The Debt-Inflation Channel of the German Hyperinflation

Online Appendix

Markus Brunnermeier, Sergio Correia, Stephan Luck,
Emil Verner, and Tom Zimmermann*

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*Brunnermeier: Princeton University, markus@princeton.edu; Correia: Board of Governors of the Federal Reserve System, sergio.a.correia@frb.gov; Luck: Federal Reserve Bank of New York, stephan.luck@ny.frb.org; Verner: MIT Sloan, everner@mit.edu; Zimmermann: University of Cologne tom.zimmermann@uni-koeln.de.

A Historical Background

In this section, we provide additional historical context for the German Hyperinflation. We first provide a chronology of the key events in the inflation. Then, we discuss existing economic history research on the economic impact of the inflation.

A.1 Chronology of Key Events

WWI and first phase of the postwar inflation. The origins of the German inflation lie in WWI (Feldman, 1993). Before the start of WWI, the mark was on the gold standard, and the exchange rate relative to the U.S. dollar stood at 4.2 marks per dollar. The Banking and Currency Laws of August 4, 1914 led to the abandonment of the gold standard, and the Reichsbank started to discount *Reichsschatswechsel*, de facto moving to a fiat currency. Exchange controls and price controls were maintained during WWI, which suppressed inflation but led to distortions and black marketeering (Feldman, 1993).

Relative to the Allied Powers, Germany relied heavily on domestic loan issuance rather than on new taxes and foreign bond issuance to finance the war (Graham, 1931; Feldman, 1993). However, Germany's public finances were not in a significantly worse condition than France's in the immediate aftermath of the war. Prices also rose in the U.K., U.S., and France during the war.[1] The most important difference would be the reparations imposed at the Treaty of Versailles (Graham, 1931; Sargent, 1982).

The WWI Armistice was signed on November 11, 1918, leading to the end of WWI fighting. November 1918 marked the start of the German Revolution. In January 1919, a Constitutional congress was convened, and the new Weimar Constitution was adopted on August 11, 1919. Meanwhile, the Treaty of Versailles was signed on June 28, 1919, which included the War Guilt Clause. As a result, Germany owed staggering but initially uncertain reparations, negatively impacting Germany's public finances. Lopez and Mitchener (2020) provide evidence that economic policy uncertainty due to reparations was an important factor contributing the the rise in inflation in Germany. Under the treaty, Germany also lost 13% of its land area and 10% of its population. At the same time, the signing of the Treat of Versailles ended the Allied war blockade of Germany, which hamstrung Germany's economy and public finances (Graham, 1931).

Following high inflation in the second half of 1919, inflation slowed in 1920. This was due to the Erzberger fiscal reforms of 1919 and 1920, which led to large tax increases, and the suppression of the Kapp Putsch in March 1920, which led to a strengthening of the mark. However, inflation accelerated again in the spring of 1921 after the Reparations Committee determined exact the reparations in May 1921, which amounted to about 6% of GDP per year (Dornbusch, 1985). Moreover, the London Ultimatum required an up front payment of 1.5 billion gold marks, about half of tax revenues, in 1921 (Dornbusch, 1985). Inflation continued to increase following the assassination of finance minister Mathias Erzberger on August 26, 1921.

[1] By the end of WWI, the mark had depreciated to 8 marks per U.S. dollar.

Second phase of the inflation. The summer of 1922 was the turning point in the inflation when high inflation turned into hyperinflation. There were three important shocks that explain the transition. First, in early June, the French government decided that the Bankers Committee could not provide reparations relief to Germany by reconsidering the May 1921 reparations schedule. This was in part a response to the Treaty of Rapallo, signed on April 16, 1922 between Germany and the Soviet Union, which opened diplomatic relations between the two countries and involved a mutual cancellation of financial claims. The Treaty violated the Treaty of Versailles. Second, the Bankers Committee determined that Germany did not have the credit to warrant an international loan to stabilize the mark (Kindleberger, 1985). Germany suspended all payments of reparations in June 1922, and Germany formally demanded postponement of reparations for 2.5 years on July 12, 1922. Cagan (1956) dates the start of the hyperinflation in July 1922, and Cagan (1991) refers to summer 1922 as the start of a "new regime" of collapse in the confidence in the mark.

Third, conflict over reparations was compounded by the assassination of the highly capable foreign minister Walther Rathenau by right-wing paramilitaries on June 24, 1922. *The Economist* noted that the Rathenau assassination and political turmoil were followed by "panic on the Berlin exchange bourse" (July 1, 1922). The mark depreciated by 7% on the day of the assassination. This led to a flight from the mark to foreign exchange, as markets began to expect additional depreciation, resulting in a large capital outflow.[2] The boost to international competitiveness from the depreciation also subsided by the second half of 1922, leading to a rising trade deficit, while firms pulled back on investment due to a credit crunch, shortage of working capital, and increased uncertainty (Feldman, 1993).

Economic performance and inflation took another turn for the worse with the occupation of the Ruhr by France and Belgium in January 1923, following arrears on German deliveries of reparations in kind. The occupation was met by passive resistance, which the Reichsbank financed by discounting of Treasuries. This led to a surge in the issuance of paper currency. During 1922 and1923, the Reichsbank also discounted commercial bills to alleviate the credit shortage.

There was a pause in the inflation from mid February to mid April 1923, when the Reichsbank attempted a first stabilization of the mark by intervening in the foreign exchange market. This briefly led to falling prices and an appreciation of the mark. The intervention was abandoned due to a large loss of central bank foreign currency reserves, as exchange rate was unsustainable given the large deficit (Dornbusch and Fischer, 1986). From May to October 1923, the price level spiraled out of control with increasingly higher rates of monthly inflation.

The the height of the hyperinflation, the economy was in crisis. Food shortages became common, as farmers refused to accept marks for their products (Feldman, 1993). Worker-employer relations deteriorated, as workers demanded wage increased to keep pace with inflation. In July 1923, government employee wages became explicitly indexed to inflation. Economic distress led to rising left- and right-wing extremism.

[2]The size of the capital outflow and the amount of German wealth held abroad is highly uncertain and was debated in the context of Germany's ability to meet reparations (Feldman, 1993).

Stabilization. Consensus for the need for stabilization grew in the hyperinflation phase, as there was a realization that the costs of inflation began to exceed the benefits of the monetary stimulus (Feldman, 1993). The foundations for the stabilization were laid starting in August 1923. The Cuno government was replaced by a "Great Coalition" government with Gustav Stresemann as chancellor and the SPD in the finance ministry. The new government introduced new tax measures with accelerated indexation and issued a 500 million Goldmark loan, which paved the way for a new monetary unit linked to the Goldmark. Passive resistance in the Ruhr was ended on September 26, 1923. At this stage, the economy was in crisis; worker-employer relations had broken down and farmers had stopped accepting marks for products, leading workers to raid farmers' fields for food (Feldman, 1993). In October 1923, the SPD left the finance ministry after cabinet reshuffle, and Hans Luther became the new finance minister. Inflation peaked at a monthly rate of 30,000% (more than 20% per day) in October, and exchange rate based pricing became widespread. The extremely rapid increase in prices led to a fall in real money balances (Cagan, 1956).

A monetary reform was introduced on October 15, 1923. The decree created a new currency unit called the Rentenmark, which was declared equivalent to 1 trillion (10^{12}) paper marks. The Rentenmark would be issued by a new bank, the Rentenbank, which would replace the Reichsbank's note issue function. The Rentenbank was backed by "fictitious" claims on industry and land and faced limits on the amount of loans it could make to the government and private sector, as well as limits on the maximum amount of Rentenmarks that could be issued. The legislation also prohibited the Reichsbank from discounting government bills. The Rentenbank came into operation and started issuing Rentenmarks on November 15, 1923. The exchange rate was fixed from November 20, 1923. There was a final depreciation of the currency from 1.26 trillion paper marks/USD to 4.2 trillion paper marks/USD between November 14 and November 20, leading to a large reduction in the real money supply. The Rentenmark was then stabilized at 4.2 Rentenmarks/USD, and the Rentenmark was then equivalent to one Goldmark.

There were several important factors behind the success of the stabilization.[3] Sargent (1982) argues that fiscal stabilization in the form of both increased taxes and cuts in government spending were crucial for success of stabilization. Government spending was cut through a 25% reduction in personnel over four months and by retiring civil servants over age 65. With this fiscal reform, Stresemann and Luther balanced the budget. In contrast to the fiscal contraction, Sargent (1982) emphasizes that the stabilization coincided with strong money growth. In additional to fiscal reform, Dornbusch (1985) emphasizes the importance of exchange rate stabilization, very high discount rates (at times around 90% per year) in November and December 1923, discounting restraints on the Reichsbank and Rentenbank, political stabilization with the end of passive resistance, and the large decrease in real money balances from the final 330% devaluation between November 14 and 20, 1923. The success of the stabilization was highly uncertain in the first few months.[4]

[3] In contrast to the stabilization of Austria and Hungary, the German stabilization did not involve foreign assistance.

[4] The stabilization also coincided with the death of the Reichsbank President Havenstein, who was replaced by Hjalmar Schacht.

In August 1924, the Dawes Plan substantially aided Germany's fiscal situation by providing reparations relief. Reparations payments were temporarily suspended, and the Dawes plan assigned Germany a more manageable schedule of payments. The plan involved a reorganization of the Reichsbank and the introduction of the Reichsmark to replace the Rentenmark. The Reichsmark (sign RM) was equal to one Rentenmark. Under the plan, France and Belgium agreed to withdraw from the Ruhr.

A.2 Historical Accounts of the Economic Impact of the Inflation

Aggregate effects of inflation and stabilization. The German economy experienced high growth and low unemployment from the end of the war to the second half 1922, avoiding the "Depression" of 1920-21 in the US, UK, and France (see Figure 3).[5] From the final months of 1922, inflation was associated with contraction, and 1923 saw a large decline in production due to a combination of the Ruhr occupation, hyperinflation, and stabilization. Graham (1931) argues that much of the adverse real effects of the inflation were due to coincident factors such as the loss of productive capacity during the war and the invasion of the Ruhr, although both Graham (1931) and Garber (1982) suggest that inflation may have resulted in a distortionary reallocation of resources toward large capital goods producers. Feldman (1993) argues that the hyperinflation itself contributed to economic crisis toward the second half of 1922, due to capital flight and a credit shortage, increased uncertainty that led firms to hold back production, large distortions in relative prices, breakdown in labor relations, a breakdown of trade, and rising social unrest.

The impact of the stabilization has also been the subject of debate. Sargent (1982) argues that the stabilization was not associated with substantial negative effects and was actually expansionary based on annual industrial production data, though it is difficult to know how much of the increase in industrial production from 1923 to 1924 was due to the end of the Ruhr crisis. Garber (1982) argues that aftermath of stabilization was associated with large transitional costs through a reallocation of resources away from industrial firms that benefited from the inflation.

Distributional effects of the inflation and the impact on firms. The inflation had distributional effects through balance sheets, as we show in the paper. Debt-financed industrialists and landowners, especially those with mortgages, benefited from the inflation, while households on fixed income lost out.[6] Feldman (1993) notes that this redistribution was well understood by contemporaries. This allowed industrial firms to self-finance a higher share of their activity, making them less reliant on banks (Feldman, 1993, p. 276). Graham (1931) argues these redistributive effects were expansionary, but also notes that it caused over-investment and misallocation of resources to less productive

[5]Graham (1931) writes: "That business in Germany was booming during most of the inflation period is a universally admitted fact" (p. 278).

[6]Graham (1931) notes that 40 billion marks of mortgage debt (one-sixth of German wealth) in 1913 was wiped out by the inflation. While urban landlords benefited from the erosion of their mortgage debt, strict regulation of rents made housing almost free for tenants during the hyperinflation.

users. Inflation also wiped out much of public debt, though lags between assessment and collection increased the deficit through the Tanzi effect (Dornbusch and Fischer, 1986).

There were also distributional effects through wages and prices. Real wages declined up through 1920, especially for skilled workers in the middle class (see Figure C.10). By the hyperinflation stage, wages raced to keep pace with rising prices. The depreciation of the mark also disproportionately benefitted exporters, who were able to regain foreign markets (Graham, 1931).

Firms responded to the inflation by increasing consolidation, such as the Stinnes' Siemens Concern. Mergers were financed by cheap debt. Vertical integration allowed firms to reduce uncertainty about the cost of materials. Horizontal integration was ostensibly pursued to the diversify risk of volatile goods prices (Graham, 1931). This wave of consolidation was an acceleration on previous structural trends in the German economy (Feldman, 1993, p. 272). Some of the industrial concerns built up during the inflation collapsed during the stabilization.

Banking and credit conditions during the inflation Banks saw large declines in the real value of their capital during the inflation. Based on data on 19 credit banks Goldschmidt (1928), finds that deflated bank capital declined by 54% from 1918 to 1923, with most of the decline occurring in 1919. Bank credit was available for firms in the first phase of the inflation (1919-21), but the second phase of the inflation witnessed a "credit crisis." This section provides further details on banking and credit conditions during the inflation.

There was a banking boom from 1919-21, as banks saw large inflows of mark-denominated foreign deposits from speculators betting on an appreciation of the mark. Banks also benefited from a widening deposit spread and from commissions on the high activity of stock and money market transactions. Banks were reported to be "swimming in money" during the first phase of the postwar inflation (Feldman, 1993).

As a result, credit conditions were not particularly tight in the first phase of the postwar inflation, and banks continued lending to industrial firms in this period. Bresciani-Turroni (1937) refers to a report of the General Association of German Banks and Bankers for 1923, which reported that: "Thanks to the aid of the banks, German industry and commerce were given the means not only to preserve their resources but to increase them in considerable measure. Industry rapidly recognized that it was economically more advantageous to incur the highest possible debts at the bank rather than to keep large deposits." Bresciani-Turroni (1937) argues that banks lost by providing cheap credit to firms, perhaps because they did not understand the implications of inflation. Banks were slow to raise interest rates due to various factors. Bresciani-Turroni (1937) argues they did not require high interest rates because they did not anticipate inflation and because the "phenomenon of monetary depreciation had not yet been properly understood by the majority of bank directors." Schacht (1927) notes that interest rates on bank loans were usually set based on the Reichsbank's discount rate, which remained low for much of the inflation.

While firms benefited from *ex post* low real interest rates, Lindenlaub (1985) argues that, before late 1921, businesses generally did not respond to inflation by maximizing borrowing in anticipation of low real interest rates. This is consistent with narrative

evidence and the behavior of forward exchange rate, which both indicate that agents did not anticipate continued high inflation before the summer of 1922. Therefore, while some industrial firms benefited from high leverage at the expense of banks, it is not clear that this was a systematic policy of the nonfinancial corporate sector.

Between 1921 and 1922, there was a large decline in real deposits, as depositors sought assets that would provide a better hedge against depreciation and to avoid taxes (Feldman, 1993). During this phase, the term structure of deposits also shortened, leading to a shortening of loan terms. Banks also gradually raised interest rates, though never sufficiently to yield positive *ex post* returns (Graham, 1931).

Credit conditions became tight during the hyperinflation phase, starting in summer 1922. In this phase, it became very difficult for firms to obtain credit and external financing almost disappeared (Graham, 1931; Dornbusch and Fischer, 1986; Feldman, 1993).[7] For example, in July 1922, *The Economist* noted an "an extreme shortness of money," due to contraction of supply and elevated demand for credit, as depreciation became widely anticipated.[8] Narrative accounts refer to a credit "famine" or "crisis" (Balderston, 1991; Feldman, 1993). This is evidenced in rising interest rates on various types of credit, including money market interest rates (Holtfrerich, 1986; Feldman, 1993).

In the hyperinflation phase, many businesses were severely liquidity constrained with rising nominal input prices and wages. Banks could not keep up the supply of credit to finance firms' working capital.[9] This led to the reintroduction of bills of exchange, which could be discounted at the Reichsbank. From the middle of 1922, the Reichsbank partially substituted for credit bank's credit by discounting bills of large firms, which made these firms less reliable on the banks (Feldman, 1993). The loan bureaus of the Reichsbank also became more active in granting credit. Large firms benefited from discounting at low real rates at the Reichsbank. Banks could also discount bills at the Reichsbank, and Graham (1931) argues banks recouped some of their losses by discounting bills at low rates at the Reichsbank, which transferred losses from banks to all holders of currency. .[10]

The inflation was also characterized by an acceleration in banking sector consolidation through banking alliances.[11] Over the period 1914-1925, the Berlin "great banks" absorbed many provincial and private banks (Balderston, 1991). For example, Deutsche Bank increased its number of branches from 15 in 1913 to 142 in 1924 (Feldman, 1993). Balderston (1991) argues that it is not clear exactly why mergers accelerated. Feldman (1993) argues it was because provincial banks traded at a discount relative to the big

[7]Neumeyer (1998) presents theory and evidence from Argentina that high inflation leads to a disappearance of nominal financial contracts due to high expected inflation with a low probability of inflation stabilization.

