The Debt-Inflation Channel of the German Hyperinflation

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Abstract

This paper studies how a large increase in the price level is transmitted to the real economy through firm balance sheets. Using newly digitized macro- and micro-level data from the German inflation of 1919-1923, we show that inflation led to a large reduction in real debt burdens and bankruptcies. Firms with higher nominal liabilities at the onset of inflation experienced a larger decline in interest expenses, a relative increase in their equity values, and higher employment during the inflation. The results are consistent with real effects of a *debt-inflation* channel that operates even when prices and wages are flexible.

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"The Germany of the inflation was paradise for anyone who owed money."

– Frederick Taylor, *The Downfall of Money* (2013).

1 Introduction

In the presence of nominal debt contracts, unexpected inflation redistributes wealth from creditors to debtors (Keynes, 1923). If levered firms are financially constrained, such wealth redistribution can affect *real* economic activity and potentially have aggregate effects (Fisher, 1933; Tobin, 1982). In theory, unexpected inflation can thus increase economic activity via a *debt-inflation* channel that can operate even when prices and wages are flexible. While the transmission of inflation to the real economy through financial frictions is well understood theoretically (Gomes et al., 2016), there is limited evidence supporting the empirical relevance of such a financial channel.

In this paper, we use Germany's inflation of 1919-1923 as a laboratory to study how a large inflationary shock transmits to the real economy through the debt-inflation channel. The German inflation is a key event in monetary history. It has been studied by generations of economists to understand the causes and consequences of high inflation (e.g., Bresciani-Turroni, 1937; Cagan, 1956; Sargent, 1982).[1] We revisit this important episode through the lens of several newly digitized sources at both the macro- and micro-level. The setting is particularly appealing for studying the debt-inflation channel because the inflation was to a large extent unanticipated. Moreover, the enormous increase in the price level puts the effects of inflation on balance sheets into sharp relief, allowing us to study a channel that may be harder to identify empirically during times of moderate inflation.

We find that the debt-inflation channel was an important factor for the transmission of the German inflation to the real economy. In the aggregate, the inflation was associated with a large reduction in real debt burdens for levered nonfinancial firms, which resulted in a large decline in bankruptcies. In the cross-section, firms with higher leverage at the onset of the inflation saw a larger decline in their interest expenses, along with a larger relative increase in their book and market equity values. The reduction in real debt burdens had real effects, as high leverage firms saw the largest increase in employment during the inflation. Altogether, our findings highlight the role of nominal rigidity in debt contracts and financial frictions in the transmission of a large inflationary shock to

[1] Throughout the paper, we refer to the entire postwar inflation from November 1918 to November 1923 as the "German inflation." As we discuss below, we reserve the term "hyperinflation" for the phase from July 1922 to November 1923 when monthly inflation exceeded 50%.

the real economy.

We begin by describing the macroeconomic environment surrounding the German inflation. The postwar German inflation can be divided into two broad phases. The first phase occurs from the end of WWI in November 1918 to June 1922.[2] In this phase, the price level increased by a factor of 30. Economic growth was strong and, unlike most other major economies at the time, Germany avoided a large economic downturn following WWI. The root cause of the inflation was deficit-financed war spending, massive WWI reparations, and a lack of political will to adjust to the burden of higher debt through reduced spending and increased taxation in an attempt to maintain social peace (Graham, 1931; Sargent, 1982; Kindleberger, 1985; Feldman, 1993). Moreover, there was no central bank policy response to high inflation; instead, the Reichsbank accommodated large deficits by discounting government securities. Evidence from forward exchange premium data and narrative accounts suggest that the inflation was initially unanticipated.

The second phase of the inflation is the hyperinflation from July 1922 to the stabilization in November 1923. This phase begins after political turmoil over WWI reparations and the assassination of the prominent foreign minister Rathenau. In this phase, the price level spirals out of control. In line with inflation expectations becoming unanchored and a flight from the mark, the forward exchange premium turns to a large discount from July 1922 onward. The hyperinflation coincides with deteriorating economic conditions and rising unemployment. The economic downturn is exacerbated by the invasion of the Ruhr and resulting collapse in industrial production.

