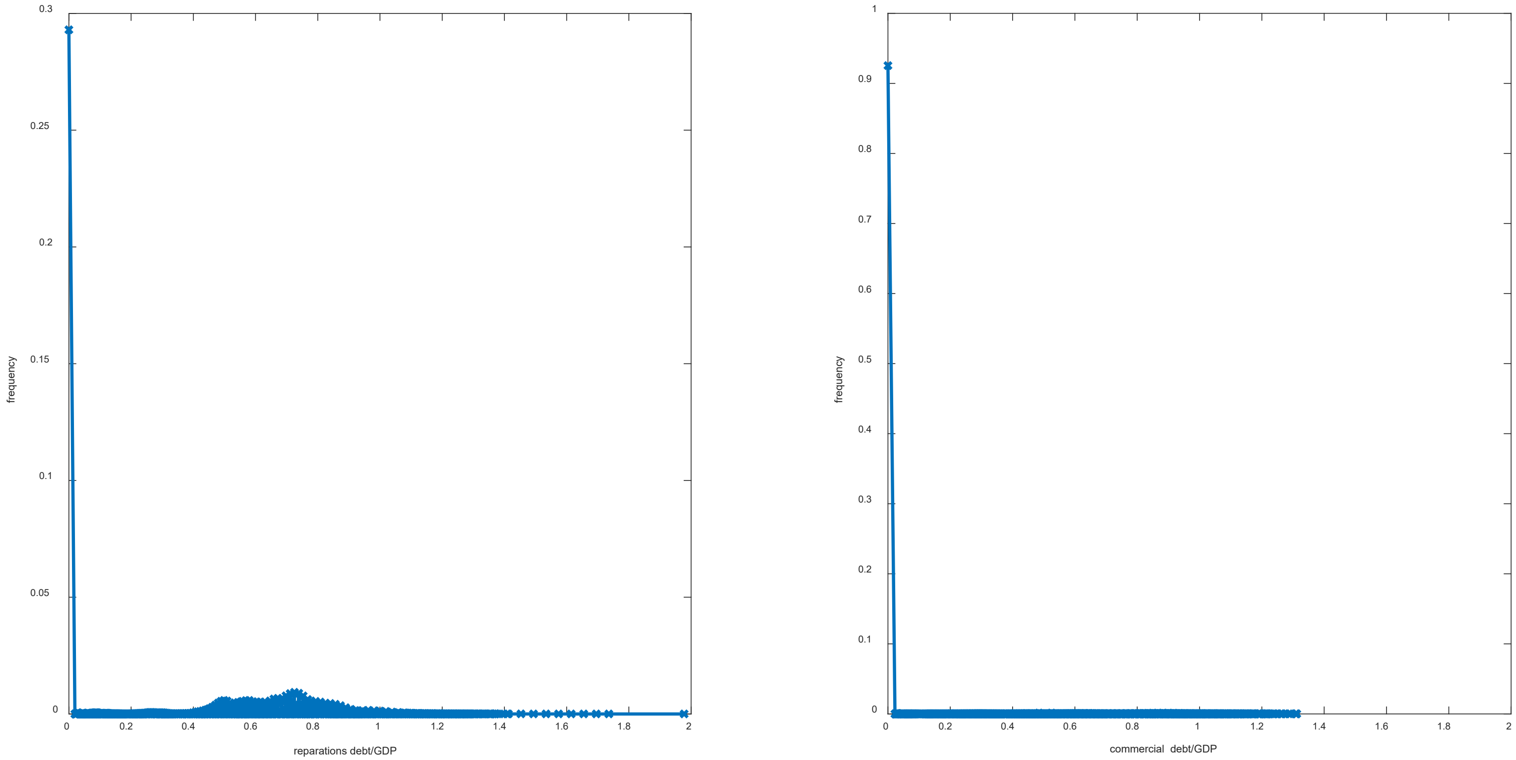
Notes: The plots show the prices of debts under different output levels and commercial debts. The level of reparations debt is fixed at 0.9831. For output, reparations, and commercial debt we use a grid of 60 equally-spaced points. In the plots, the debt starts from the third grid point. The output loss from a default on only the reparations debt is identical to the benchmark case.

Figure 5: Prices of Debts under the Dawes-Plan Model - output loss from a default on junior debt is smaller than the standard case