[8]In July 1922, *The Economist* also reported that "the instability of the standard of value is gradually killing long-period credit in Germany."

[9]Banks could not index advances to the price level (Balderston, 1991). More broadly, indexation of financial contracts was not widespread due to restrictions on foreign currency pricing, thought commodity-indexed bonds started to be issued in late 1922 (Feldman, 1993).

[10]Graham (1931) notes: "It has indeed been suggested that the big industrial borrowers virtually stole the banks, but, insofar as this occurred, the commercial bank directorates largely recouped their losses at the expense of the Reichsbank."

[11]A notable example was the merger between Darmstadt Bank für Handel und Industrie and Nationalbank für Deutschland into Danat Bank (Damstädter- und Nationalbank) in July 1922.

banks and because big banks partly saw acquiring the assets of smaller banks (at least the real assets such as buildings) as an inflation hedge.

B Model of the Debt-Inflation Channel of Inflation

This section lays out a simple model to illustrate the following mechanisms:

1. Inflation and Bankruptcies: When firms have nominal debt and can default, unexpected inflation increases firms' net worth, leading to a decline in default rates.
2. The Debt-Inflation Channel and Firm Activity: If firms are financing-constrained, unexpected inflation relaxes financing constraints and leads to an increase in labor demand, employment, and output. The debt-inflation channel is stronger for a higher initial level of leverage.
3. The Nominal Rigidity Channel: If unions face a menu cost in adjusting wages, small increases in inflation have a large effect on output through the nominal rigidity channel by reducing real wages. The nominal rigidity channel thus complements the debt-inflation channel. However, for high inflation, wages become flexible, and inflation only has real effects through the debt-inflation channel.

We consider a static model with two subperiods: "morning" and "evening." The economy is populated by a unit mass of entrepreneurs, who operate the productive technology, and workers, who monopolistically provide labor to firms.

Firms. Firms are run by risk neutral entrepreneurs and with utility function $U(C) = C$. Firms have initial capital stock K_0 and owe nominal debt to workers D_0. Capital is subject to a real shock $Z_i \sim G$. In the morning, the entrepreneur decides whether to default or produce. The real value of an entrepreneur is the maximum of zero and

$$J = K_0 - Z_i - \frac{D_0}{P} + V,$$

where V is the value of the firm to the entrepreneur from continuing production (defined below) and P is the price level, which is assumed to be exogenous.[12] Firms with negative value default. The cutoff value for Z^* for default is defined by:

$$Z^* = K_0 - \frac{D_0}{P} + V(Z^*). \tag{6}$$

When a firm defaults, the entrepreneur gets zero consumption and exits the economy. The capital of the entrepreneur is then destroyed (i.e., it has a liquidation value of zero). The measure of active entrepreneurs is $G(Z^*)$. The value of nominal debt in the economy is $G(Z^*)D_0$.

Each firm i operates a Cobb-Douglas technology using capital and labor $\{L_{ij}\}_{j\in[0,1]}$ from each worker,

$$Y_i = F(K_i, \{L_{ij}\}) = AK_i^{\alpha} L_i^{1-\alpha},$$

[12]The price level can be endogenized by assuming that there is stock of money that is required for transactions and that is randomly adjusted by the monetary authority. In that case, the price level is determined by $M = P(K_0 - K + Y)$, where K_0 is initial capital, K is capital used in production, Y is aggregate production.

where

$$L_i = \left(\int_0^1 (L_{ij})^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}},$$

is a CES aggregate of labor provided by each worker j to entrepreneur i.

Each firm with $Z \leq Z^*$ uses initial capital net of debt along with intra-period debt D_i to invest in capital and pay labor in the morning. The flow of funds condition for entrepreneur i is

$$D_i - D_0 - PZ_i = WL_i + P(K_i - K_0) \tag{7}$$

To introduce financing constraints, we assume that firms are subject to a working capital constraint on D_i, similar to Jermann and Quadrini (2012). The constraint is given by:

$$D_i \leq \xi PAK_i^{\alpha} L_i^{1-\alpha}. \tag{8}$$

Combining (7) and (8) yields the following constraint:

$$D_0 + PZ_i + WL_i + P(K_i - K_0) \leq \xi PAK_i^{\alpha} L_i^{1-\alpha} \tag{9}$$

The firm's problem is

$$P \cdot V = \max_{K_i, L_i} PAK_i^{\alpha} L_i^{1-\alpha} - WL_i - PK_i \quad \text{s.t. (9).}$$

The first-order conditions are:

$$\begin{aligned} [K_i]: \quad & F_K - 1 - \lambda(1 - \xi F_K) = 0 \\ [L_i]: \quad & PF_L - W - \lambda(W - \xi PF_L) = 0, \end{aligned}$$

where λ is the Lagrange multiplier on the constraint (9).

There are two cases, depending on whether the financing constraint binds. In the following, for simplicity to illustrate the main points, we consider parametrizations of G and ξ such that all firms are constrained. Regardless of whether the constraint binds, the capital-labor ratio is

$$\frac{K_i}{L_i} = \frac{\alpha}{1-\alpha} \frac{W}{P}. \tag{10}$$

When the constraint binds, we can solve for firm i's labor demand by combining (9) and (10):

$$L_i^d = \frac{K_0 - \frac{D_0}{P} - Z_i}{\frac{1}{1-\alpha}\frac{W}{P} - \xi A \left(\frac{\alpha}{1-\alpha} \frac{W}{P} \right)^{\alpha}}. \tag{11}$$

Firm labor demand is an increasing function of its initial resources, $K_0 - \frac{D_0}{P} - Z_i$. Again

assuming all firms are constrained, aggregate labor demand is given by

$$L^d = G(Z^*)\frac{K_0 - \frac{D_0}{P} - \frac{\int_{\underline{Z}}^{Z^*} Z dG(Z)}{G(Z^*)}}{\frac{1}{1-\alpha}\frac{W}{P} - \xi A\left(\frac{\alpha}{1-\alpha}\frac{W}{P}\right)^{\alpha}} \tag{12}$$

For a constrained firm, the real value of production is,

$$V = \frac{D_0}{P} + Z_i - K_0 + (1-\xi)AK_i^{\alpha}L_i^{1-\alpha}$$

so the value of the firm from not defaulting is

$$J = (1-\xi)AK_i^{\alpha}L_i^{1-\alpha} = (1-\xi)A\left(\frac{\alpha}{1-\alpha}\right)^{\alpha}\left(\frac{W}{P}\right)^{\alpha}L_i^d.$$

Thus, a firm defaults if it would choose a negative amount of labor, L_i^d. From (11), we see that the cutoff value of default is the value such that $L_i^d = 0$, or

$$Z^* = K_0 - \frac{D_0}{P},$$

In other words, the firm defaults if the real value of its initial debt exceeds the value of capital. it has negative initial net worth. The share of defaulting firms is $1 - G(Z^*)$, which provides our first result.

Result 1: Debt-Inflation and Firm Bankruptcies. The share of defaulting firms declines for higher levels of inflation, P:

$$\frac{\partial(\text{Default share})}{\partial P} = -\frac{D_0}{P^2}G'\left(K_0 - \frac{D_0}{P}\right) < 0.$$

Workers. The household chooses its overall level of consumption and labor to maximize

$$U(C,L) = \ln(C) - \chi\frac{L^{1+\varphi}}{1+\varphi}$$

subject to the budget constraint:

$$C = \frac{W}{P}L + \frac{G(Z^*)D_0}{P}$$

The budget constraint uses the assumption that workers hold a diversified portfolio of debt claims with aggregate nominal value $G(Z^*)D_0$. Each worker sets a wage W_j at which they are willing to work. Given that the production technology aggregates different varieties of labor according to a CES function, the total units of labor demanded from a

worker j who sets wage W_j will be

$$L(W_j) = \left(\frac{W_j}{W}\right)^{-\epsilon} L^d,$$

where L^d is the aggregate quantity of labor demanded by entrepreneurs. In equilibrium, all varieties of labor set the same wage $W_j = W$. Household aggregate labor supply is given by

$$\frac{W}{P} = \frac{\epsilon}{\epsilon - 1}\chi L^{\varphi} C,$$

which can be rewritten as

$$\frac{W}{P} = \frac{\frac{\epsilon}{\epsilon-1}\chi L^{\varphi}}{1 - \frac{\epsilon}{\epsilon-1}\chi L^{1+\varphi}} \left(\frac{G(Z^*)D_0}{P}\right). \tag{13}$$

An increase in inflation P lowers real debt held by households, raising labor supply through a wealth effect. Intuitively, households reduce consumption of leisure and increase labor as the inflation erodes their wealth.[13]

Flexible wage equilibrium. With flexible wages, the equilibrium in the labor market is given by the solution to (12) and (13). Capital of non-defaulting firms can be consumed immediately or used for production, at which point it depreciates entirely. Hence, the aggregate resource constraint is

$$\int_{\underline{Z}}^{Z^*} A K_i^{\alpha} L_i^{1-\alpha} dG(Z) = \int_{\underline{Z}}^{Z^*} [C_{ie} + K_i - K_0] dG(Z) + C_w,$$

where C_e and C_w denote the consumption of the enterpreneur and household.

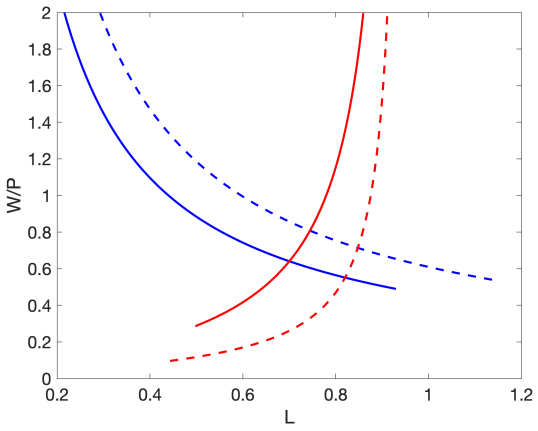
The labor market equilibrium is illustrated in Figure B.9. In response to an increase in the price level P, labor demand shifts outward, as firms financing constraints are relaxed. Moreover, labor supply shifts outward due to the negative wealth effect. The increase in labor supply dampens the increase in the real wage, consistent with the fact that real wages did not rise and actually declined during the German inflation.

Result 2: The Debt-Inflation Channel and Firm Activity. If firms have nominal debt and are financing-constrained, inflation boosts labor demand (12), increasing employment and output. The higher the level of initial debt D_0, the stronger the increase in labor demand and, thereby, the debt-inflation channel. The increase in the real wage is offset by the wealth effect on labor supply from the erosion of workers' real debt holdings.

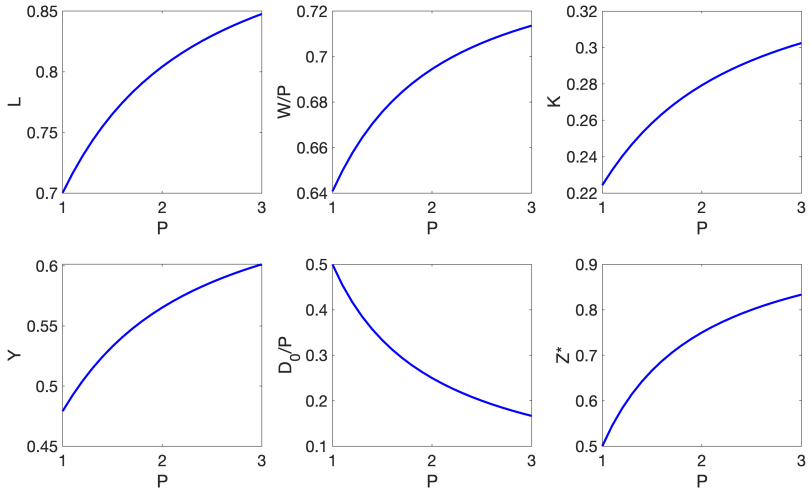
[13] If we instead assume that utility is quasi-linear, $U(C, L) = C - \chi \frac{L^{1+\varphi}}{1+\varphi}$, then labor supply would be $\frac{W}{P} = \frac{\epsilon}{\epsilon-1}\chi L^{\varphi}$, removing the wealth effect.

Figure B.9: *Labor Market Equilibrium with Flexible Wages Following an Inflation Shock*

(a) *Labor market equilibrium*



(b) *Outcomes as a function of inflation P*



Notes: Panel (a) illustrates the labor market equilibrium for a low (solid curves) and high (dashed curves) of P. Panel (b) plots equilibrium outcomes from the model with flexible wages as a function of P.

Introducing nominal wage rigidity. We introduce nominally rigidity by assuming that initially, the wage for all workers is set at W_0, which we assume is the equilibrium flexible wage with $P = 1$. Workers can alter their wages W_j, but incur a cost by doing so. Specifically, there is a menu cost of altering the wage: a worker that changes W_j from its baseline W_0 pays a cost $\psi \geq 0$ regardless of the final value of W_j. The presence of a menu cost will generate different behavior of the economy in times of normal inflation and times of hyperinflation, since workers will choose to change their wages only when inflation is at a high enough level.

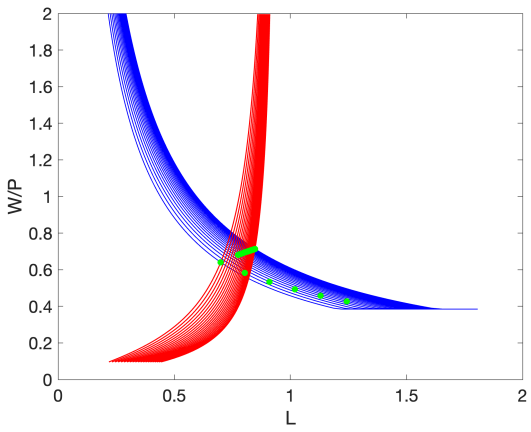
Denote W^*, L^* denote equilibrium in the labor market if the wage is adjusted. $L^d(W)$ is labor demand for a given wage W. The wage is adjusted if utility from the flexible price equilibrium, net of the cost of adjustment, exceeds the utility from the allocation

with $W = W_0$:

$$\ln\left(\frac{W^*}{P}L^* + G(Z^*)\frac{D_0}{P}\right) - \chi\frac{(L^*)^{1+\varphi}}{1+\varphi} - \psi \geq \ln\left(\frac{W_0}{P}L^d(W_0) + G(Z^*)\frac{D_0}{P}\right) - \chi\frac{L^d(W_0)^{1+\varphi}}{1+\varphi}$$

Result 3: Nominal Rigidity Channel of Inflation: Labor market equilibrium in response to shock to P depends on the size of the inflation shock. For a small inflation, the nominal wage is not updated, W/P falls, and employment increases significantly through both the nominal rigidity and debt-inflation channels. For a large increase in the price level, the wage is updated, and inflation only affects real outcomes through the debt-inflation channel. This result is illustrated with an example in Figure B.10 for various levels of the price level P.

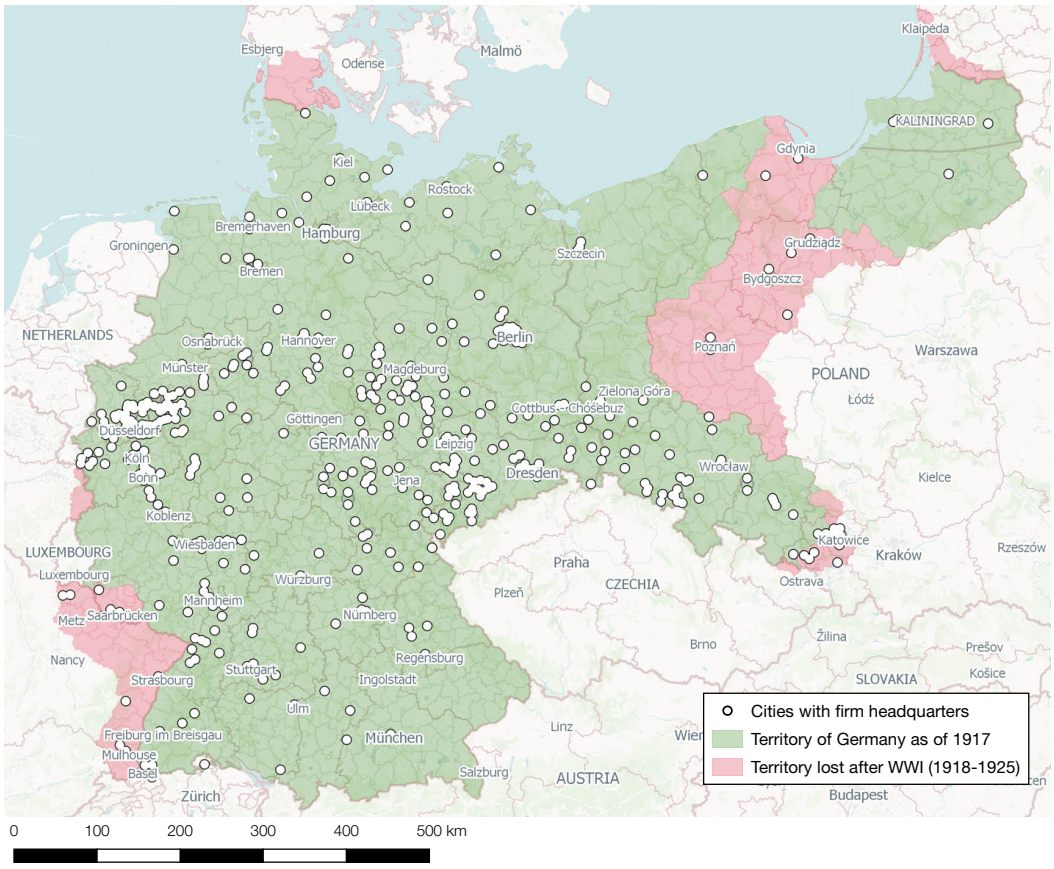
Figure B.10: *Labor Market Equilibria with Nominal Wage Rigidty for Different Levels of P*



Notes: This figure illustrates labor market equilibrium for increasing values of P in the model with nominal wage rigidity. The downward sloping blue curves are labor demand curves for different levels of P, while the upward sloping red curves are labor supply curves. Green dots indicate the equilibrium, which depends on whether the nominal wage is adjusted.