To study the impact of the inflation on the real economy through firm balance sheets, we construct a new firm-level database by digitizing a financial manual with firm-level information on balance sheets, income statements, employment, and outstanding bonds for about 700 joint-stock firms in Germany. We merge these data with newly digitized stock returns. Information on employment and stock returns is particularly valuable, as accounting statements potentially provide a distorted representation of firm financial conditions during the hyperinflation phase, especially in 1923.[3] We supplement these data with a range of other newly digitized datasets, including data on bankruptcies, retail prices, and wages.

What are the macro-financial implications of the inflation? Using time-series variation,

[2]Inflation begins with the outset of WWI following the abandonment of the gold standard. The price level in German increased by a factor of 2.4 during WWI. We focus mainly on the post-WWI period because inflation was higher during this period and economic activity and inflation during the war was heavily influenced by wartime policies and controls.

[3]Accounting statements become more reliable again starting in January 1924, when firms were required to draw up revalued "Goldmark" balance sheets, as we discuss in section 3.

we find a striking negative relation between inflation and firm bankruptcies. Bankruptcies consistently declined with rising inflation and remained at historically low levels even with the economic turmoil of 1923. Moreover, the relation is convex. For low to moderate inflation, additional inflation is associated with sharply lower firm bankruptcies. At levels of annual inflation above 500%, additional inflation only weakly reduced bankruptcies. Intuitively, once the price level has doubled several times within a few years, debts have already been wiped out, making bankruptcy increasingly unlikely. To better understand the negative relation between inflation and bankruptcies, we document that inflation is associated with a massive fall in financial leverage. We find that the ratio of nominal liabilities to assets falls by around 25 percentage points for the average firm, representing a 60% decline. Interest expenses as a share of total expenses also fall by 10 percentage points from 1918 through 1923.

The aggregate decline in real debt burdens and bankruptcies during the inflation raises several intriguing questions. What is the extent of redistribution toward levered firms from the inflation? Does the erosion of the real value of nominal debt have real effects in terms of firms' employment? Do equity-holders benefit from leverage, and how is this reflected in equity prices?

To answer these questions, we examine the impact of inflation in the cross-section of firms. We estimate a difference-in-differences specification, sorting firms by their leverage at the onset of the inflation. Firms with higher initial leverage have significantly stronger employment growth relative to firms with lower leverage. In terms of magnitudes, 10 percentage points higher initial leverage is associated with 3.5% higher employment during the inflation. The expansionary effect on employment is strongest in the first phase of inflation up to 1922. The hyperinflationary phase of 1922-23 has limited additional real effects on high leverage firms. Abstracting from general equilibrium effects, the debt-inflation channel accounts for a 17% increase in employment, which is similar to the overall employment increase during the inflation.

We provide several pieces of evidence to support the interpretation that the real effects on employment are driven by the debt-inflation channel. First, high leverage firms see larger reductions in the share of interest expenses to total expenses. At the same time, these firms increase the share of production expenses, such as expenses for salaries and raw materials. This pattern is consistent with inflation lowering real debt payments, relaxing liquidity constraints, and thereby allowing firms to increase spending on production inputs.

Second, the debt-inflation channel should especially benefit firms with a higher proportion of long-term debt, as these firms are less exposed to a repricing of debt as expected inflation rises. Many firms in our sample relied on fixed-rate long-term debt financing. Exploiting additional details on the maturity structure of firms' liabilities, we estimate a triple difference-in-differences specification and find that the decline in interest expenses and the increase in employment is strongest for highly levered firms with a high proportion of long-term debt to total debt.