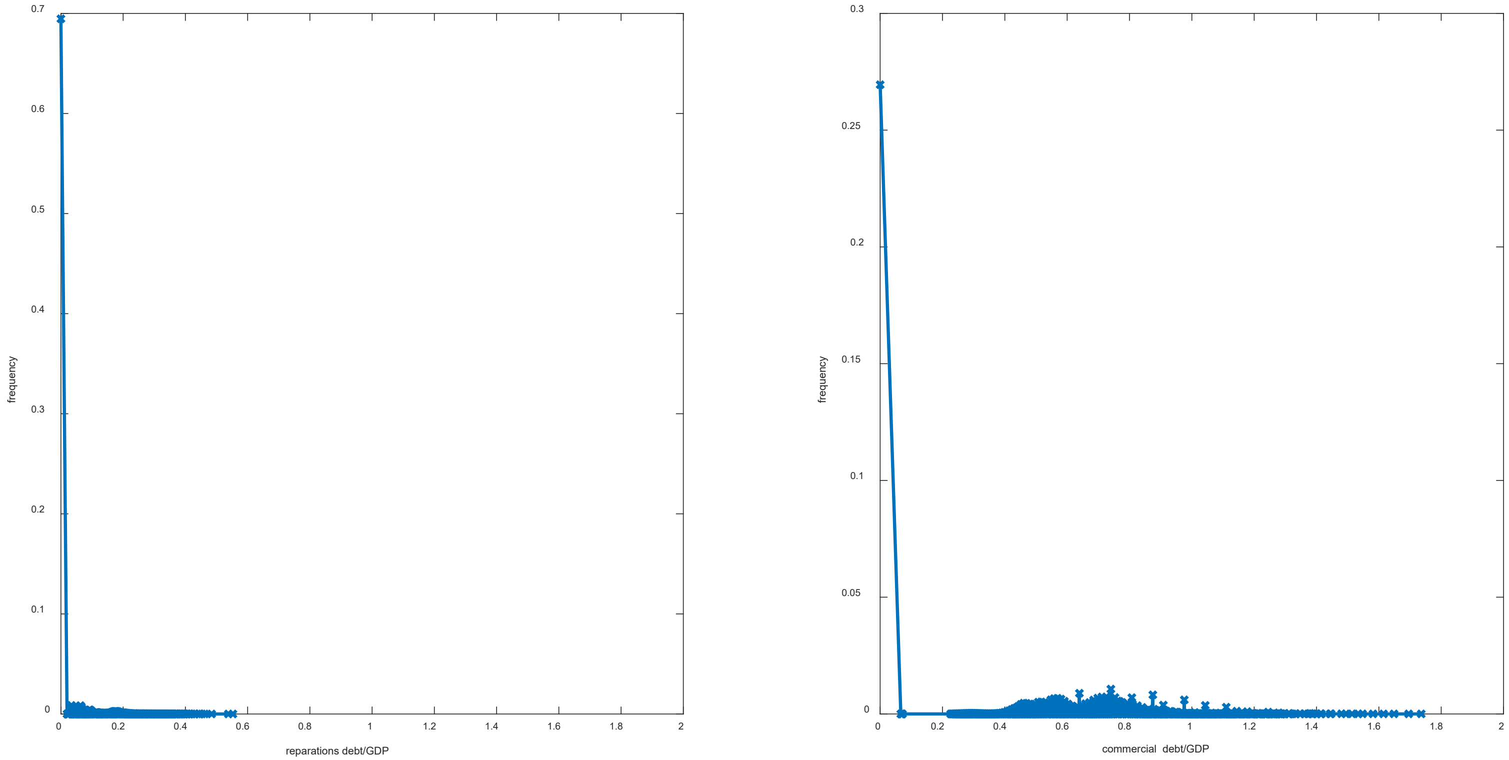
Notes: The plots show the prices of debts under different output levels and commercial debts. The level of reparations debt is fixed at 0.9831. For output, reparations, and commercial debt we use a grid of 60 equally-spaced points. In the plots, the debt starts from the third grid point. The output loss from a default on only the reparations debt is 20% smaller than the benchmark case.

Figure 6: Distribution of Debt/GDP under the Dawes-Plan Model



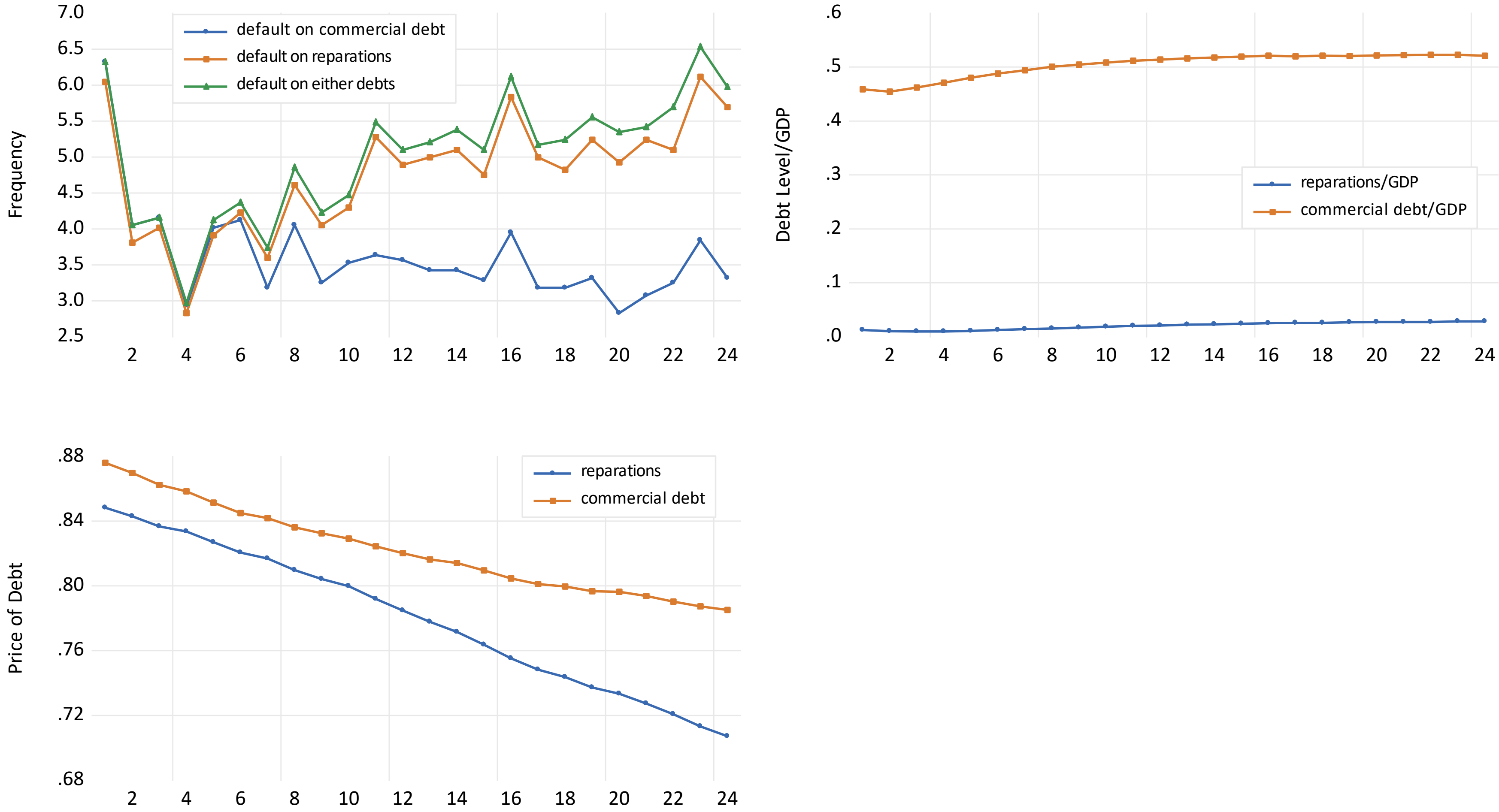
Notes: The figure reports the distribution of debt/GDP from simulating the model for 1,000,000 periods with 100,000 burn-in periods. The losses from defaulting on either reparations or commercial debt are identical, as in the benchmark case of only one debt instrument.