C Supplementary Figures and Tables

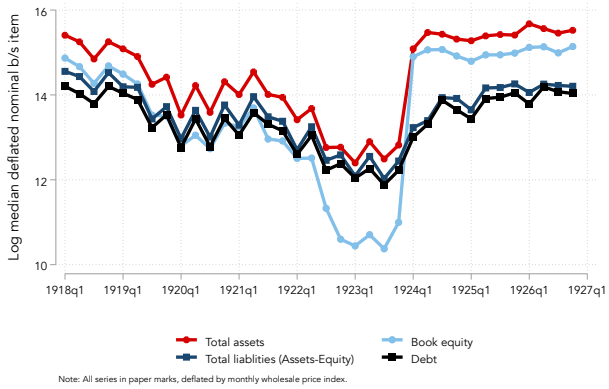
Figure C.1: *Map of Firm Headquarter Locations.*



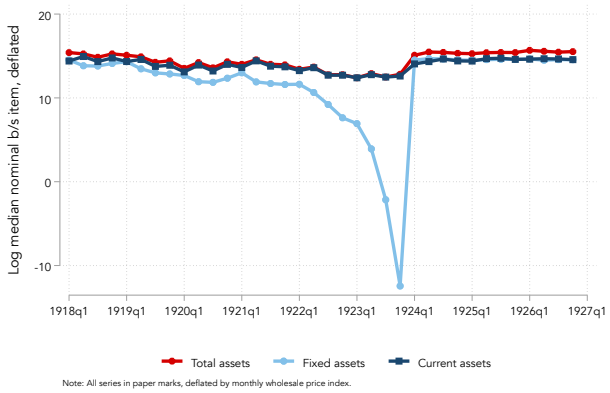
Notes: This map portrays the headquarter locations of all firms in our *Saling's* sample, alongside Germany's territorial extent as of 1917.

Figure C.2: *Balance Sheet Dynamics in Saling: Deflated Levels.*

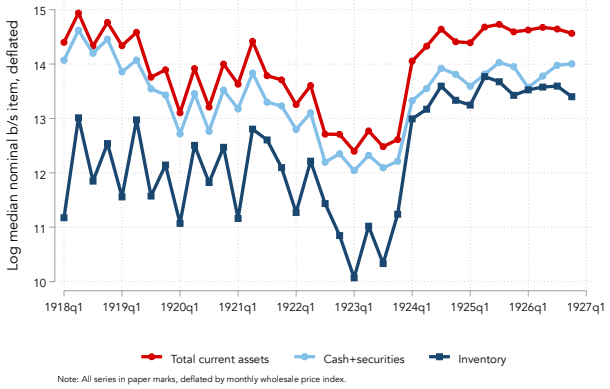
(a) *Evolution of median of liability components in paper marks, deflated.*



(b) *Evolution of median of asset components in paper marks, deflated.*

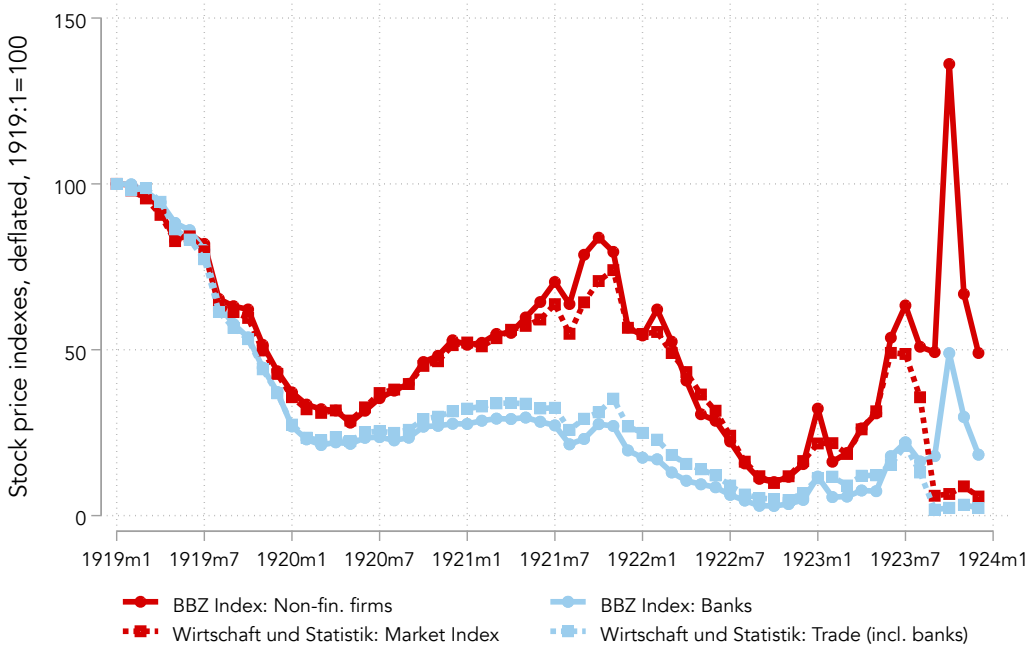


(c) *Evolution of median of current asset components in paper marks, deflated.*



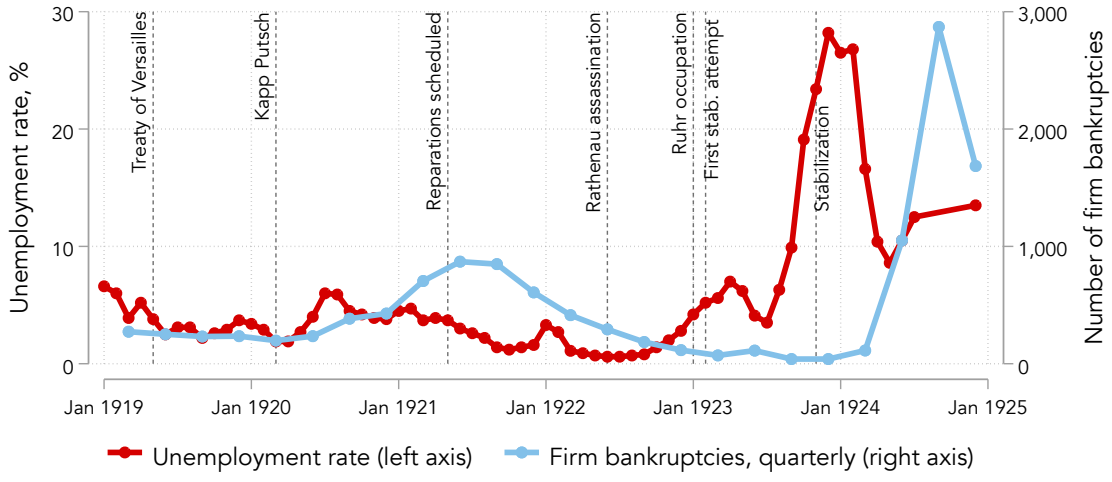
Notes: This figure plots the evolution of the medians of key balance sheet items in paper marks, deflated by the wholesale price index. The large changes in 1924Q1 occur due to the introduction of revalued Goldmark balance sheets.

Figure C.3: *Nonfinancial Equity and Bank Equity Returns Based on Indexes from Berliner Börsen Zeitung and Wirtschaft und Statistik.*



Notes: This figure plots equity indexes for nonfinancial firms and banks. We use two sources. The first is an equal-weighted from our hand-collected stock price data from *Berliner Börsen Zeitung* (BBZ). The second is published stock price indexes from *Wirtschaft und Statistik*. *Wirtschaft und Statistik*'s index for "Trade," includes banks, so we use this series as a comparison for our index of bank stocks from BBZ.

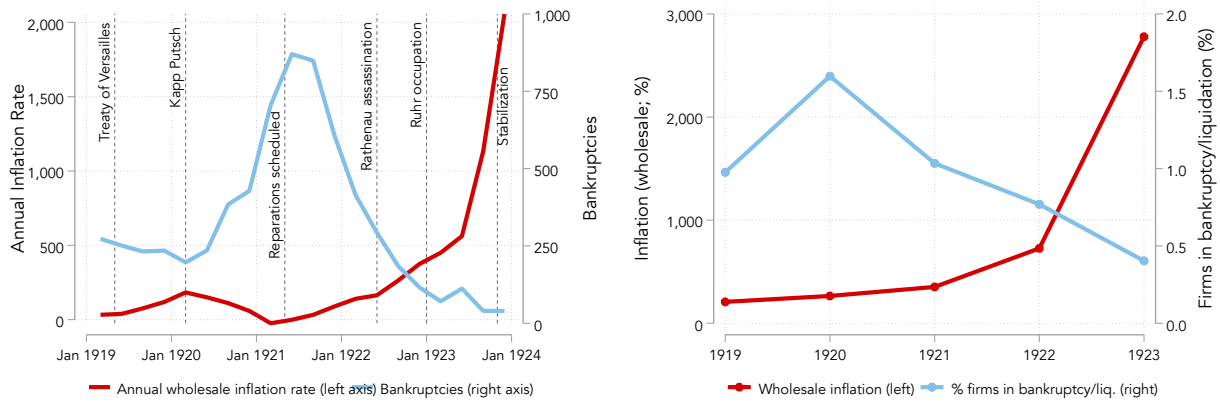
Figure C.4: *Unemployment and Firm Bankruptcies.*



Notes: Quarterly bankruptcies are from the *Vierteljahrshefte zur Statistik des Deutschen Reichs Herausgegeben vom Statistischen Reichsamt* and *Wirtschaft and Statistik*. Unemployment for industries is from *Reichsarbeitsblatt*.

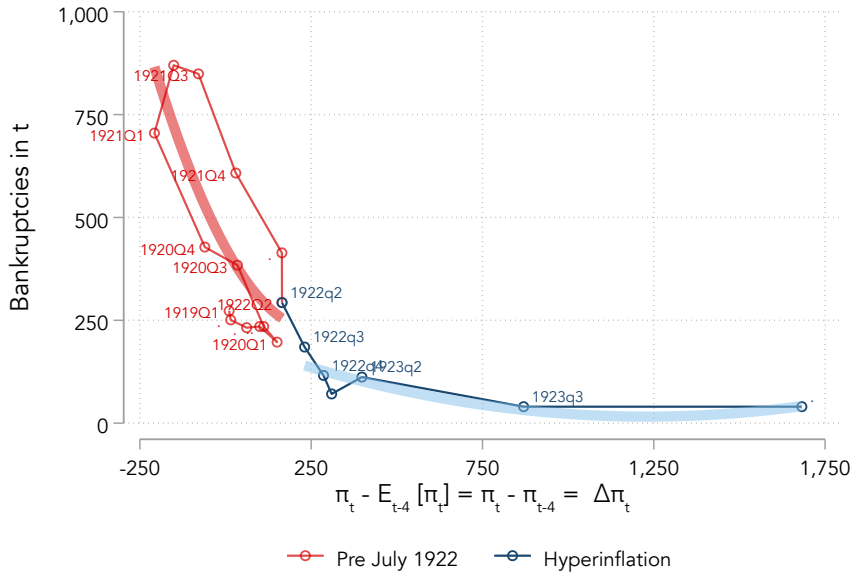
Figure C.5: *Inflation and Firm Bankruptcies.*

(a) *Inflation and bankruptcies by quarter.* **(b)** *Inflation and rate of bankruptcies by year.*



Notes: Quarterly counts of firm bankruptcies are obtained from the *Vierteljahrshefte zur Statistik des Deutschen Reichs Herausgegeben vom Statistischen Reichsamt*. Inflation of wholesale prices as reported in *Zahlen zur Geldentwertung*.

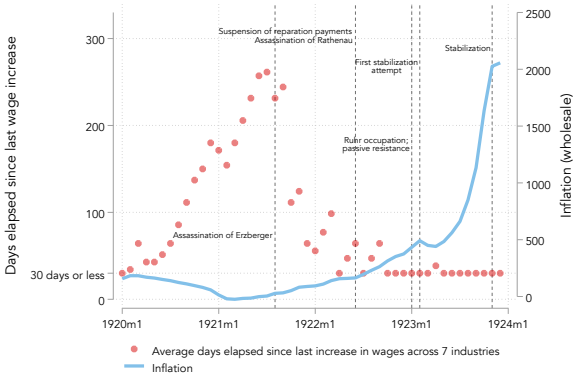
Figure C.6: *Inflation and Firm Bankruptcies: Robustness using the Acceleration in Inflation.*



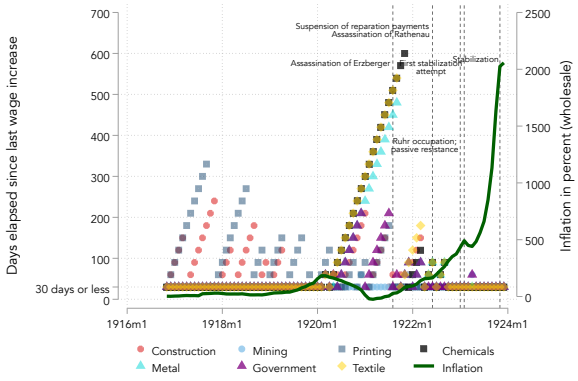
Notes: This figure plots the number of firm bankruptcies in quarter t against inflation over the past four quarters net of expected inflation over the same period. Expected inflation is assumed to be inflation over the past year from quarter $t-8$ to $t-4$. Inflation is calculated as the log change (times 100). Quarterly counts of firm bankruptcies are obtained from the *Vierteljahrshefte zur Statistik des Deutschen Reichs Herausgegeben vom Statistischen Reichsamt*. Inflation of wholesale prices as reported in *Zahlen zur Geldentwertung*.

Figure C.7: *Interval between Wage Adjustment Falls during the Inflation: Evidence from Industry-Level Wages.*

(a) *Wage adjustments.*



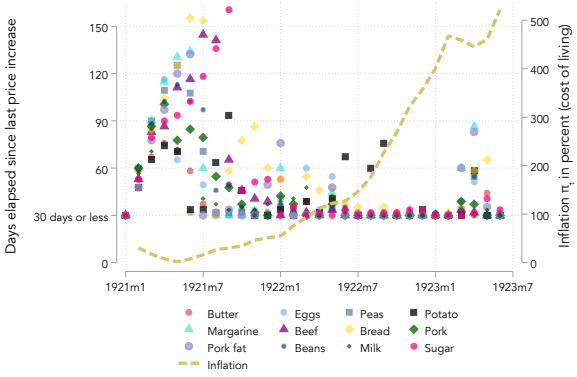
(b) *Wage adjustments, by industry.*



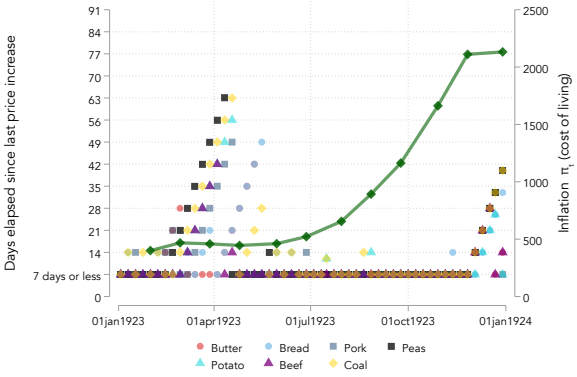
Notes: This figure plots the duration of unchanged wages over time. Wages are as reported in *Zahlen zur Geldentwertung in Deutschland von 1914 bis 1923* and *Wirtschaft und Statistik* (various issues). Inflation is defined as the difference between the log of the wholesale price level in month t and month $t-12$, times 100.