Third, high leverage firms see a larger increase in the real value of book equity. Firms do not use the windfall reduction in interest expenses to increase dividends, instead keeping the money inside the firm. Finally, while market equity returns are very negative during the inflation, high leverage firms experience relatively higher stock market returns. On average, high leverage firms have 10-13% higher annual risk-adjusted returns relative to low leverage firms during the inflation. Overall, firm-level evidence suggests that the largely unexpected inflation redistributed wealth from debt holders to shareholders of levered firms, relaxing financing constraints and allowing these firms to expand employment and production.

We reinforce these results and rule out several potentially confounding explanations with a series of robustness tests. First, the estimates are robust to a range of firm-level controls such as size, the share of fixed assets, and profitability. Second, high leverage firms might have differential exposure to growth opportunities or credit supply shifts, but we show that the results are robust to controlling for proxies of these confounders. Third, the results are also unlikely to be driven by differential cyclicality, as firms with high leverage at the onset of the inflation do not have higher business cycle exposure in other periods. Finally, higher employment growth for highly levered firms is unlikely to be explained by differential exposure to wage rigidity. Wages were mostly set at the industry level by union bargaining, and all the results are robust to the inclusion of detailed industry-by-time fixed effects.

The debt-inflation channel relies on nominal rigidity through debt contracts, rather than nominal rigidity in wages and prices, as traditionally assumed in New Keynesian models (e.g., Galí, 2015). There is an analogy between nominal debt rigidity and nominal wage rigidity, as both can reduce firm expenses following an inflationary shock. However, a difference is that existing nominal debt contracts cannot be renegotiated after a large inflationary shock, whereas prices and wages can potentially be reset. Consistent with this, we document that wages adjust with increasing frequency in response to rising inflation. For example, wages are adjusted every 9 months when annual inflation is close to 0% but every 60 days once inflation exceeds 100% and every 30 days or less once inflation exceeds 200%. We find a similar pattern for retail prices. This evidence is consistent with menu cost models (Alvarez et al., 2019). While a quantification of the relevant roles of nominal rigidity through debt versus prices and wages is beyond the scope of this paper, the evidence is consistent with the view that the debt-inflation channel can operate even for large inflationary shocks when nominal rigidity in wages and prices becomes less relevant.

Our paper relates to four strands of literature. First, we contribute to the literature studying the role of firm debt in the transmission of inflation to the real economy. Our empirical evidence speaks directly to theoretical models of the debt-inflation channel (Bhamra et al., 2011; Gomes et al., 2016). Hausman et al. (2019) document that the departure from the Gold Standard during the Great Depression led to an increase in crop prices in the U.S., which boosted spending in regions with high farm debt. An empirical literature focusing on the 1970s inflation in the U.S. finds mixed evidence for the hypothesis that equity valuations of firms with leverage benefit from inflation (see, for example, Summers, 1981; French et al., 1983; Ritter and Warr, 2002). More recently, Kang and Pflueger (2015) find that inflation risk is priced in corporate bond yields, as unexpectedly low inflation increases a firm's real liabilities. Bhamra et al. (2021) find that high inflation is associated with low equity market valuations and low default rates in U.S. data since 1970, similar to our evidence for Germany's inflation. We complement these papers by examining whether inflation has real effects at the firm level during an extreme inflationary shock.

Second, our findings contribute to the literature on firm financing frictions and the transmission of shocks to firms' net worth. Empirical studies find that firms adjust investment and employment in response to exogenous shocks to their net worth (e.g., Blanchard et al., 1994; Kaplan and Zingales, 1997; Rauh, 2006; Benmelech et al., 2019). Our analysis shows that an unexpected inflationary shock can generate substantial real effects on firms' real activity through its impact on firm balance sheets.

Third, our findings on the frequency of price and wage adjustments inform the literature on price setting. The evidence that the frequency of price and wage adjustment rises with inflation is consistent with the early accounts of Pazos (1972) and Simonsen (1983). Alvarez et al. (2019) show theoretically and empirically that higher levels of inflation increase the frequency of price changes and lead to a wider price dispersion, but only in high-inflation regimes (see also Gagnon 2009; Nakamura et al. 2018). Alvarez et al. (2019) also calibrate large welfare losses in hyperinflations due to high dispersion in relative prices. There is less evidence on wage adjustment during high and hyperinflation, but existing work focusing on times with low and moderate inflation finds that wage contract lengths shorten with higher inflation (Cecchetti, 1987; Card and Hyslop, 1997).