Figure 7: Distribution of Debt/GDP under the Dawes-Plan Model - output loss from a default on junior debt is smaller than the standard case



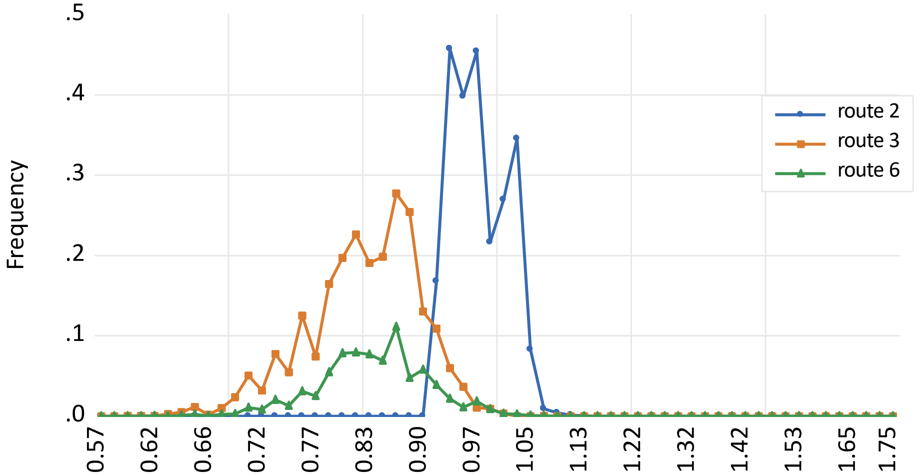
Notes: The figure reports the distribution of debt/GDP from simulating the model for 1,000,000 periods with 100,000 burn-in periods. The output loss from a default on only the reparations debt is 20% smaller than the benchmark case.

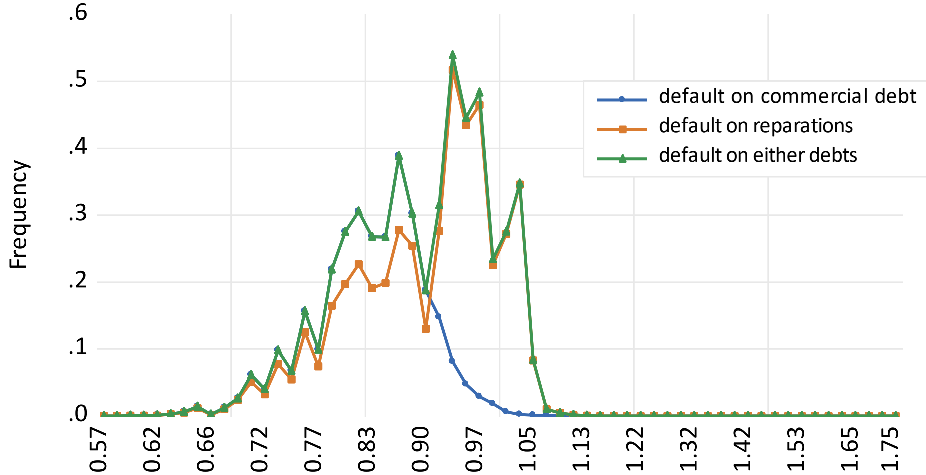
Figure 8: Default Frequencies, Debt to GDP Ratio, and Prices of Debts with Transfer Protection Clause at Work



Notes: We simulate the Dawes-Plan model (in which the transfer protection clause is present and assume that default on the reparations debt is excusable) for 1 million periods. We search for periods that satisfy the following initial conditions: output level is below the 25% quantile, and reparations are above the 75% quantile of the 1 million simulated periods. For those periods that satisfy the above initial conditions, we trace out their statistics for the subsequent 24 periods (quarters). The figures report the average value of the relevant statistics.