Figure C.8: *Interval between Price Adjustment Falls during the Inflation: Evidence from Cost-of-Living Index Prices.*

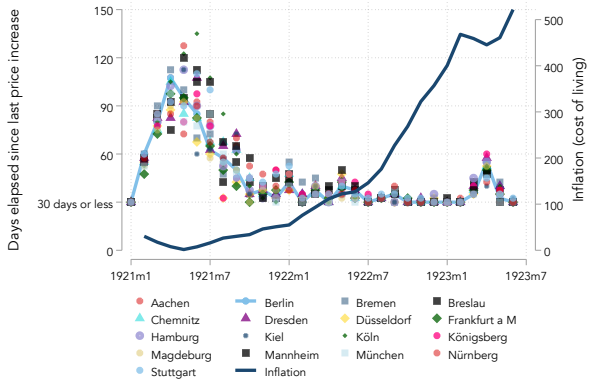
(a) *Frequency of price adjustments by type of good.*



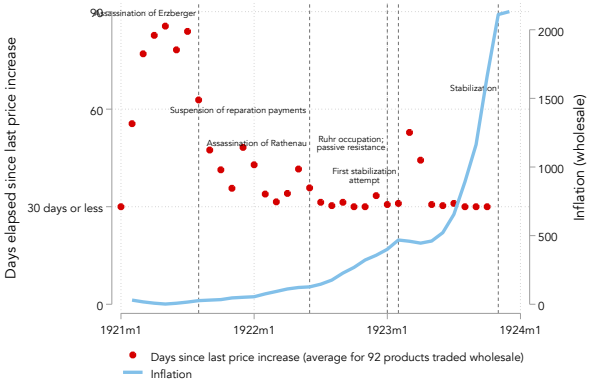
(b) *Price adjustment by product for Berlin in 1923.*



(c) *Price adjustments of 12 consumptions goods by city.*



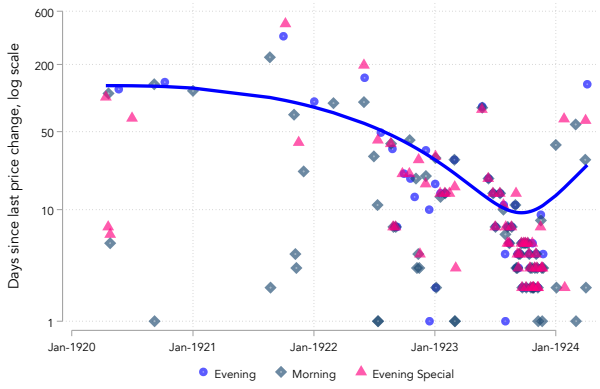
(d) *Price adjustments for 95 wholesale-traded products.*



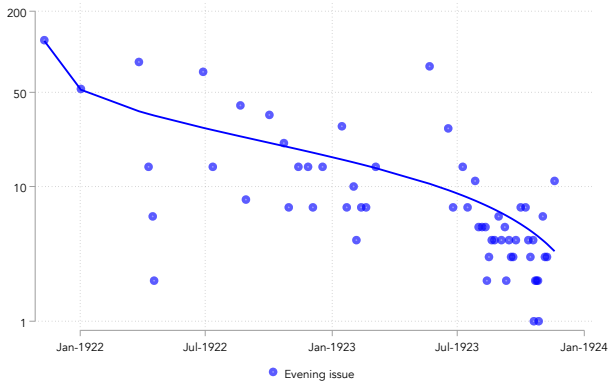
Notes: This figure plots the duration of retail product prices, for products underlying the cost-of-living index. Retail prices are as reported in *Zahlen zur Geldentwertung in Deutschland von 1914 bis 1923* and *Wirtschaft und Statistik* (various issues). Inflation is defined as the difference between the log of the cost-of-living index in month t and month $t-12$, times 100.

Figure C.9: *Interval between Price Adjustment Falls during the Inflation: Evidence from Newspaper Prices.*

(a) *Daily newspaper prices, Berliner Börsen Zeitung.*



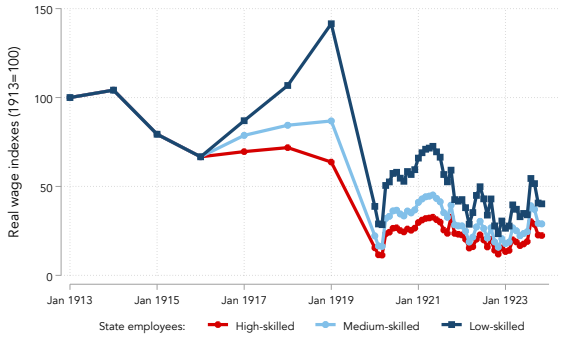
(b) *Daily newspaper prices, Berliner Tageblatt und Handels-Zeitung.*



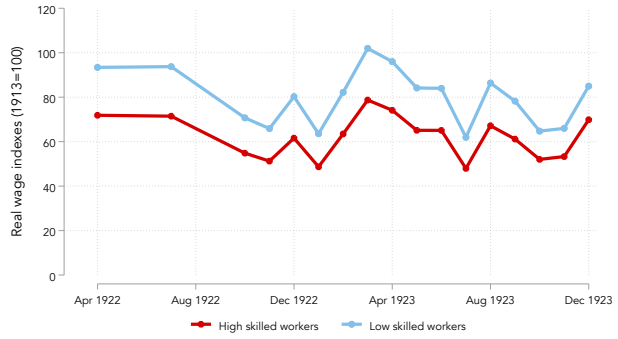
Notes: This figure plots the duration of unchanged prices for various issues of two German newspapers, the *Berliner Börzen Zeitung* and the *Berliner Tageblatt und Handels-Zeitung*. Daily newspaper prices are hand-collected from scans of the newspapers.

Figure C.10: *Real Wages Declined Relative to 1913 during Germany's Inflation, Especially for High-skilled Workers.*

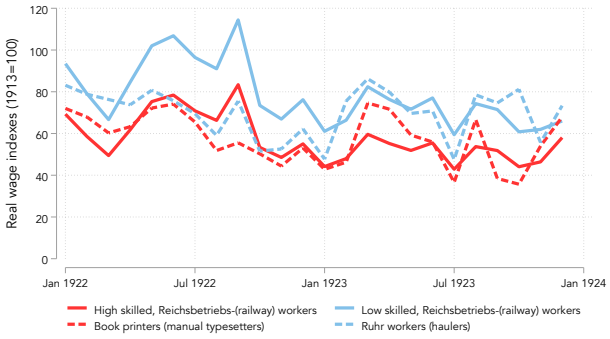
(a) *Real wages of state employees*



(b) *Real wages of high and low skilled workers, six-industry average*



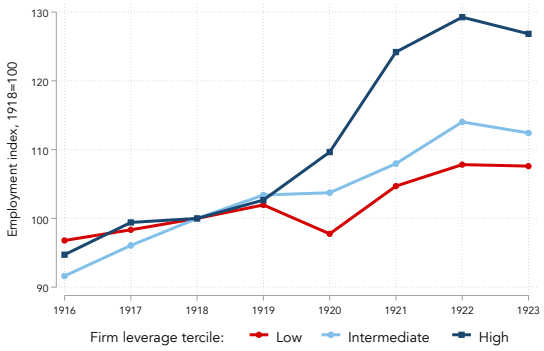
(c) *Real wages of public railroad workers, Ruhr workers, and book printers*



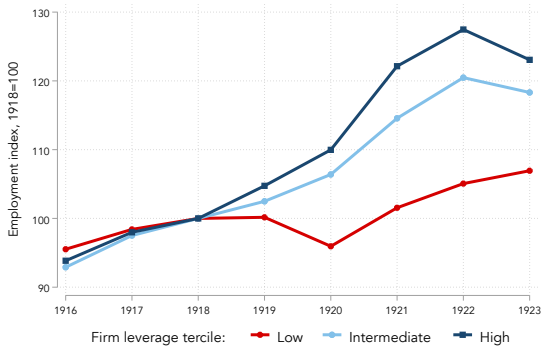
Notes: This figure plots the evolution of real wages for various groups of workers and industries. Wage data are from *Wirtschaft und Statistik*. Real wages are deflated by wholesale prices.

Figure C.11: *Employment Dynamics across Low and High Leverage Firms: Alternative Measures of Leverage.*

(a) *Sorting firms by average liabilities to assets over 1917-1919*

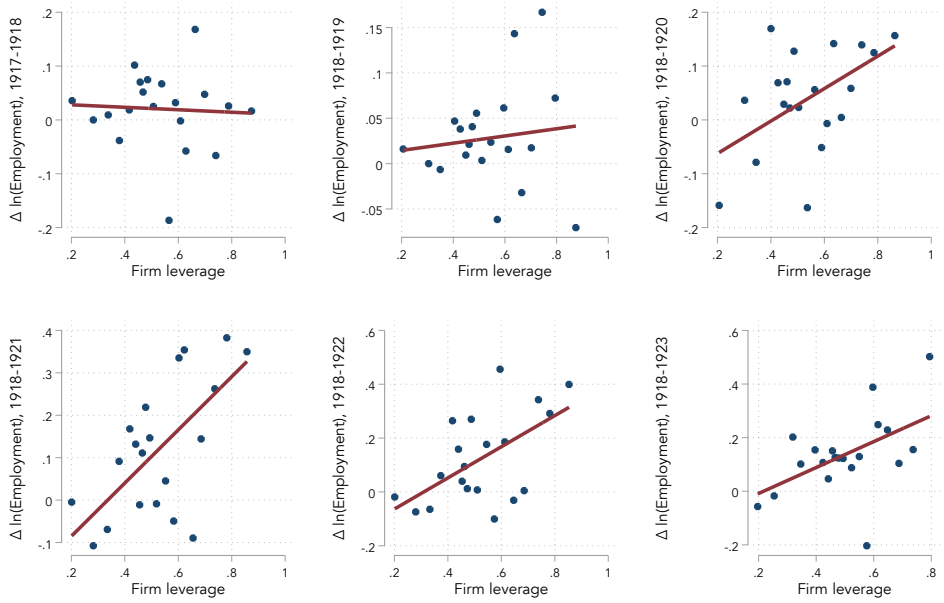


(b) *Sorting firms by average financial debt to assets over 1918-1919*



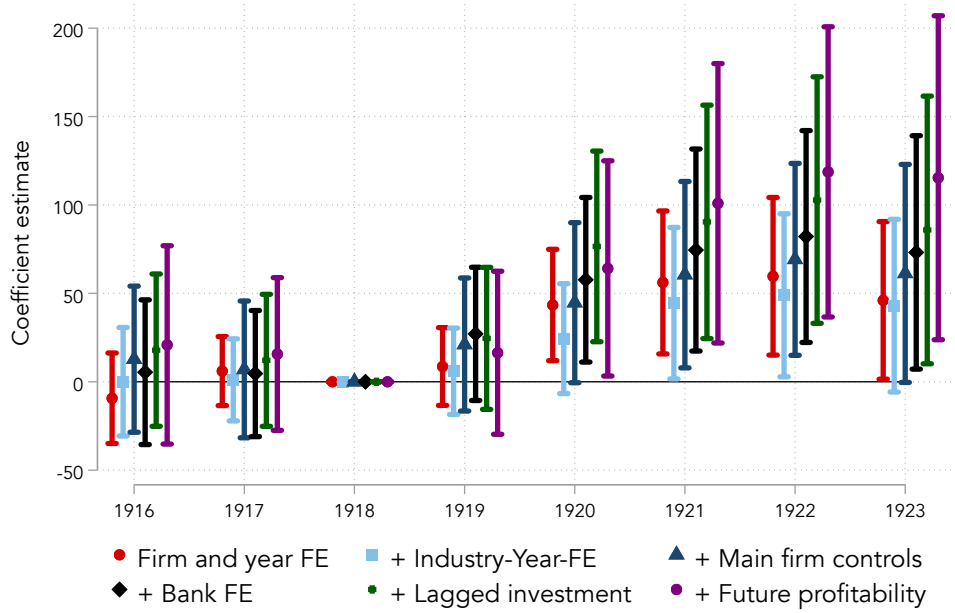
Notes: This figure presents the average evolution of employment for firms in the bottom, middle, and top terciles of leverage. Leverage is defined as the average of liabilities-to-assets over 1917 to 1919 (panel a) or financial debt to assets (panel b). Employment is indexed to 100 in 1918 for each group.

Figure C.12: *Firm Leverage and Firm Employment Growth During the Inflation.*



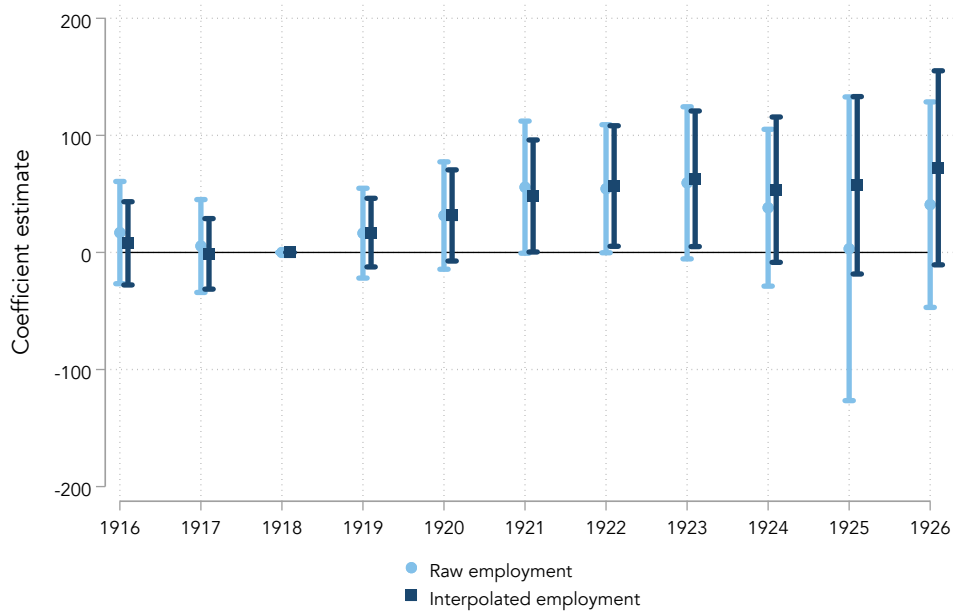
Notes: This figure plots binned bivariate means of firm-level employment growth (defined as the change in log employment, multiplied by 100) in each year from 1917 to 1923, relative to 1918. Firm leverage is defined as $\frac{Liabilities}{Assets}$, averaged over 1918 and 1919.

Figure C.13: *Firm Leverage and Firm Employment: Robustness to Inclusion of Various Sets of Controls.*



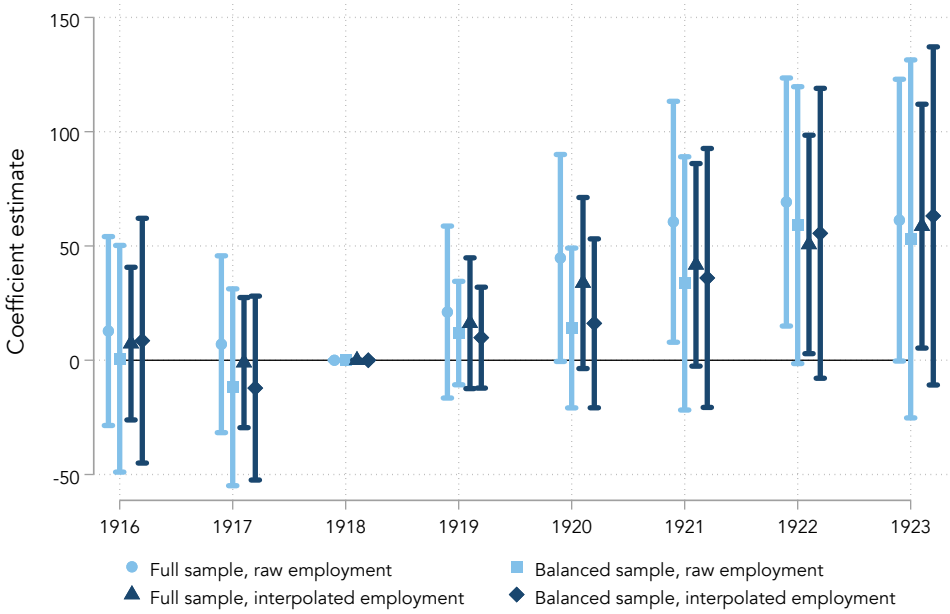
Notes: This figure is similar to Figure 7, but it reports estimates for various other control sets. "Firm and year FE" are from estimates of (1) with only firm and year fixed effects. "+ Industry-Year FE" are from a specification that adds industry-year fixed effects. "+ Main firm controls" further include firm controls interacted with year fixed effects. Firm controls are log assets, fixed assets to total assets, return on assets, and EBIT margin, all as of 1918-1919. "+ Bank FE" are from a specification that further adds fixed effects for a connection to one of seven major banks, as well a fixed effect for firms with a connection to a bank that is not one of the major banks and a fixed effect indicator for firms without any banking connections. This specification also includes the distance to Berlin, another proxy of exposure to shifts in credit supply. "+ Lagged investment" is from a specification that also controls for investment in 1916, 1917, and 1918. Investment is defined as $\frac{FixedAssets_{it}-FixedAssets_{it-1}}{TotalAssets_{it-1}}$. "+ Future profitability" also controls for return on assets and EBIT-margin in 1920, 1921, and 1922, during the inflation boom. Bank fixed effects and all controls are also interacted with year fixed effects. Error bars represent 95% confidence intervals from standard errors clustered at the firm level.