Finally, our paper contributes to the large literature on the German inflation and big inflations more broadly.[4] Few episodes have attracted as much attention from economists. The extensive work on the German hyperinflation, however, has almost entirely relied on aggregate time-series data.[5] We provide several new insights based on novel industry- and firm-level data. Previous studies have discussed that inflation eroded public debt (Dornbusch, 1985) and private debt (Graham, 1931), but we are the first to document that the fall in bankruptcies lines up closely with the preceding rise in the price level. Moreover, we are the first to quantify the impact of the debt-inflation channel of the inflation on firm balance sheets, stock market valuations, and real firm-level outcomes.

The remainder of the paper is structured as follows. Section 2 provides a conceptual framework to motivate the empirical analysis. Section 3 describes our newly digitized macro- and firm-level data. Section 4 presents aggregate evidence on the debt-inflation and nominal rigidity channels of inflation. Section 5 presents evidence of the financial channel in the cross-section of firms, and section 6 concludes.

2 Conceptual Framework

This section lays out a conceptual framework summarizing our hypotheses for how a large increase in the price level can affect the real economy. The discussion in this section is based on a simple model laid out in Appendix B. Since the mechanisms are intuitive, we leave the formal model for the appendix.

In theory, the equity owners of a firm with nominal debt will benefit from unanticipated inflation, as inflation reduces real debt burdens. This should increase net worth and the market value of equity for more levered firms. In the absence of financing frictions or costs of financial distress, the reduction in real debt burdens benefits equity owners but does not change employment, investment, or production.

If firms face financing frictions and/or costs of financial distress, inflation can boost real activity through what we refer to as the *debt-inflation* channel of inflation. The debt-inflation channel is the inverse case of Irving Fisher's famous debt-deflation channel (Fisher, 1933). Our model highlights that the debt-inflation channel can operate through two mechanisms. First, the reduction in real debt burdens reduces the likelihood that

[4]Prominent studies of the German inflation include Schacht (1927), Bresciani-Turroni (1937), Graham (1931), Holtfrerich (1986), and Feldman (1993). Important studies of hyperinflations, including the German inflation, include Cagan (1956), Sargent (1982), Dornbusch and Fischer (1986), and Lopez and Mitchener (2020). Section 4 and Appendix A provide an overview of the historical context and reviews existing historical studies on Germany's inflation.

[5]A recent exception is Braggion et al. (2022), who analyze security holdings of clients of a major bank. They find that investors exposed to higher local inflation have lower demand for stocks, likely due to money illusion.

a firm will default and go into bankruptcy. This mechanism is also at the heart of the models in Bhamra et al. (2011) and Gomes et al. (2016), where unanticipated inflation reduces leverage and reduces the share of firms in costly bankruptcy, thereby increasing output.

Hypothesis I: Inflation and Firm Bankruptcies. *When firms have nominal debt and can default, unexpected inflation increases firms' net worth, leading to a decline in bankruptcy rates.*

Second, the reduction in real debt burdens reduces debt overhang and allows a financially constrained firm to expand employment, investment, and production (Myers, 1977). The reduction in real debt burdens increases both a firm's liquidity and net worth, so it can affect real outcomes by relaxing both collateral or cash-flow based constraints (e.g., Kiyotaki and Moore, 1997; Lian and Ma, 2021). Along similar lines, Cordoba and Ripoll (2004) consider a variant of the Kiyotaki and Moore (1997) model with money and nominal debt. In that model, unexpected inflation leads to redistribution toward constrained productive agents, which relaxes their financing constraint and leads to an increase in production. Furthermore, if an increase in inflation also increases expected inflation, then the increase in net worth and production is larger when debt is of longer maturity and at a fixed interest rate.