Figure 9: Default Frequencies with Transfer Protection Clause at Work

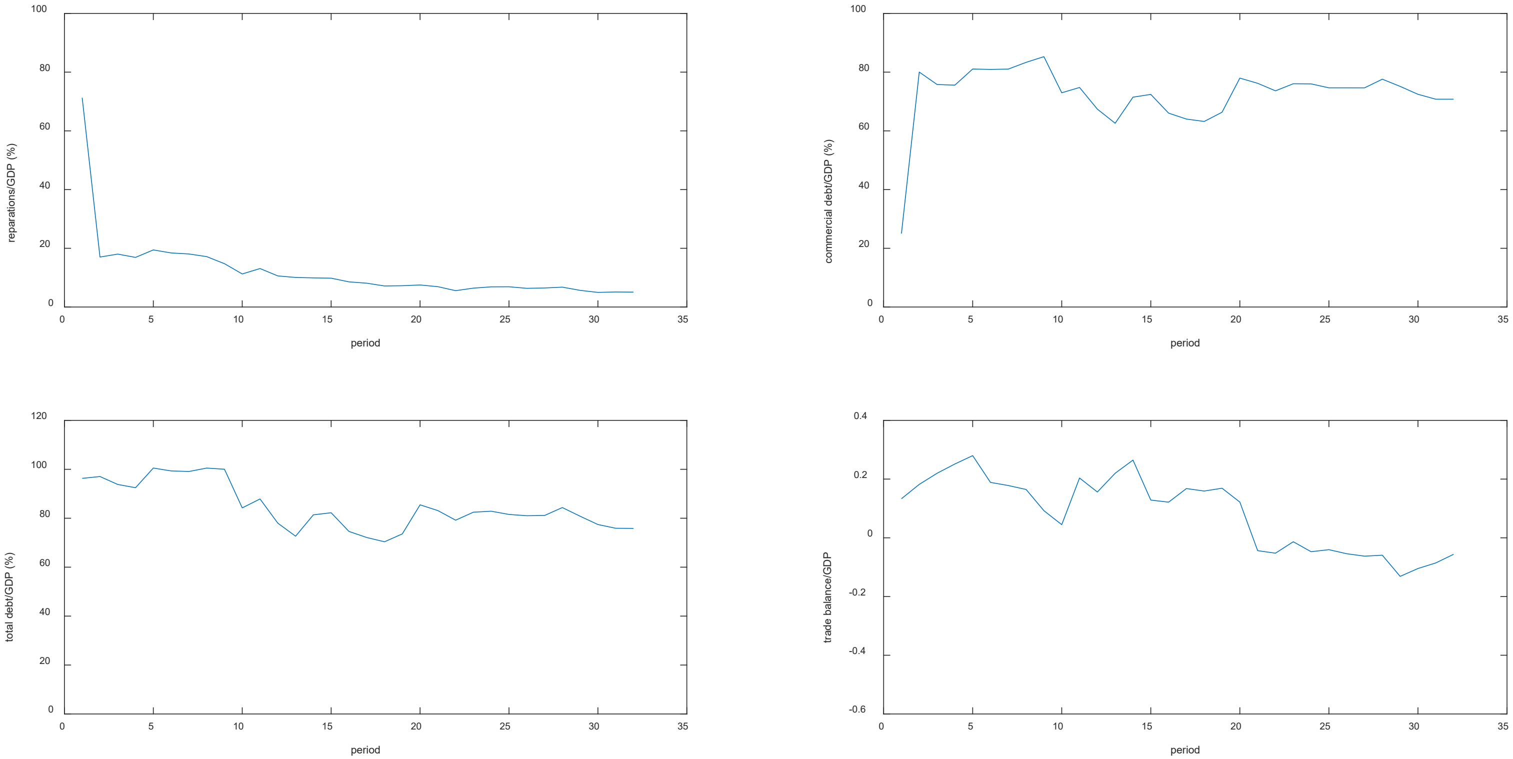




Notes: Default on commercial debt includes route 3 and route 6 of Figure 2. Default on reparations includes route 2 and route 3 of Figure 2.