Figure C.14: *Firm Leverage and Firm Employment: Longer-Run Effects.*



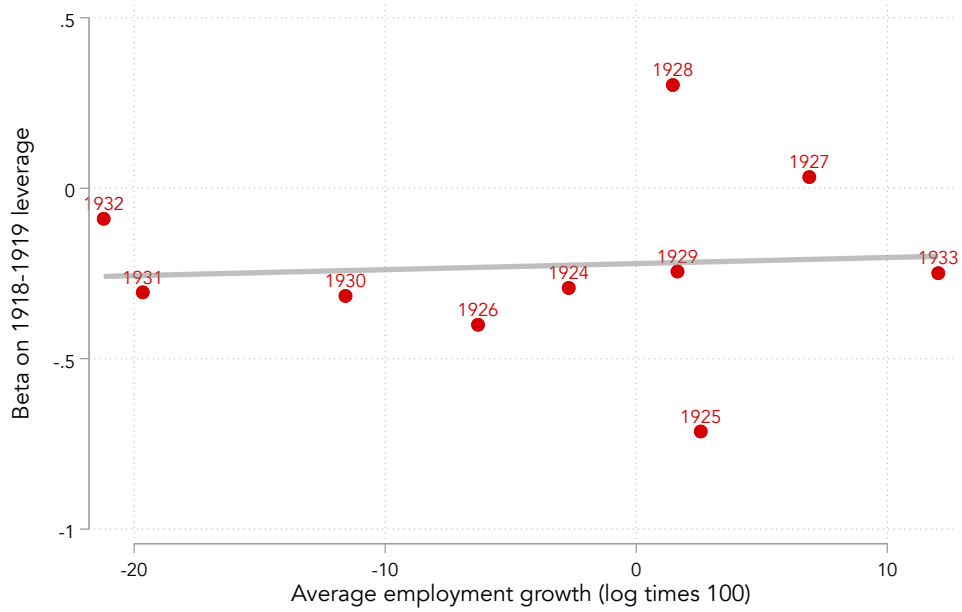
Notes: This figure is similar to Figure 7, but it reports estimates for a longer panel of employment data that extends to 1926. Estimates from "Raw employment" use the raw employment data reported in *Saling's*. Estimates from "Interpolated employment" use interpolated employment as the dependent variable. Interpolated employment is constructed by linearly interpolating gaps in the raw employment series. For example, the firm "Gebrüder Bing AG" reported employment of 16,000 in 1924 and 6,500 in 1926 but did not report employment in 1925, so we impute employment in 1925 to equal 11,250.
All specifications control for industry-year fixed effects and firm controls interacted with year fixed effects (log assets, fixed assets to total assets, return on assets, and EBIT margin, all as of 1918-1919). Error bars represent 95% confidence intervals from standard errors clustered at the firm level.

Figure C.15: *Firm Leverage and Firm Employment: Robustness to Alternative Measures of Employment and Sample Restrictions.*



Notes: This figure is similar to Figure 7, but it reports estimates for alternative measures of employment and sample restrictions. Estimates denoted by "Full sample, raw employment" are equivalent to the estimates in Figure 7(b) "Industry-Year FE and firm controls." Estimates denoted by "Balanced sample, raw employment" restrict to the sample of firms that report employment in Salings in every year between 1916 and 1923. "Full sample, interpolated employment" uses all firms that report employment and linearly interpolates gaps in employment. "Balanced sample, interpolated employment" is estimated on the sample of firms for which interpolated employment is available in every year between 1916 and 1923.
All specifications control for industry-year fixed effects and firm controls interacted with year fixed effects (log assets, fixed assets to total assets, return on assets, and EBIT margin, all as of 1918-1919). Error bars represent 95% confidence intervals from standard errors clustered at the firm level.

Figure C.16: *Firm Leverage and Firm Employment Growth: Placebo on Post-Hyperinflatin period from 1924-1933.*



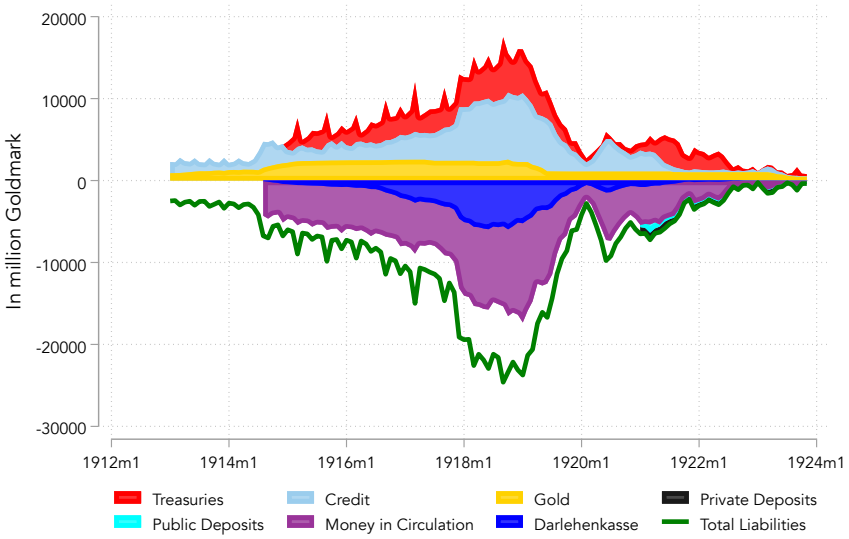
Notes: This figure shows that firms with higher leverage as of 1918-1919 do not have higher business cycle exposure in the post-inflation period (1924-1933). The figure correlates average annual firm employment growth with the beta from a regression of firm employment growth on firm leverage:

$$\Delta \ln(Employment_{it}) = \alpha^t + \beta^t Leverage_{i,1918-1919} + \gamma_s^t + X_i \Gamma^t + \epsilon_{it}, \quad t = 1924, ..., 1933,$$

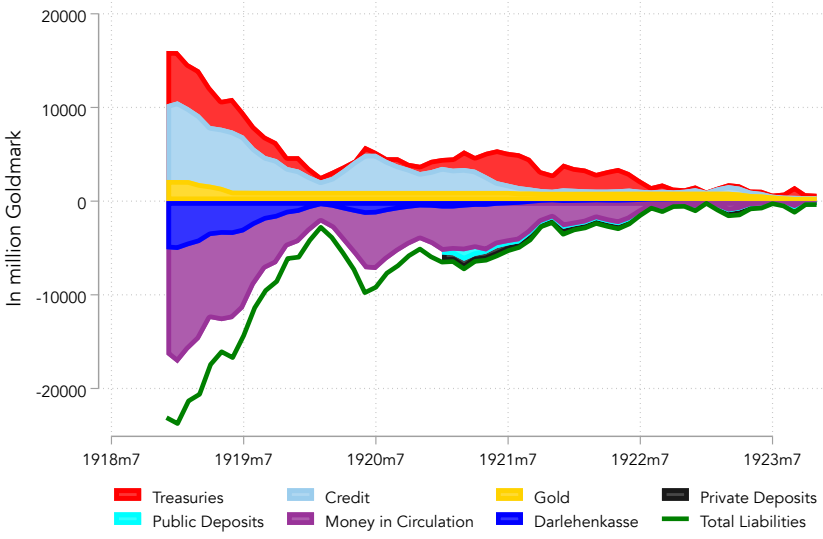
where leverage is defined as $\frac{Liabilities}{Assets}$ averaged over 1918 and 1919, γ_s^t is an industry fixed effect, and X_i are firm controls. The regression is estimated each year from 1924 to 1933. This exercise tests whether high leverage firms have higher employment growth during years of high aggregate employment growth. The flat relationship implies that high leverage firms do not have a higher "beta" on the employment expansions and contractions after the hyperinflation. For example, high leverage firms do not have stronger employment growth during the 1927-1928 expansion, and high leverage firms also do not see larger employment declines in the Great Depression (1930-32).

Figure C.17: *Reichsbank Balance Sheet in Goldmarks.*

(a) *1914-1923*



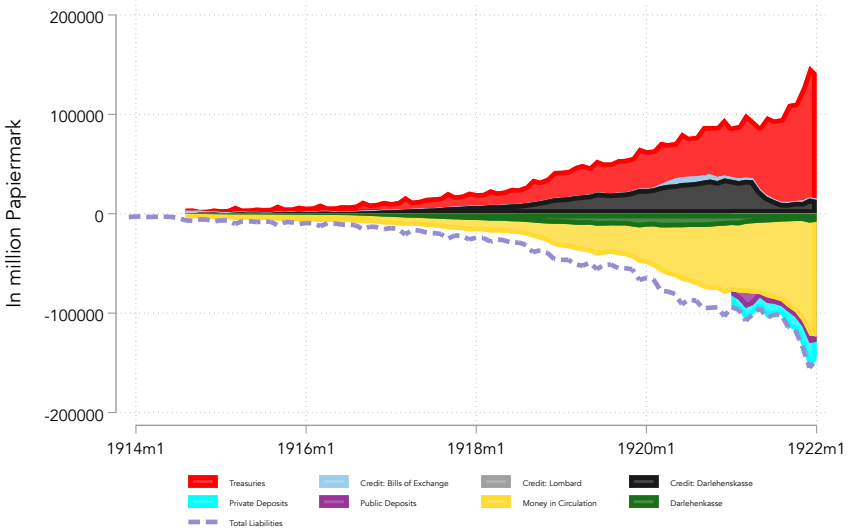
(b) *1919-1923*



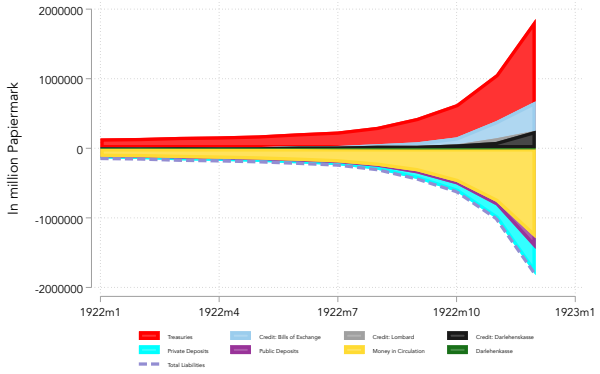
Notes: Data are from *Zahlen zur Geldentwertung*.

Figure C.18: *Reichsbank Balance Sheet in Papiermarks.*

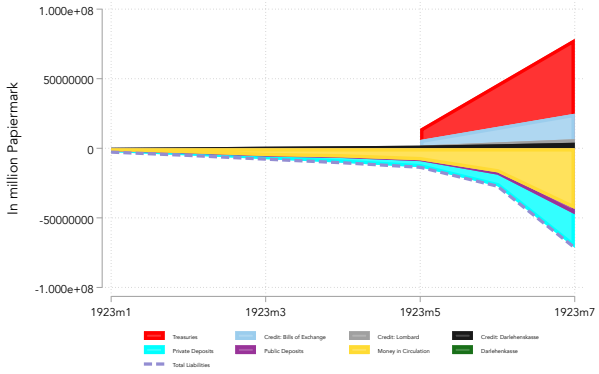
(a) *1914-1921*



(b) *1922*



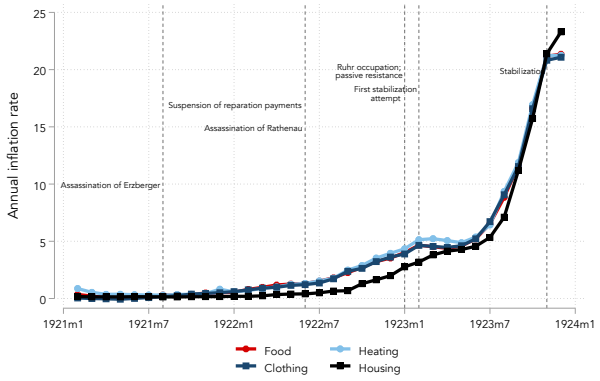
(c) *1923*



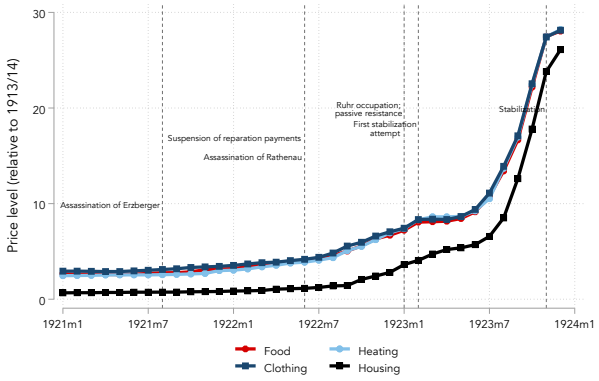
Notes: Data are as reported in *Zahlen zur Geldentwertung*.

Figure C.19: *Cost of Living and Wholesale Prices by Type.*

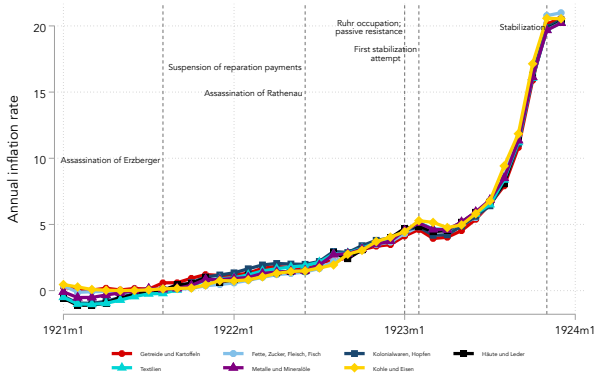
(a) *Cost of living inflation.*



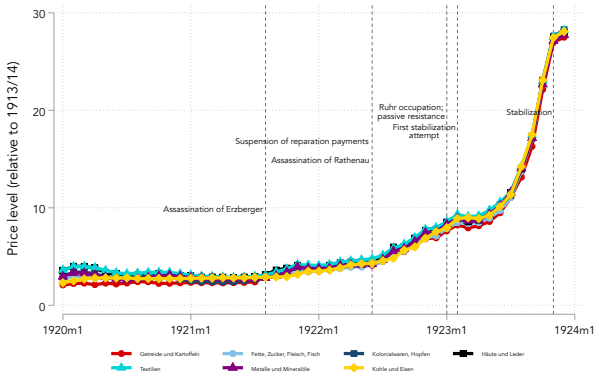
(b) *Cost of living price level.*



(c) *Wholesale goods inflation.*



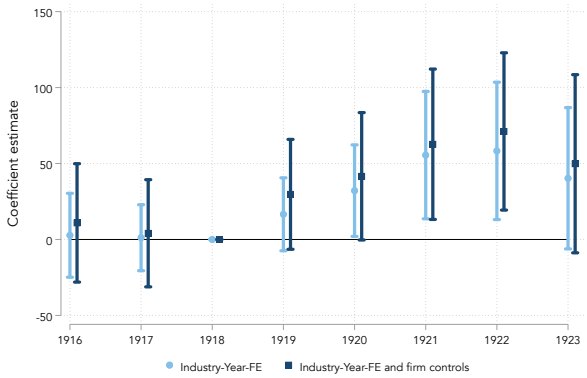
(d) *Wholesale goods price level.*



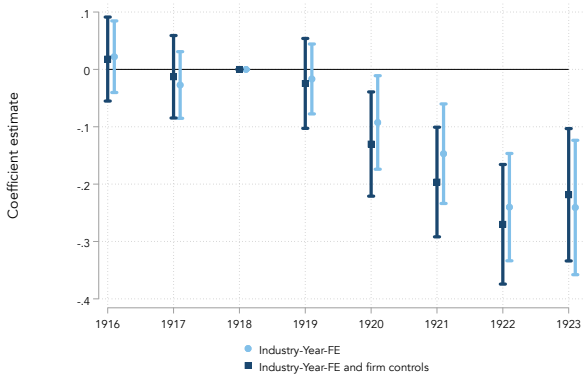
Notes: Data are from *Zahlen zur Geldentwertung*.