Hypothesis II: The Debt-Inflation Channel and Firm Activity. *If firms are financing-constrained, unexpected inflation relaxes financing constraints and leads to an increase in employment and output. The debt-inflation channel is stronger for firms with higher initial leverage.*

Several caveats to this financial channel are worth noting. First, at the firm level, inflation has real effects through a debt-inflation channel if firms are financing-constrained and if debt contracts are nominal and at fixed interest rate. If instead debt is floating, indexed to inflation, or denominated in foreign currency, then inflation does not necessarily increase firms' net worth or output. Second, in general equilibrium, unanticipated inflation results in a loss for the holders of nominal debt. If the holders of the debt are households, then this can lead to an increase in labor supply through a wealth effect, leading to a further increase in employment and output (see Appendix B). On the other hand, if inflation reduces the net worth of banks holding the debt, then the reduction in credit supply can depress firm activity.[6]

The debt-inflation channel is relevant even in the absence of nominal rigidities traditionally assumed in macroeconomic models of inflation (e.g. Galí, 2015). In our model in appendix B, we introduce a nominal rigidity by assuming a fixed cost of wage adjustment.

[6]While our main focus is on the debt-inflation channel operating through nonfinancial firms' balance sheets, we discuss the impact of inflation on bank credit supply in section 5. For recent evidence that inflation can impair the intermediation of credit, see Drechsler et al. (2022) and Agarwal and Baron (2022).

With this assumption, moderate inflation leads to a fall in real wages, boosting labor demand, employment, and output. This *nominal rigidity channel* and the debt-inflation channel both lead to an increase in employment. However, in the model, high inflation leads wage setters to pay the fixed menu cost of updating wages, and wages adjust to the higher price level. Thus, for high levels of inflation, inflation only has real effects through the debt-inflation channel, though the absence of nominal rigidities also weakens the debt-inflation channel. Golosov and Lucas (2007) emphasize that menu costs imply small real effects of money-induced inflation. Inflation could nonetheless have substantial real effects through the debt-inflation channel, as existing nominal debt contracts cannot be renegotiated following an inflationary shock, in contrast to wages and prices.

3 Data

3.1 Firm-Level Data

We construct a firm-level dataset with annual information on balance sheets, income statements, employment, and outstanding bonds from *Saling's Börsen-Jahrbuch*, an investor manual. The data from *Saling's* are available for over 700 nonfinancial firms and 60 banks each year. In this paper, we focus on the sample of nonfinancial firms and exclude banks and insurance companies. We focus our data collection on the period 1916-1926, covering the entirety of the postwar inflation period (1919-1923), as well as the three preceding and subsequent years.

We digitize the balance sheets and income statements in *Saling's* using optical character recognition (OCR), applying the methods discussed in Correia and Luck (2023). We hand-check the OCR output, with particular attention to cases where accounting identities fail to hold. We then standardize the financial statement items to obtain harmonized balance sheets and income statements. Other data from *Saling's* such as employment and information on outstanding bonds are hand-collected. Appendix D provides a detailed discussion on how these data were collected, validated, and standardized. As a concrete example of the underlying data source, Appendix Figure D.1 provides annotated balance sheet and income statements for the firm H. Berthold AG, the largest type foundry in the world at the time. Table 1 provides summary statistics for key firm-level variables. Appendix Figure C.1 presents a map with the geocoded location of firm headquarters.

An important point to note when using data from *Saling's Börsen-Jahrbuch* is that balance sheets provide a misleading account of firms' financial situations during the hyperinflation, especially in 1923.[7] "Inflation accounting" did not exist at the time, and dealing with inflation was a major challenge for firms' accounting. In particular, real items such as fixed assets become significantly undervalued relative to nominal items such as cash holdings. In response to the distortion of paper mark balance sheets caused by the hyperinflation, the government passed the regulation on Goldmark accounts (*Verordnung über Goldbilanzen*) in December 1923. The regulation required firms to prepare new opening balance sheets for financial years beginning on or after January 1, 1924 in Goldmarks.[8] This preparation required a full revaluation of all assets and liabilities (Sommerfeld, 1924). In Appendix D, we provide a more detailed discussion of these measurement issues and the revalued Goldmark balance sheets.