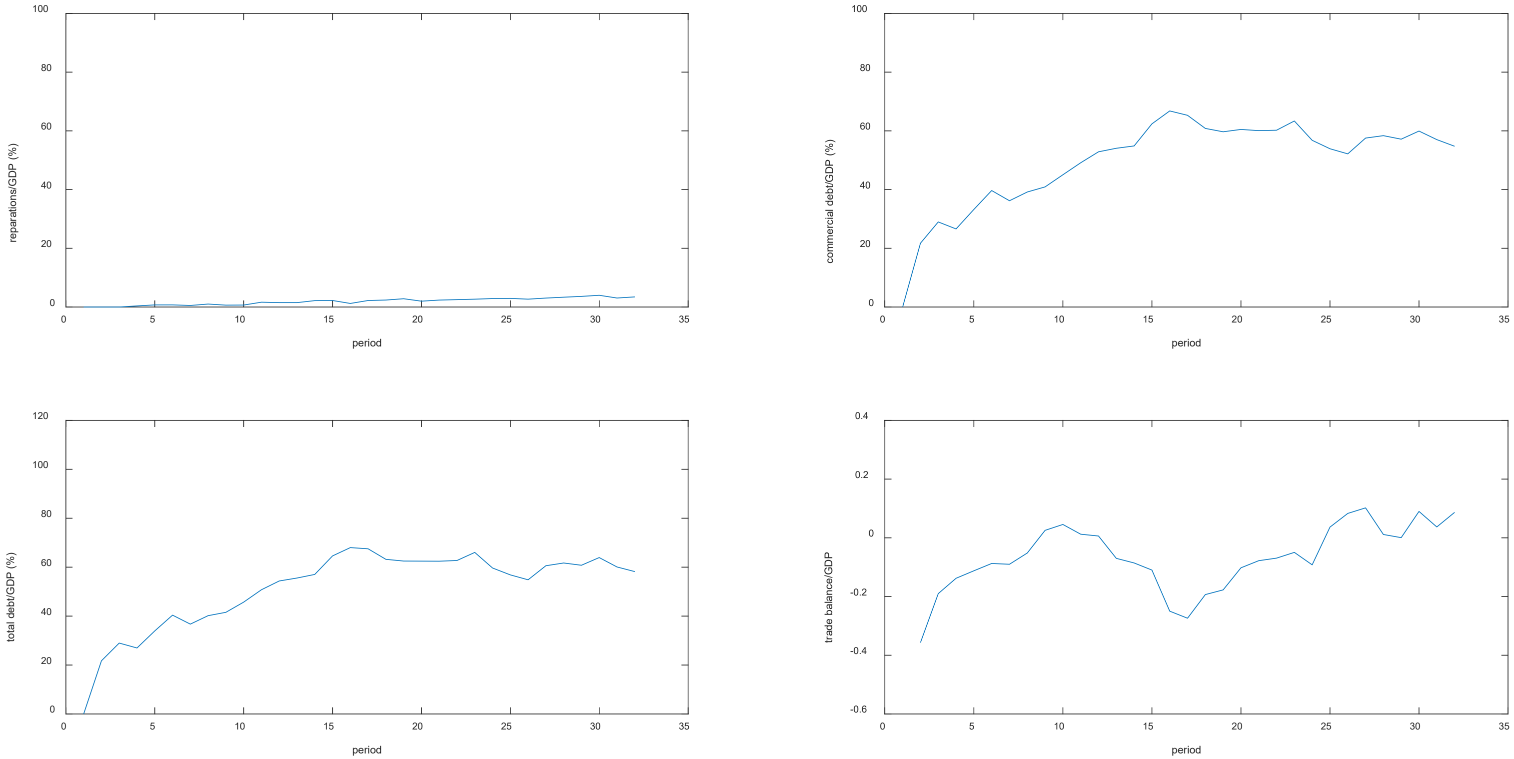
Default on either debts includes route 2, route 3, and route 6 of Figure 2.

Figure 10: Seniority Reversal - Aggressive Substitution of Reparations Debt by Commercial Debt, all the Non-Default Zone



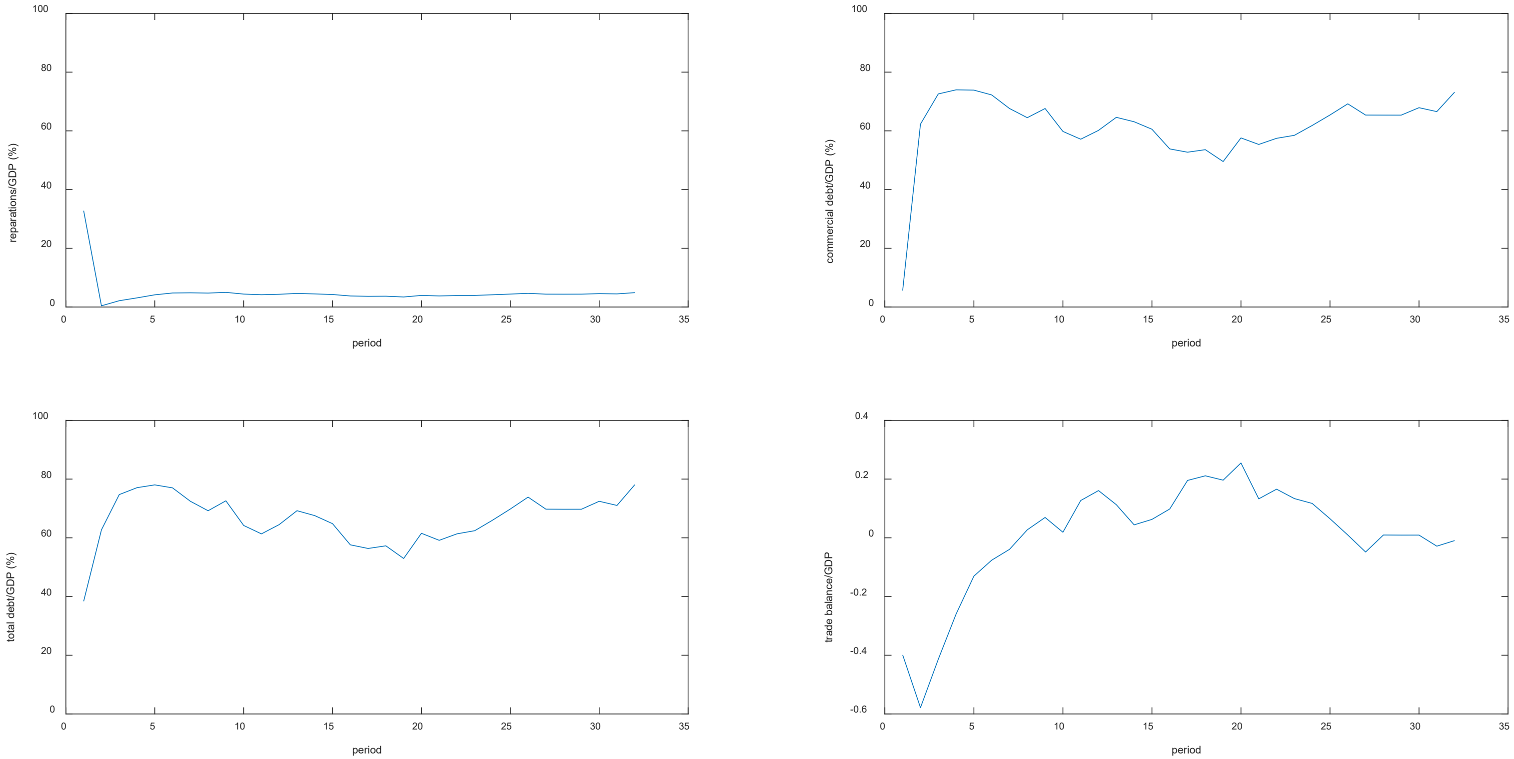
Note: For the details of the simulation, please see Section 4.3 of the main text.