Figure C.20: *Firm Leverage, Interest Expenses, and Material Expenses and Salaries: Robustness using Financial Debt to Assets.*

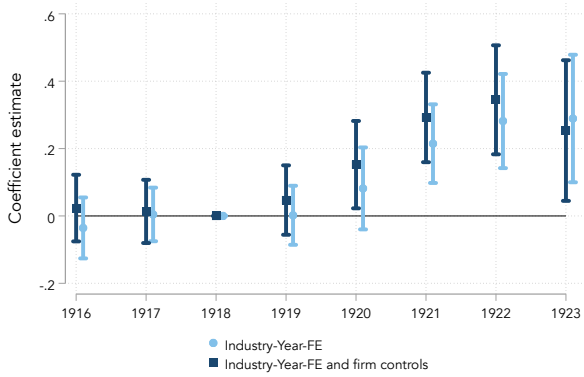
(a) *Employment.*



(b) *Interest Expenses.*



(c) *Production Expenses.*

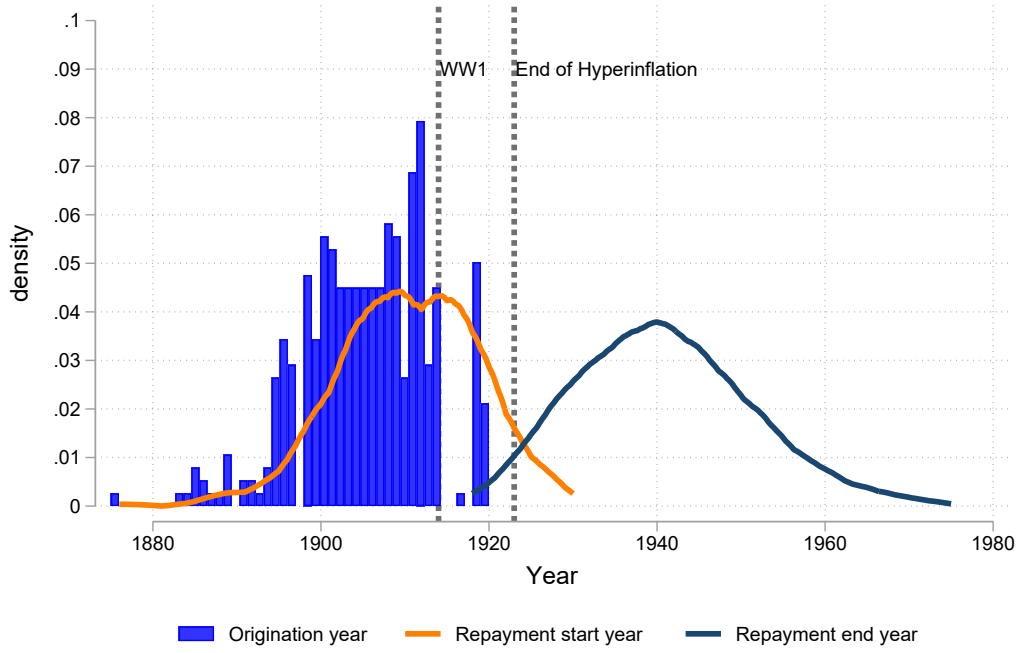


Notes: The figure plots the sequence of estimates $\{\beta_k\}$ from estimating the following model:

$$y_{it} = \alpha_i + \gamma_{st} + \sum_{k \neq 1918} \beta_k Debt/Assets_{i,1918-1919} \mathbf{1}_{k=t} + \sum_{k \neq 1918} X_i \Gamma_k \mathbf{1}_{k=t} + \epsilon_{it},$$

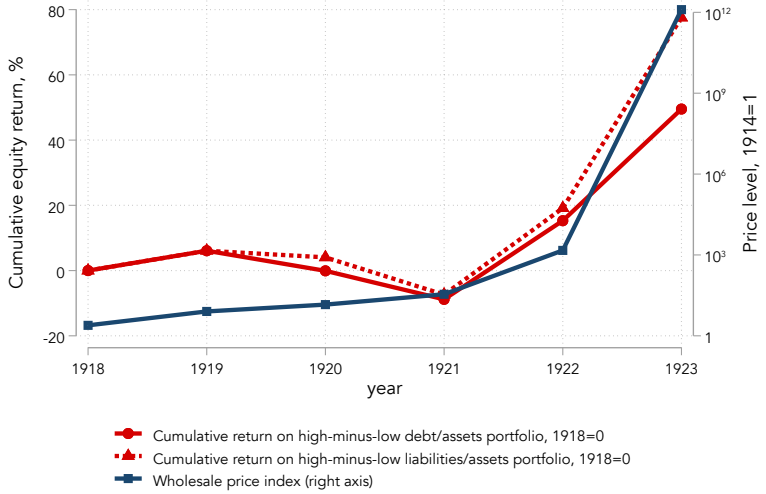
where y_{it} is either log employment, the ratio of interest expenses to total expenses, or the ratio of materials and salary expenses to total expenses. Further, α_i is a set of firm fixed effect, γ_{st} a set of industry-year fixed effects, $Debt/Assets_{i,1919}$ is firm i's financial debt-to-assets ratio in 1919 and X_i is our set of firm-level control variables. Error bars represent 95% confidence intervals based on standard errors clustered at the firm level.

Figure C.21: *The Prevalence of Long-Term Bonds: Origination Year, Repayment Start Year, and Final Maturity for Outstanding Bonds of Nonfinancial Firms in 1918 and 1919.*



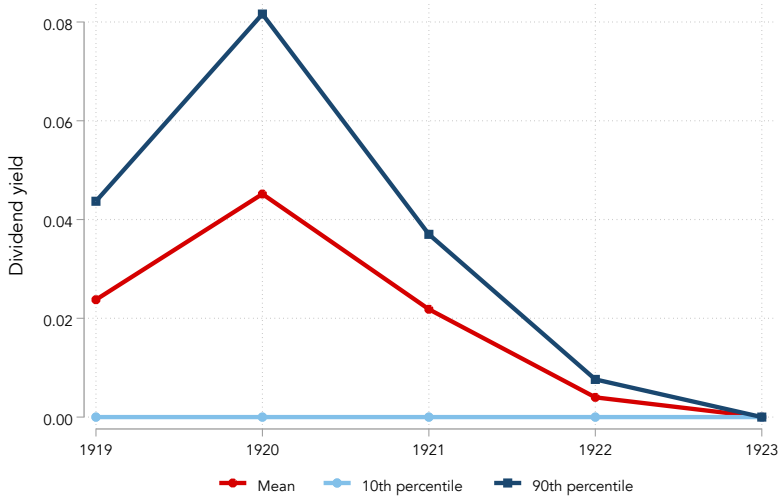
Notes: This figure shows the origination year, repayment start year, and final maturity for outstanding bonds reported by nonfinancial firms in 1918 and 1919. Data obtained from *Saling's Börsenjahrbuch* published in 1919 and 1920. $N = 417$. 51% of firms in the sample report information on at least one bond.

Figure C.22: *High Leverage Firms' Stock Returns Outperformed Low Leverage Firms during the Inflation.*



Notes: This figure plots the cumulative return on a portfolio that goes long firms in the top quintile of leverage and short firms in the bottom quintile of leverage (1918=0). Returns for year t are based on portfolios that are resorted at the end of year $t-1$ based on leverage reported in year $t-1$.

Figure C.23: *Dividend Yields, 1919-1923.*



Notes: This figure plots the mean, 10^{th} percentile, and 90^{th} percentile of the dividend yield distribution from 1919 to 1923. The dividend yield for a firm is defined as the total dividend per share paid out in year t relative to the share price at the end of year $t-1$. The analysis is based on firm-level data collected from the *Berliner Börsen Zeitung*.

Table C.1: *Time Series Estimates of the Bankruptcy-Inflation Relation.*

	(1)	(2)	(3)	(4)	(5)	(6)
Inflation	-0.28**	-1.06***	-2.39**	-4.26	-0.093*	-0.43**
	(0.10)	(0.29)	(0.82)	(2.48)	(0.044)	(0.15)
Inflation^2		0.00041**		0.011		0.00015*
		(0.00015)		(0.014)		(0.000066)
Observations	20	20	14	14	7	7
R^2	0.30	0.52	0.42	0.45	0.47	0.77
Sample	1919-1923	1919-1923	1919-July 1922	1919-July 1922	July 1922-1923	July 1922-1923
Frequency	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly

Notes: This table shows results from estimating the following equation:

$$\text{Bankruptcies}_t = \alpha + \beta \times \pi_t + \epsilon + t,$$

were t is quarterly, and π_t is the inflation in wholesale prices from $t-4$ to t. Quarterly counts of firm bankruptcies are obtained from the *Vierteljahrshefte zur Statistik des Deutschen Reichs Herausgegeben vom Statistischen Reichsamt*. Inflation of wholesale prices as reported in *Zahlen zur Geldentwertung*. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table C.2: *Correlates of Firm Leverage.*

	$\text{Leverage}_{i,1918-1919}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(\text{Total Assets})_{i,1918-1919}$	0.061***					0.065***
	(0.0049)					(0.0059)
$\text{Fixed Assets/Total Assets}_{i,1918-1919}$		-0.15***				-0.076**
		(0.031)				(0.036)
$\text{EBIT margin}_{i,1918-1919}$			0.092***			-0.0085
			(0.030)			(0.031)
$\text{ROA}_{i,1918-1919}$				-0.035		-0.072
				(0.12)		(0.11)
Observations	794	794	754	739	793	724
R^2	0.18	0.040	0.014	0.00013	0.12	0.32
Industry Fixed Effects					✓	✓

Notes: This table shows results from estimating the following equation:

$$\text{Leverage}_{i,1918-1919} = \alpha + \beta \times X_{i,1918-1919} + \epsilon_i,$$

where $Leverage_{i,1918-1919}$ is defined as average liabilities to assets over 1918-1919 and $X_{i,1918-1919}$ is a firm level variable. Robust standard errors in parentheses. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table C.3: *Firm Leverage and Employment—Robustness to Different Measures of Leverage.*

Dependent Variable	ln(Employment)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liabilities/Assets$_{i,1918}$ $\times \mathbf{1}_{t\geq 1920}$	37.2**	25.4*						
	(14.4)	(15.2)						
Debt/Assets$_{i,1918} \times \mathbf{1}_{t\geq 1920}$			37.8**	32.3*				
			(15.8)	(16.6)				
Liabilities/Assets$_{i,1919}$ $\times \mathbf{1}_{t\geq 1920}$					43.8***	38.1**		
					(15.1)	(15.4)		
Debt/Assets$_{i,1919} \times \mathbf{1}_{t\geq 1920}$							43.9***	41.7***
							(14.8)	(14.9)
Observations	1785	1742	1785	1742	1857	1809	1857	1809
Number of Firms	331	326	331	326	344	338	344	338
R^2	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Year FE	✓		✓		✓		✓	
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Industry-Year-FE		✓		✓		✓		✓

Notes: This table reports results from a model estimating:

$$y_{it} = \alpha_i + \delta_{st} + \beta \times (Leverage_{i,1919} \times \mathbf{1}_{t\geq 1920}) + \Gamma \times (X_i \times \mathbf{1}_{t\geq 1920}) + \epsilon_{it}.$$

where y_{it} is firm i's number of employees (in logs, multiplied by 100). $Leverage_{i,t}$ is either the ratio of firm i's financial debt or total liabilities to total assets in year t. α_i is a set of firm fixed effects, δ_{st} is a set of industry-time fixed effects, and X_i is a vector of firm-level controls consisting of firm size (log of assets), the share of fixed assets in total assets, return on assets, and profit margin. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table C.4: *Firm Leverage and Employment—Robustness to Various Additional Controls.*

Panel A: Liabilities/Assets Leverage Measure						
	ln(Employment)					
	(1)	(2)	(3)	(4)	(5)	(6)
Liabilities/Assets$_{i,1918-1919}$ $\times \mathbf{1}_{t\geq 1920}$	45.7***	51.8**	58.6***	58.9***	54.0***	47.0**
	(16.1)	(21.9)	(21.7)	(22.2)	(20.5)	(21.2)
Observations	1912	1726	1719	1626	1626	1470
Number of Firms	357	322	321	302	302	274
R^2	0.97	0.97	0.97	0.97	0.97	0.98

Panel B: Debt/Assets Leverage Measure						
	ln(Employment)					
	(1)	(2)	(3)	(4)	(5)	(6)
Debt/Assets$_{i,1918-1919}\times \mathbf{1}_{t\geq 1920}$	44.0***	49.0**	56.1***	59.0***	52.4***	44.9**
	(16.2)	(21.2)	(21.0)	(21.3)	(20.1)	(20.1)
Observations	1912	1726	1719	1626	1626	1470
Number of Firms	357	322	321	302	302	274
R^2	0.97	0.97	0.97	0.97	0.97	0.98
Year FE	✓					
Firm FE	✓	✓	✓	✓	✓	✓
Industry-Year-FE		✓	✓	✓	✓	✓
Baseline Controls $\times$ $\mathbf{1}_{t\geq 1920}$		✓	✓	✓	✓	✓
Large Banks FE $\times$ $\mathbf{1}_{t\geq 1920}$		✓	✓	✓	✓	✓
Quintiles of Dist. to Berlin $\times$ $\mathbf{1}_{t\geq 1920}$			✓	✓	✓	✓
Lagged Investment Controls $\times$ $\mathbf{1}_{t\geq 1920}$				✓	✓	✓
Future Profitability Controls $\times$ $\mathbf{1}_{t\geq 1920}$					✓	✓
Sample	Full	Full	Full	Full	Full	Tradable

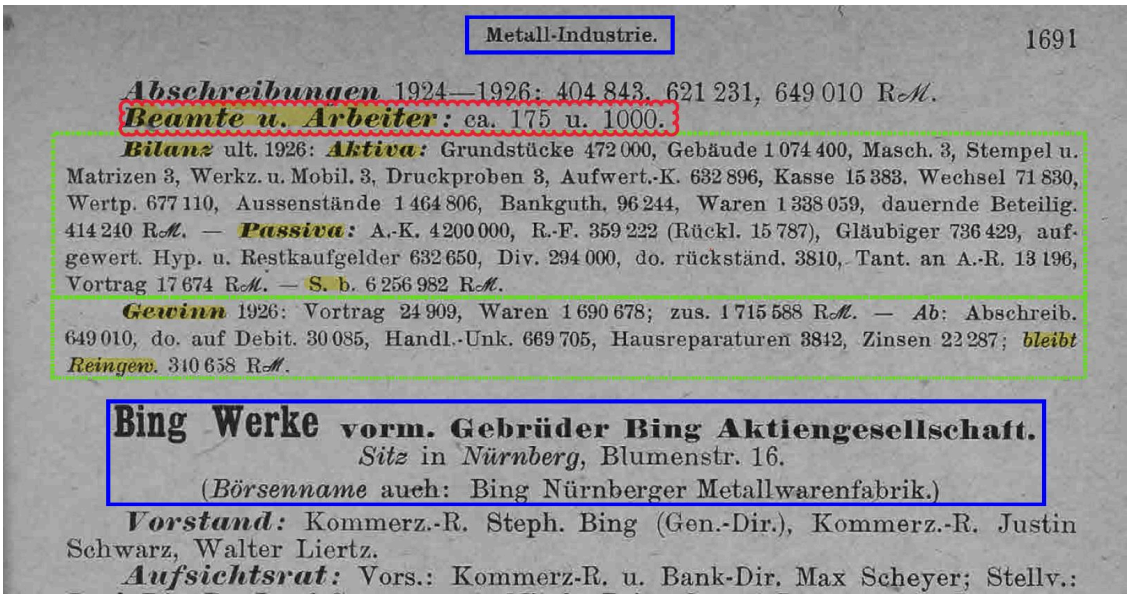
Notes: This table is similar to Table 2 but adds additional controls for proxies of credit supply. Panels A and B present estimates of (2) using liabilities-to-assets and debt-to-assets as of 1918-19 as the leverage variable, respectively. Column 1 corresponds to columns 1 and 4 in Table 2. Column 2 adds industry-year fixed effects, baseline firm controls, and fixed effects for bank connections. The baseline controls are firm size (log of assets), the share of fixed assets in total assets, return on assets, and profit margin. The bank fixed effects are defined as indicator variables for whether a firm has a connection to one of seven major banks (Commerz- und Privat-Bank, Darmstädter Bank, Deutsche Bank, Deutsche Nationalbank, Disconto-Gesellschaft, Dresdner Bank, and Berlin Handels-Gesellschaft). We also include an indicator variable for firms with a connection to a bank that is not one of the major banks and an indicator for firms without any banking connections (nine bank-time FE in total). Columns 3 further control for five dummy variables for quintiles of the distance from a firm's headquarters to Berlin. Column 4 adds controls for firm investment in 1916, 1917, and 1918. Investment is proxied with $\frac{FixedAssets_{it}-FixedAssets_{it-1}}{TotalAssets_{it-1}}$. Column 5 adds controls for proxies of future profitability: return on assets and EBIT-to-revenue in 1920, 1921, and 1922. All controls in all columns are interacted with the post-1920 fixed effect. Column 6 restrict to the sample of firms in the tradable sector, defined as mining and manufacturing industries. This excludes firms in construction, utilities, transport, and services. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

D Data Appendix

D.1 Firm-level Financial Data

We obtain firm financial information from *Saling's Börsen-Jahrbuch*, a German investor manual published annually throughout our sample and made available in digital format by the University of Mannheim.[14] For each firm, *Saling's* lists a header followed by sections on various topics such as the composition of the board, dividend payments, firm history, existing bonds, etc. We focus on five key sections. First, we compile general information about the firm, including its name, any name variants, the location of its headquarters, and its industry. These are represented in the two blue boxes in Figure D.1. Second, we obtain balance sheet information, reported in *Saling's* in paragraph form, as shown in the first dashed green box of fig. D.1. Third, we obtain firms' income statements, as shown in the second green box. Fourth, we obtain employment counts, as shown in the red box. Finally, we also obtain information on outstanding bonds as described in more detail further below in this Appendix.