Our analysis uses two approaches to overcome the inflation-induced measurement challenge. First, we rely on balance sheet variables before the hyperinflation (before 1922) and from the more accurate Goldmark balance sheets (usually from January 1, 1924), avoiding use of the 1923 balance sheet values. This allows us to see what happened to key balance sheet variables from before to after the inflation, but it has the obvious drawback of not being informative about the timing of the effects on balance sheet outcomes. Moreover, our main analysis sorts firms based on their balance sheet exposure to inflation before the start of the inflation.

Second, we examine variables that are not subject to accounting issues throughout the inflation—employment and stock prices—as well as ratios based on income statements, where measurement error is less severe. Employment is reported for about one-third of the firms in *Saling's*. Aggregating employment growth across firms in *Saling's* captures the aggregate fluctuations in employment reasonably well (see Figure D.5). There are gaps in the firm-level employment variable for some firms, as some firms do not report employment in all years. In our baseline analysis, we use the raw employment data reported by firms, but in the appendix we show the results are robust to requiring that firms report in all years and to interpolating missing employment values.

Finally, monthly stock and bond prices for nonfinancial firms and banks are hand-collected from *Berliner Börsen-Zeitung* (BBZ), a financial newspaper. We also collect dividends to construct total returns. Appendix Figure D.8 provides an example of data from *Berliner Börsen-Zeitung*. The equal-weighted stock price indexes constructed

[7] Income statements can also be distorted due to the addition of nominal values at different price levels, but the distortions are most severe for balance sheets. For income statements, we rely on ratios such as the share of interest expenses to total expenses, which are less likely to be distorted by inflation as long as different expenses occur at similar times in the year. See Sweeney (1934) for details on how inflation distorted balance sheets during the 1920s hyperinflations in Europe.

[8] The Goldmark was not an actual currency in circulation but used for accounting purposes and equivalent to the new Rentenmark, which had an exchange rate of 4.2 per U.S. dollar.

from the BBZ data closely track corresponding indexes published by a contemporary statistical publication (*Wirtschaft und Statistik*), providing a reassuring validation of our hand-collected stock market data (see Appendix Figure C.3).

Table 1: *Summary Statistics: Firm-Level Dataset.*

	N	Mean	Std. dev.	10th	90th
Liabilities/Assets$_{i,1918-1919}$	794	0.46	0.18	0.23	0.68
Debt/Assets$_{i,1918-1919}$	794	0.37	0.18	0.13	0.59
$\ln(\text{Assets})_{i,1918-1919}$	794	15.02	1.25	13.51	16.76
Fixed Assets/Assets$_{i,1918-1919}$	794	0.36	0.24	0.09	0.74
ROA$_{i,1918-1919}$	739	0.10	0.06	0.03	0.18
EBIT margin$_{i,1918-1919}$	754	0.36	0.22	0.10	0.68
$\Delta_{1919-1924}$Liabilities/Assets$_i$	656	-0.25	0.20	-0.47	0.00
Employment$_{i,1919}$	233	4,167.06	9,422.45	400.00	9,934.00
$\Delta \ln(\text{Employment})_{i,t}$	1,353	3.52	21.94	-2.90	19.24

Notes: This table reports summary statistics for the firm-level dataset based on *Saling's Börsen-Jahrbuch*. Variables with "1918 − 1919" subscripts are averaged over 1918 and 1919. $\Delta \ln(Employment)$ is the annual change in log firm employment (times 100) from 1919 through 1923.