Figure 11: Seniority Reversal – Initial Low GDP and No Room for Reparations Debt



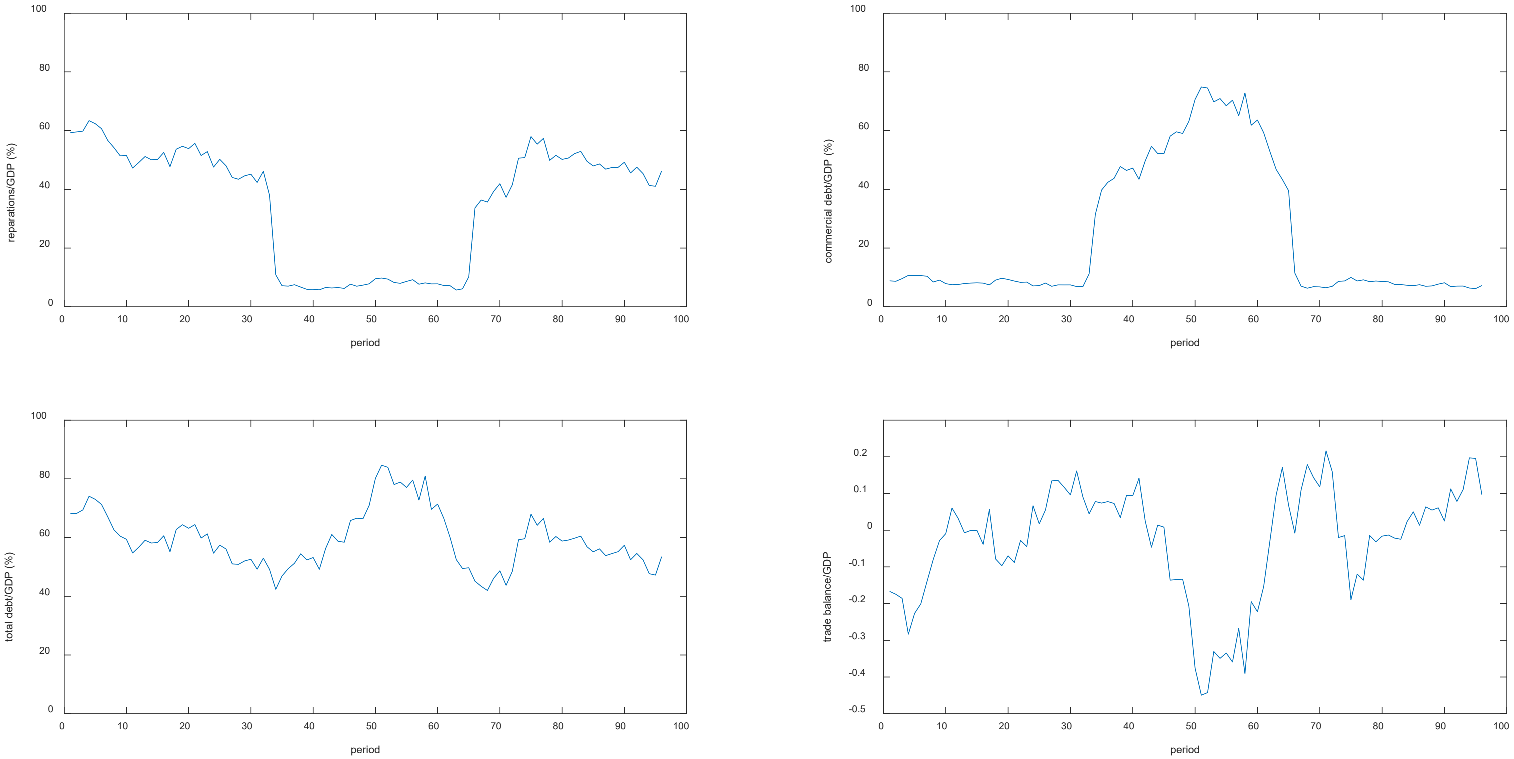
Note: For the details of the simulation, please see Section 4.3 of the main text.

Figure 12: Seniority Reversal - Credit-Restricted Sovereign Suddenly Open to Commercial Debt Borrowing