Figure D.1: *Annotated Extract of the 1927 Edition of* Saling's Börsen-Jahrbuch.


Metall-Industrie. 1691

Abschreibungen 1924—1926: 404 843, 621 231, 649 010 R*M*.
Beamte u. Arbeiter: ca. 175 u. 1000.
Bilanz ult. 1926: **Aktiva:** Grundstücke 472 000, Gebäude 1 074 400, Masch. 3, Stempel u. Matrizen 3, Werkz. u. Mobil. 3, Druckproben 3, Aufwert.-K. 632 896, Kasse 15 383, Wechsel 71 830, Wertp. 677 110, Aussenstände 1 464 806, Bankguth. 96 244, Waren 1 338 059, dauernde Beteilig. 414 240 R*M*. — **Passiva:** A.-K. 4 200 000, R.-F. 359 222 (Rückl. 15 787), Gläubiger 736 429, aufgewert. Hyp. u. Restkaufgelder 632 650, Div. 294 000, do. rückständ. 3810, Tant. an A.-R. 13 196, Vortrag 17 674 R*M*. — S. b. 6 256 982 R*M*.
Gewinn 1926: Vortrag 24 909, Waren 1 690 678; zus. 1 715 588 R*M*. — *Ab*: Abschreib. 649 010, do. auf Debit. 30 085, Handl.-Unk. 669 705, Hausreparaturen 3842, Zinsen 22 287; *bleibt Reingew.* 340 658 R*M*.

Bing Werke vorm. Gebrüder Bing Aktiengesellschaft.
Sitz in *Nürnberg*, Blumenstr. 16.
(*Börsenname* auch: Bing Nürnberger Metallwarenfabrik.)

Vorstand: Kommerz.-R. Steph. Bing (Gen.-Dir.), Kommerz.-R. Justin Schwarz, Walter Liertz.
Aufsichtsrat: Vors.: Kommerz-R. u. Bank-Dir. Max Scheyer; Stellv.:

Notes: This scanned image illustrates some of the key sections of *Saling's* that we identify and process to construct our balance sheet, income statement, and employment data. These are, from top to bottom: i) the page header indicating the industry of the firms in the current book chapter (blue solid box), ii) employment count (red curved box), iii) a balance sheet (first solid green box), iv) an income statement (second solid green box), and v) the firm header containing its name and the location of its headquarters. Some of the keywords used to identify blocks are also highlighted in yellow.

[14] In particular, we use the second volume of this series, known as *Saling's Börsen-Papiere - Zweiter (finanzieller) Teil (Berliner Börse)*. Note also that its editions are listed as if spanning two consecutive years, such as "1921/22", but their publication date is actually about the middle of the first of the two years (e.g., approximately "June 1921").

Data extraction Properly extracting the data for our analysis requires understanding and addressing three key challenges. First, and most straightforward, is the digitization and optical character recognition (OCR) process itself. The challenges here are similar to those of other historical documents. Second, balance sheet (and income statement) information was not standardized in *Saling's* at the time, so the information was not available in tabular form but in a rather unwieldy textual form. Moreover, balance sheet items were not standardized to belong to only certain categories, but instead reflected open-ended categories mostly defined by the firms themselves. Lastly, the reports had substantial but subtle changes through time, including multiple currencies as well as post-inflation balance sheet revaluation.

To address these three challenges, we applied a series of data extraction and validation methods, which can be summarized in the following six steps:

1. Download all scanned pages from *Saling's* from the University of Mannheim digital repository, for the years 1916-1928, using the images with the highest available quality.

2. These pages often had scanning artifacts that made optical character recognition (OCR) challenging. We address these problems through the methods discussed in Correia and Luck (2023). Then, we feed the cleaned-up pages into multiple OCR engines (Amazon Textract and Google Cloud Vision).

3. We apply several ad-hoc algorithms to detect the different blocks of text that contain our relevant information. To identify industries, we look for the top-most centered block of text in each page. To identify firm headers, we search for text with certain characteristics (large font, centered, with large margin above) as well as for certain keywords ("Sitz in", "Börsenname", etc.). Similarly, we identify balance sheets and income statements through keywords ("Bilanz", "Aktiva", etc.) with text possessing certain characteristics (i.e., indented and at the beginning of a paragraph).

4. The previous step might have not detected all relevant blocks due to, e.g., OCR typos, so we apply several additional strategies to select any other remaining blocks. For instance, for firm headers we:

   (a) Digitize the firm index located at the beginning of the book, and correlate it with the pages where firm headers were detected.

   (b) Search for paragraphs that only appear once per firm (such as "Vorstand" in fig. D.1) and flag any instances of these paragraphs that appear consecutively without being interspersed by firm headers.

   (c) Exploit the panel dimension of the dataset to detect firms that are missing in certain years but not in others.

5. Once properly identified, the information in each block is converted to key-value pairs and standardized. For this, we apply certain automated steps (remove abbreviations, apply spell-checkers, etc.) and then manually construct a crosswalk from the mostly ad-hoc labels into standardized labels.

Table D.1: *Schema for standardized balance sheet items*

Assets	**Liabilities**
Long-term Assets	Paid In Equity Capital
Intangibles	Trade Credit
Property	Bills of Exchange
Plants and Equipment	Debt to Banks
Other	Foreign Debt
Current Assets	Long-term Bonds
Cash and Receivables	Reserves
Inventory	Pensions
Securities	Taxes
Other	Capital
	Other
	Interest
	Unpaid Wages
	Taxes
	Profit
	Dividends
	Guarantees
	Other

Table D.1 shows the schema of our standardized balance sheets based on a coarsened version of Germany's General Commercial Code (Handelsgesetzbuch). Coarsening the balance sheet into less detailed items is necessary because the original items are often not sufficiently informative to break balance sheet items down further. For instance, Table D.2 lists a snippet of this crosswalk, showing ten of the more than 3,000 unique labels that map into the "long-term assets" category. Table D.3 shows the schema of our standardized income statement. Profit, calculated as total revenue minus expenses, is reported before dividends, and maps into the profit item in the standardized balance sheet.

6. Lastly, we manually review all extracted data against their scanned image, with the main goal of finding any typos in the digitized balance sheet values. We pay particular attention to cases where balance sheet identities do not hold.

Identification of fiscal years Whenever a firm's fiscal year does not coincide with the calendar year, there might be ambiguities in the exact as-of dates listed in the income statements. For instance, an income statement for the period "1925-26" might correspond to any range of dates throughout this period. Whenever such ambiguities arrive, we clear them through the *Geschäftsjahr* ("fiscal year") section of each firm's report.

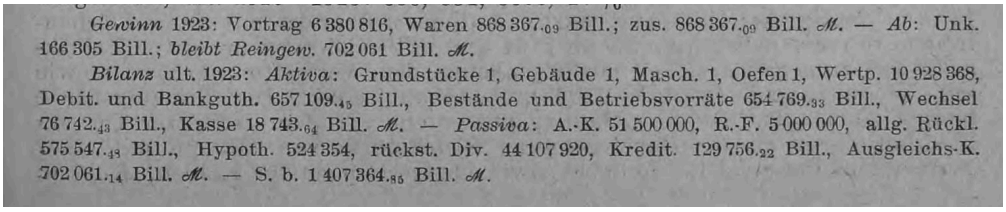
Data quality through the hyperinflation Balance sheet numbers during the hyperinflation years are particularly challenging to digitze. Because of inflation, the numbers

Table D.2: *Sample of labels that map into "long-term assets", with their English translation.*

German label	English translation
Gebäude	Building
Grundstücke	Plots of land
Grundstück und Gebäude	Land and building
Fabrikgebäude	Factory building
Betriebsgebäude	Operations building
Grubenfelder	Mining fields
Verwaltungsgebäude	Administrative building
Bahnhofsanlage	Train station facility
Grundstück in Hannover	Property in Hanover
Grundstück einschließlich Gleisanschluss	Land including railway connection

became extremely long. *Saling's* often switched to reporting data in millions, billions, or trillions with decimal values as subindices. For instance, Figure D.2 illustrates some of the difficulties in extracting the information for that period, as the numbers were extremely long and complex ("1407368.$_{85}$ Bill. M").

Figure D.2: *Extract of the 1924 Edition of* Saling's *for the Firm* Bayerische Spiegelglasfabriken AG.



Gewinn 1923: Vortrag 6 380 816, Waren 868 367.$_{09}$ Bill.; zus. 868 367.$_{09}$ Bill. ℳ. — *Ab*: Unk. 166 305 Bill.; *bleibt Reingew.* 702 061 Bill. ℳ.

Bilanz ult. 1923: *Aktiva*: Grundstücke 1, Gebäude 1, Masch. 1, Oefen 1, Wertp. 10 928 368, Debit. und Bankguth. 657 109.$_{45}$ Bill., Bestände und Betriebsvorräte 654 769.$_{33}$ Bill., Wechsel 76 742.$_{43}$ Bill., Kasse 18 743.$_{64}$ Bill. ℳ. — *Passiva*: A.-K. 51 500 000, R.-F. 5 000 000, allg. Rückl. 575 547.$_{43}$ Bill., Hypoth. 524 354, rückst. Div. 44 107 920, Kredit. 129 756.$_{22}$ Bill., Ausgleichs-K. 702 061.$_{14}$ Bill. ℳ. — S. b. 1 407 364.$_{85}$ Bill. ℳ.

Notes: Notice how numbers are prefixed by "Bill." to indicate they are in trillions of Marks (English trillion is equivalent to a German *billionen*). Further, decimal parts are reported as subindices following the integers.

A more fundamental measurement challenge arises due to the impact of inflation on accounting. Several historical sources indicate that balance sheet statements were not adjusted for inflation, leading to measurement error problem during the hyperinflation, especially in 1923. For example, the 1923 financial report of Darmstädter und Nationalbank stated that "the figures in our balance sheet and profit- and-loss statement are, as in those of all German companies, unfit for any serious scrutiny, and to examine them in detail is folly" (Sweeney, 1934). Similarly, Hoffmann and Walker (2020) provide examples of firms in 1923, noting that the calculation of balance sheets and income in paper marks "lost its economic meaning" and that firms only reported financial statements out of legal obligation. As we discuss in section 3, we are therefore extremely cautious in drawing inferences based on financial statements from 1923. Note that our main analysis (e.g., Figure 7 and Table 2) is not affected by measurement error induced by inflation, as we sort firms by leverage from balance sheets constructed before the inflation in 1918-1919.

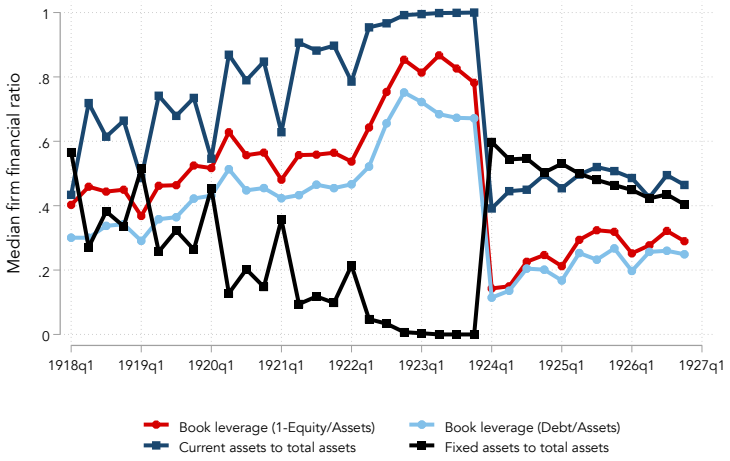
The impact of hyperinflation on the reliability of financial accounts was understood by contemporaries. Some firms began voluntarily reporting balance sheets in Goldmarks

Table D.3: *Schema for standardized income statement items*

Revenue
Expenses
Operating Expenses
Materials
Salaries
Taxes
Other
Interest Expenses
Depreciation
Debt Appreciation
Other Expenses
Reserves
Capital
Pensions
Balance Carryforward
Profit = Revenue - Expenses

by the middle of 1923. In December 1923, the government required all firms to prepare new opening balance sheets by January 1, 1924 in Goldmarks through the regulation on Goldmark accounts (*Verordnung über Goldbilanzen*) in December 1923.

Figure D.3: *Balance Sheet Dynamics in Saling: Ratios.*



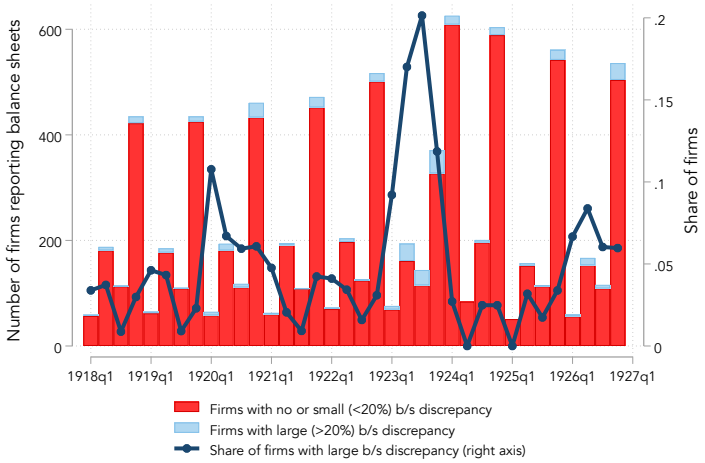
Notes: This figure plots the evolution of the median of key balance sheet ratios in the *Saling's* data over time. The large changes in 1924Q1 occur due to the introduction of revalued Goldmark balance sheets.

Treating the Goldmark balance sheets as correct, we can compare the changes in

balance sheet items before and after the introduction of Goldmark balance sheets to understand how hyperinflation distorted accounting. This reveals that accounting distortions caused by inflation are not symmetric across the balance sheet items. Instead, the revalued Goldmark balance sheets reveal that "real" positions such as fixed assets, inventories, and book equity are systematically more likely to be undervalued than "nominal" items such as cash, other short-term assets, and debt.[15] Appendix Figure D.3 illustrates that the introduction of Goldmark balance sheets leads to large positive revaluations of fixed assets, inventories, and book equity. An implication is that the level of leverage (liabilities-to-assets) is significantly overstated by balance sheets during the hyperinflation.

Clerical errors in balance sheets reported in Saling's also became much more common in 1923. For example, Figure D.4 shows that violations of the balance sheet accounting identity spikes to about 40% in 1923, from around 5% in other years. Specifically, we test whether the sum of all assets equals the sum of all liabilities and equity, as well as whether these sums equal total assets (reported separately). Failure of accounting identities to hold for 5% of balance sheets outside of the hyperinflation is likely due to clerical errors or cases where firms do not report small balance sheet items.

Figure D.4: *Saling Firm-Level Balance Sheet Data: Data Quality.*



Notes: This figure plots the number and share of firms with no or small balance sheet discrepancies and large balance sheet discrepancies. Balance sheet discrepancies are defined as instances of a larger than 20% pairwise difference between either the sum of assets, the sum of liabilities and equity, or reported total assets.

[15]Sweeney (1934) also uses the Goldmark balance sheets as the correct balance sheets to illustrate the misleading nature of the paper mark balance sheets during the hyperinflation. Based on a case study of one firm, Sweeney (1934) finds that current assets and current liabilities are more likely to be correct in the 1923 paper mark balance sheets, while measurement error is most severe for less liquid, long-term assets, such as fixed assets and book equity. However, it should be noted that even the revalued Goldmark balance sheets may have undervalued real assets, as uncertainty about the costs of stabilization and whether it would succeed led to conservative valuations (Graham, 1931, p. 242).

D.2 Firm-level Employment Data

Roughly one-third of all firms report information on the number of employees. Some firms report the total employment while other firm distinguish between blue-collar and white-collar workers. For our analysis, we always use the total number of employees. The red box in Figure D.1 shows an example of how a firm reports the number of employees (both blue collar "Arbeiter" and white collar "Beamte").

In contrast with balance sheet and income statement data, reporting of employment data is less standardized. Table D.4 lists some of the different section headers and keywords used throughout the text. We therefore hand-collect the employment data in *Saling's*. We collect employment information from 1916 through 1933 in order to perform placebo tests on years after the hyperinflation.