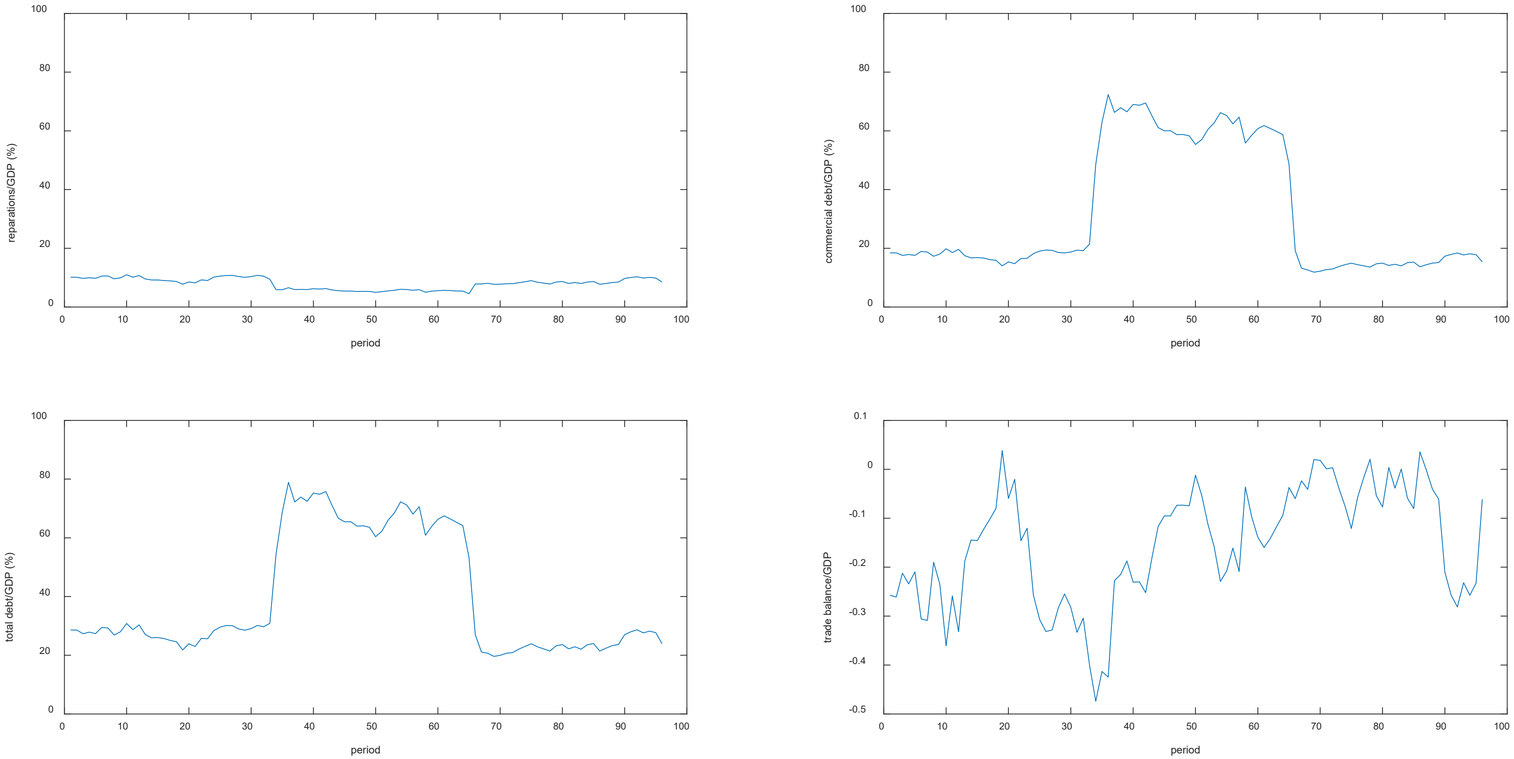
Note: For the details of the simulation, please see Section 4.3 of the main text.

Figure 13: Seniority Reversal - Commercial Debt Replaces Reparations Debt under the Dawes Plan



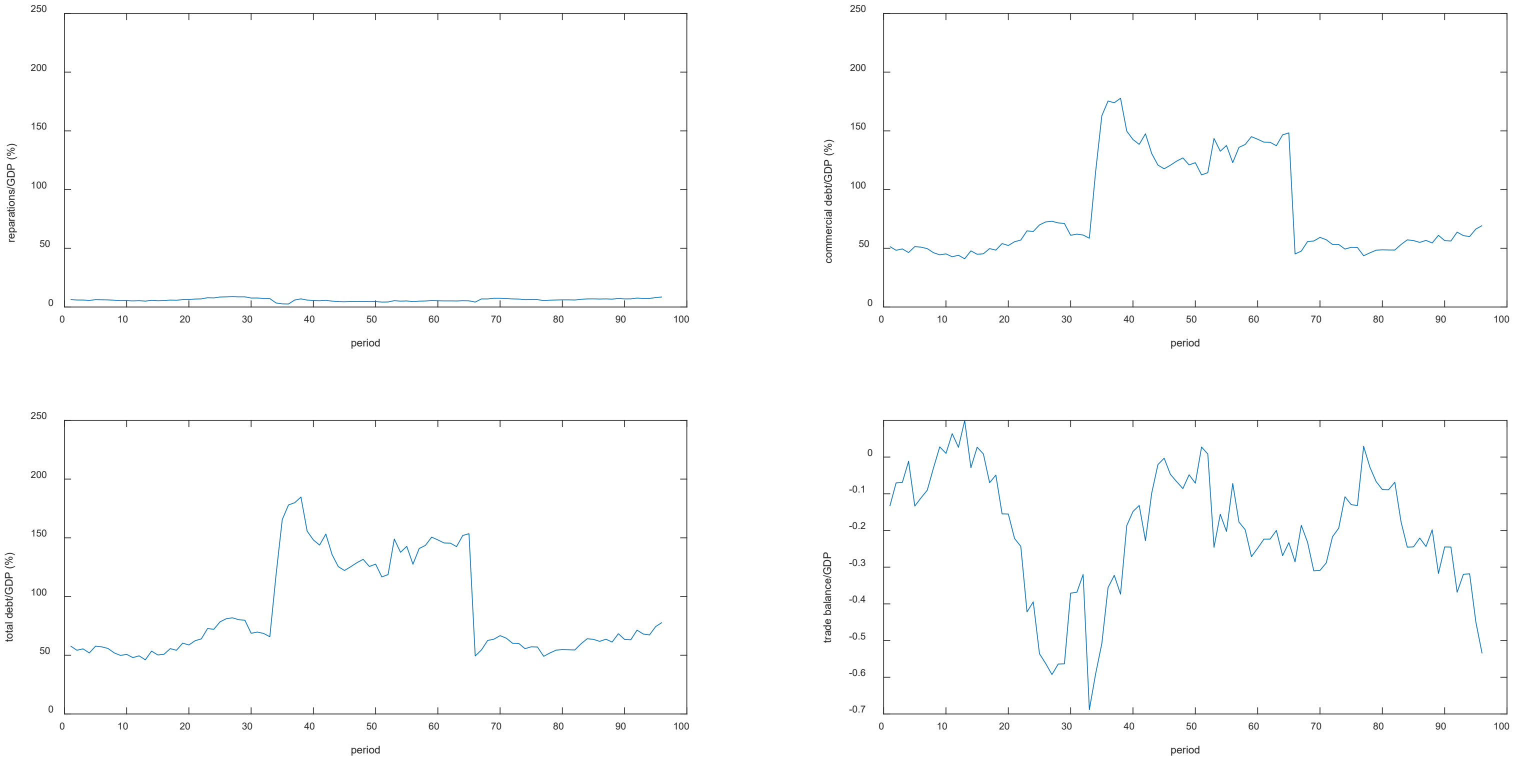
Note: For the details of the simulation, please see Section 4.3 of the main text.

Figure 14: Seniority Reversal - Reparations Debt is Restricted



Note: For the details of the simulation, please see Section 4.3 of the main text.

Figure 15: Seniority Reversal under Rational Expectation



Note: For the details of the simulation, please see Section 4.4 of the main text.

Table 1: Net Capital Inflows to European Debtor Countries, 1924-1930 and 1931-1937

	Net Capital Flows (in million US dollars)		**Net Capital Flows Per Capita** (in US dollars)	
Country	**1924-1930**	**1931-1937**	**1924-1930**	**1931-1937**
Austria	860	150	128.74	22.46
Bulgaria	50	-20	8.73	-3.49
Estonia, Latvia, and Lithuania	0	-40	0.00	-7.43
Finland	40	-150	11.49	-43.10
Germany	4190	-1010	64.38	-15.52
Greece	310	120	48.67	18.84
Hungary	320	-20	36.99	-2.31
Italy	710	50	17.36	1.22
Poland	400	-70	12.71	-2.22
Romania	440	110	73.33	18.33
Yugoslavia	80	50	5.81	3.63
TOTAL	**7400**	**-830**	**408.22**	**-9.61**

Sources: Net capital inflows are taken from Feinstein and Watson (1995), Table 3.4. Per capita inflows are obtained by dividing inflows by the population estimate for the 1930 provided by Mitchell (2007). Positive (negative) sign indicates net capital imports (exports).

Table 2: Calibration of Parameters

Parameter	Value	Description
σ	2	Inverse of elasticity of intertemporal substitution
β	0.8150	Discount factor
r^*	0.85%	World real interest rate
θ	0.0288	Re-entry probability
β_1	1.4498	Coefficient of AR (2) process for logarithm of output
β_2	-0.6240	Coefficient of AR (2) process for logarithm of output
σ_ϵ	0.0470	Standard deviation of innovation to AR (2) process for logarithm of output
a_0	-0.8400	Parameter of output loss function
a_1	1	Parameter of output loss function
a_2	0	Parameter of output loss function

Table 3: First and Second Moments of the Benchmark Model

Default Frequency	$\mu(d/y)$	$\mu(r-r^*)$	$\sigma(r-r^*)$	$corr(r-r^*, y)$	$corr(r-r^*, tb/y)$
3.0	69.0	4.4	4.6	-0.38	0.81

Notes: $\mu(d/y)$ denotes the mean quarterly debt-to-GDP ratio in percentage terms; $\mu(r-r^*)$ denotes the mean country premium, in percentage terms per year; $\sigma(r-r^*)$ denotes the standard deviation of the country premium; $corr(r-r^*, y)$ denotes the correlation between country premium and output; $corr(r-r^*, tb/y)$ denotes the correlation between country premium and trade-balance-to-GDP ratio. With the exception of the default frequency, all moments are conditional on the country being in good financial standing.

Table 4: Level of Foreign Debt and Output Cost of Default

	Default Frequency	$\mu(d/y)$	$\mu(r - r^*)$	$\sigma(r - r^*)$	$corr(r - r^*, y)$	$corr(r - r^*, tb/y)$
$a_1 = -0.840$	3.0	69.0	4.4	4.6	-0.38	0.81
$a_1 = -0.7560$	1.7	151.5	2.2	2.6	-0.52	0.79
$a_1 = -0.9240$	4.3	28.7	7.6	6.6	-0.20	0.80

Notes: $\mu(d/y)$ denotes the mean quarterly debt-to-GDP ratio in percentage terms; $\mu(r - r^*)$ denotes the mean country premium, in percentage terms per year; $\sigma(r - r^*)$ denotes the standard deviation of the country premium; $corr(r - r^*, y)$ denotes the correlation between country premium and output; $corr(r - r^*, tb/y)$ denotes the correlation between country premium and trade-balance-to-GDP ratio. With the exception of the default frequency, all moments are conditional on the country being in good financial standing.