Table D.4: *Sample of keywords used to detect employment figures, with their English translation.*

German keyword	English translation
Beamte und Arbeiter	Civil Servants and Workers
Gesamtbelegschaft	Total Workforce
Arbeiterzahl	Number of Workers
Zahl der Arbeiter durchschnittlich	Average Number of Workers
Zahl d. Beamten u. Arbeiter	Number of Civil Servants and Workers
Arbeiter und Angestellte	Blue-collar and White-collar Workers
Arb.	Workers

As a check on the quality of the employment data reported in *Saling's*, Figure D.5 compares average employment growth in *Saling's* with the change in the aggregate unemployment rate (on an inverted scale). While these variables need not exactly coincide, it is reassuring that the two variables co-move reasonably closely, suggesting that the employment information in *Saling's* captures the aggregate fluctuations in employment reasonably well. Employment growth among firms in *Saling's* captures the boom in the 1920-1922 period, the slowdown in 1923 and after the stabilization in 1924, the boom in the latter part of the 1920s, and the collapse after 1929.

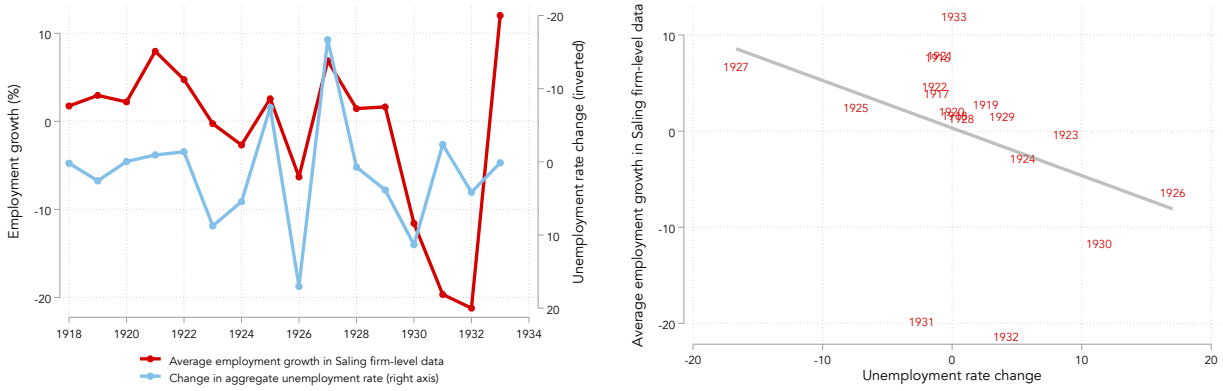
The main analysis in the paper uses the employment data as it is reported in *Saling's*. The panel on firm employment over 1916-1923 is unbalanced and contains some gaps, as sometimes firms do not report in a given year. To address this concern, for robustness, we fill in gaps in employment by linearly interpolating between values. We also consider a balanced sample for both the raw and interpolated employment dataset. Figure C.15 shows the main result in the paper is robust to these exercises.

D.3 Long Term Bond Data

We collect granular data on outstanding bonds reported in *Saling's*. Next to balance sheets and income statements, the manual reports details on the terms and history of outstanding long-term bonds. Figure D.6 shows an example of a bond issued by the firm "Friedr. Bayer & Co." (a predecessor of the still existing Bayer AG) reported in the

Figure D.5: *Employment Growth in Saling's Compared with the Aggregate Unemployment Rate.*

(a) *Time series comparison.* **(b)** *Scatterplot.*



Notes: This figure validates self-reported employment in the *Saling's* data by comparing it with the change in the aggregate unemployment rate. Aggregate employment growth in *Saling's* is computed as the average of the change in firm log employment (multiplied by 100). The annual unemployment rate is the annual average of the monthly rate and is from the *Reichsarbeitsblatt*.

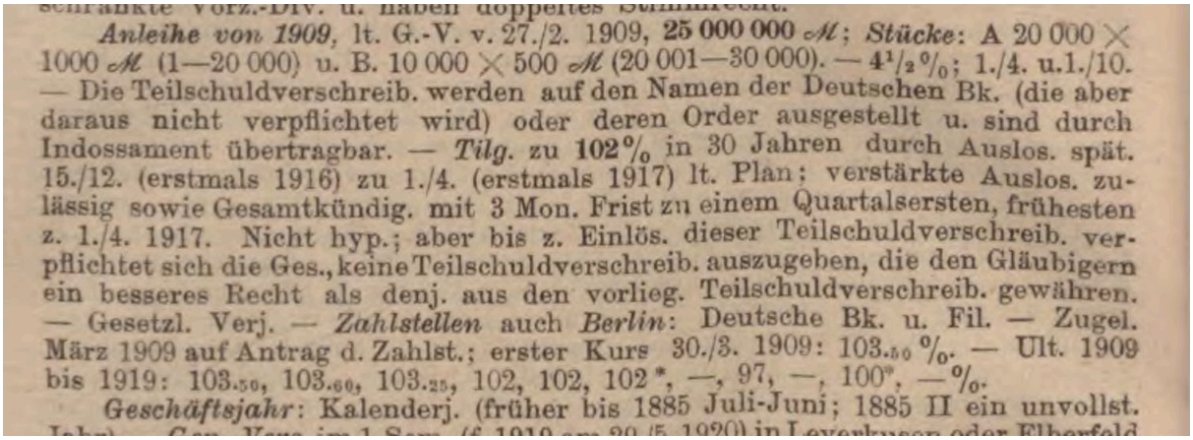
1920 edition of *Saling's*. Data on long-term bonds are reported in a subsection of the description of a firm's financials. The header of each subsection indicates whether a bond is a regular bond ("*Anleihe*") or a mortgage ("*Hypotheken-Anleihe*"). Further details on the contractual terms of each bond are then reported in a non-standardized text format. The description typically contains the original volume of the bond, the origination date, the interest payment, whether the bond has a prepayment option, and further details on the amortization schedule. Bonds can differ in their amortization schedules. Most bonds have specified dates when amortization starts and ends (and the bonds hence matures). Alternatively, some bonds only report an origination date but no final maturity date. However, these bonds report the scheduled amortization rate, thus allowing us to calculate the implicit final maturity date. For a subset of publicly traded bonds, the manual also reports the end-of-year bond price (if available).

Given the non-standardized reporting format, we collect all bond information by hand. We go through each page of the manual and search for reported bonds. For each bond we find, we then collect all available terms on the bond via the editor displayed in Appendix D.3. that provides a standardized sheet of available variables.

D.4 Stock Price Data

We obtain stock price data from *Berliner Börsen- Zeitung*, a contemporary newspaper, published twice each workday (morning and evening edition) and once on Saturdays and Sundays. We collect the end-of-month prices for each stock between 1919 and 1924 and map firm names between stock prices and Saling's data based on string matching with a manual overlay. We also collect information on dividends. Figure D.4 compares

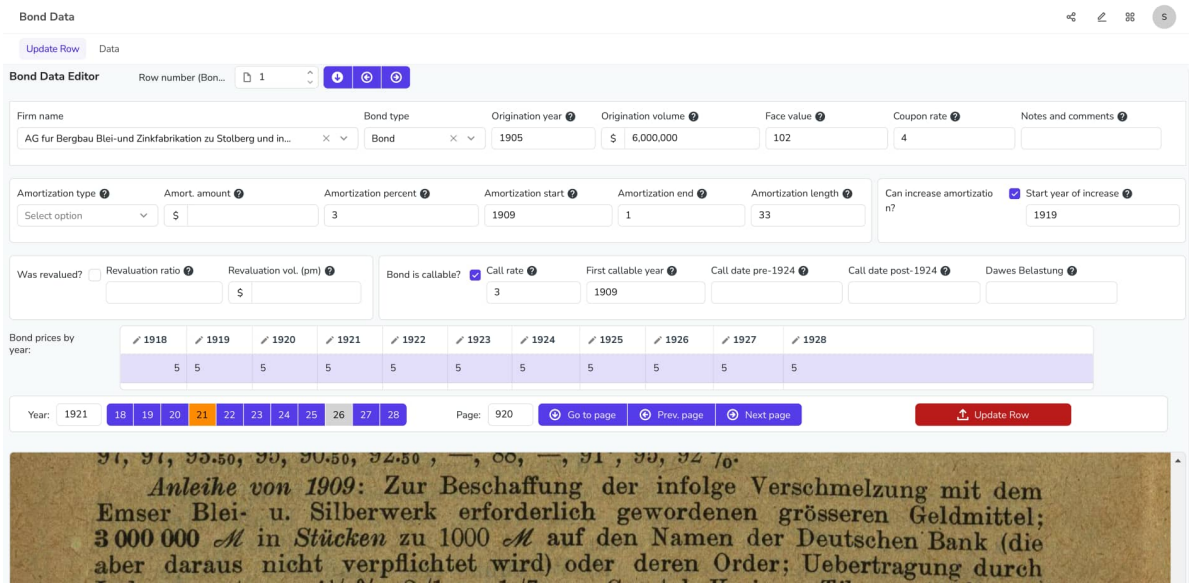
Figure D.6: *Sample bond information from the 1920 edition of* Saling's*, for the firm Bayer AG.*



Anleihe von 1909, lt. G.-V. v. 27./2. 1909, **25 000 000** ℳ; *Stücke*: A 20 000 × 1000 ℳ (1—20 000) u. B. 10 000 × 500 ℳ (20 001—30 000). — 4½%; 1./4. u.1./10. — Die Teilschuldverschreib. werden auf den Namen der Deutschen Bk. (die aber daraus nicht verpflichtet wird) oder deren Order ausgestellt u. sind durch Indossament übertragbar. — *Tilg.* zu **102**% in 30 Jahren durch Auslos. spät. 15./12. (erstmals 1916) zu 1./4. (erstmals 1917) lt. Plan; verstärkte Auslos. zulässig sowie Gesamtkündig. mit 3 Mon. Frist zu einem Quartalsersten, frühesten z. 1./4. 1917. Nicht hyp.; aber bis z. Einlös. dieser Teilschuldverschreib. verpflichtet sich die Ges., keine Teilschuldverschreib. auszugeben, die den Gläubigern ein besseres Recht als denj. aus den vorlieg. Teilschuldverschreib. gewähren. — Gesetzl. Verj. — *Zahlstellen* auch *Berlin*: Deutsche Bk. u. Fil. — Zugel. März 1909 auf Antrag d. Zahlst.; erster Kurs 30./3. 1909: 103.50 %. — Ult. 1909 bis 1919: 103.50, 103.60, 103.25, 102, 102, 102 *, —, 97, —, 100*, —%.

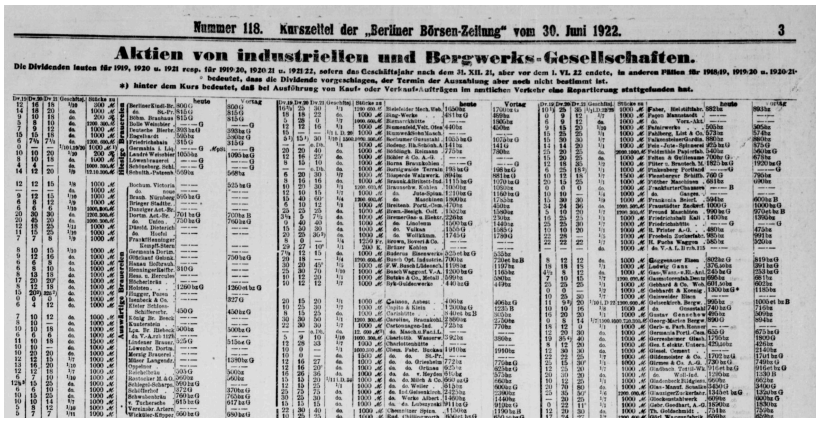
Geschäftsjahr: Kalenderj. (früher bis 1885 Juli-Juni; 1885 II ein unvollst.

Figure D.7: *Screenshot of bond editor app including snippet of scanned bond information.*



Notes: This image shows the digitization process for bond data. We track a given bond issuance across multiple years in order to record its different characteristics and history.

Figure D.8: *Example of Firm-Level Stock Price Data from Berliner Börsen-Zeitung.*


Nummer 118. Kurszettel der „Berliner Börsen-Zeitung" vom 30. Juni 1922. 3

Aktien von industriellen und Bergwerks-Gesellschaften.

Notes: Stock prices of industrial firms from *Berliner Börsen-Zeitung*, 1922.

the equal-weighted price index we construct from these data with price indexes reported in *Wirtschaft und Statistik*. The series track each other closely, except for a divergence in the final months of the inflation when inflation was extremely high. A reason for this divergence can be due to comparing prices for different days, which can make a significant difference during hyperinflation.

We construct annual real total log returns as $\ln(1+R_t) = \ln\left(\frac{P_t/W_t + D_t/W_t}{P_{t-1}/W_{t-1}}\right)$, where P_t is the price at the end of year t, D_t is the dividend in year t, and W_t is the wholesale price index at the end of year t.

D.5 Data Quality Control and Data Restrictions

Throughout the data digitization process, we apply several quality checks. A key quality check stems from exploiting simple accounting identities that must hold within balance sheets and income statements. For instance, we flag balance sheets if assets and liabilities are not equal. We also flag income statements if the reported net profit is not equal to the operating revenue net of the expenses. Further, we flag financial ratios that by definition cannot exceed or fall short of a certain value. We then manually check all flagged observations to identify and correct mistakes whenever possible.

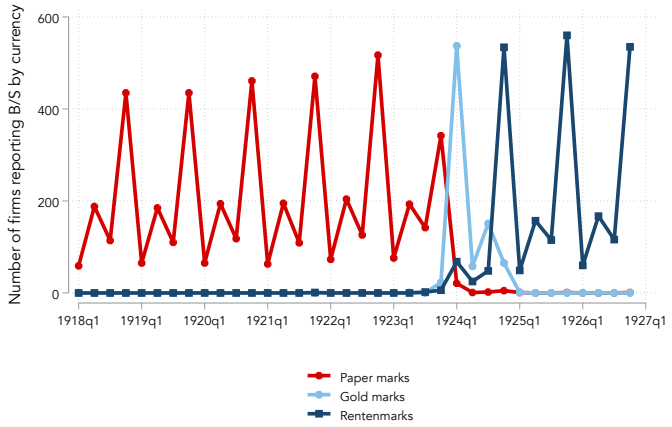
To further ensure that results are not driven by outliers that result from human mistakes made during the digitization process or errors in the underlying historical data source, we winsorize firm-level data. Specifically, we winsorize variables constructed from balance sheets at the 1st and the 99th percentiles in each year. Employment and variables constructed from income statements tend to be more error-prone and thus more noisy than balance sheets variables. Indeed, manual checks verify that balance sheet data is the most reliable data due to the ability to flag errors when the sum of assets is not equal to the sum of liabilities. Hence, rather than winsorizing, we trim employment and variables constructed from income statements at the 1st and 99th percentiles. Moreover, for a subset of variables constructed based on income statements that turn out to be

especially noisy, we apply more rigid winsorization and trimming. For instance, we trim the share of interest expenses as a share of total expenses at the 95^{th} percentile, as extremely high shares of interest expenses are implausible and are thus likely driven by data errors. Further, to broadly account for several visually detectable outliers, we winsorize ROA and EBIT margins at the 2.5^{th} and 97.5^{th} percentiles.

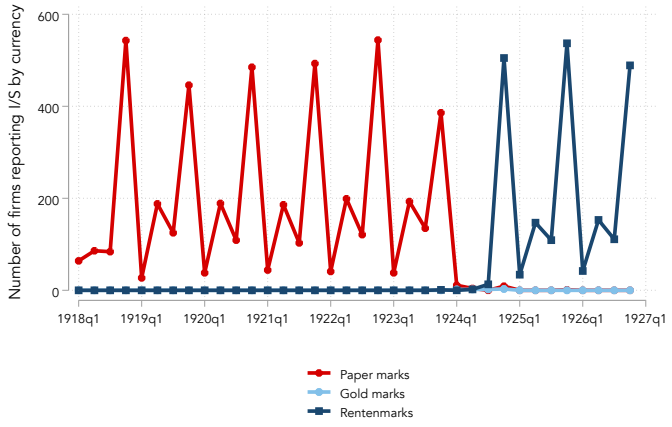
Finally, we drop firms with a headquarter located outside of Germany's post-WWI borders or firms with balance sheets and income statements that are not denominated in paper marks, Reichsmarks, or Goldmarks. We also exclude insurance companies, credit banks, and mortgage banks from our analysis. Figure D.9 reports the number of firms reporting balance sheets and income statements, by currency, after imposing these sample restrictions.

Figure D.9: *Number of Firms in Reporting in Saling After Sample Restriction.*

(a) *Number of firms reporting B/S by currency of reporting.*



(b) *Number of firms reporting I/S by currency of reporting.*



Notes: This figure plots the number of firms reporting balace sheets and income statements by quarter and currency of reporting in the *Saling's* data. The sample period is 1918Q1-1926Q4. The majority of firms report balance sheets at the end of the year (fourth quarter). The spike in balance sheets in 1924Q1 is the new revalued Goldmark balance sheets. Rentenmark balance sheets refers to Rentenmarks or Reichsmarks, which have the same value.