3.2 Aggregate, Industry-level, and Regional Data

We supplement our new firm-level dataset with aggregate-, industry-, and regional-level data by digitizing contemporary publications of various government agencies. Our main source is a publication called *Zahlen zur Geldentwertung in Deutschland von 1914 bis 1923*, published by the government agency for statistical analysis, the *Reichsamt für Statistik*, in 1925. This publication provides data on the daily mark-per-dollar exchange rate, cost-of-living and wholesale prices indexes by month, wages by industry, weekly prices for consumption goods in Berlin during 1923, as well as stock market indices by broad industry categories. Additional data on wages by industry and monthly prices for consumption goods at the city level are obtained from the contemporary publication *Wirtschaft and Statistik*, which was published at a monthly frequency starting in January 1921, and at a bi-monthly frequency from January 1922 onwards. Further, we obtain information on firm bankruptcies and liquidations by industry and prices for wholesale goods from the *Vierteljahrshefte zur Statistik des Deutschen Reichs Herausgegeben vom Statistischen Reichsamt* and the annual *Statistisches Jahrbuch für das deutsche Reich*, which were published through 1919-1923 at the quarterly and annual frequency, respectively. Finally, we digitize parts of the appendix of the *Reichsarbeitsblatt*, published by the

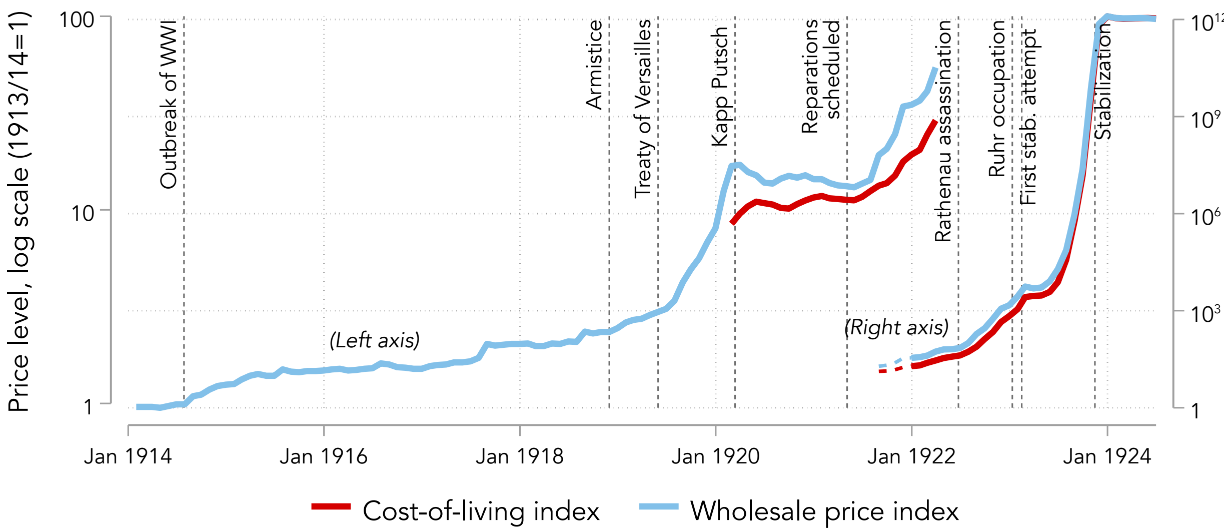
Ministry of Labor (*Reichsarbeitsministerium*), which contains information on monthly unemployment.

4 Aggregate Evidence on the Debt-Inflation Channel

4.1 Background on Weimar Germany's Inflation

To set the stage, we start with a brief overview of Weimar Germany's inflation. Appendix A provides further historical background and a chronology of critical events.

Figure 1: *The Price Level during Germany's Inflation.*



Notes: This figure shows the evolution of the price level in Germany between January 1914 and June 1924, with the cost-of-living index only available from February 1920 onwards. Due to the extreme changes in price levels, prices are reported in logarithms and over two axes, with the first phase of the inflation on the left axis and the second phase on the right axis. The source for the wholesale price index (Gesamtindex der Grosshandelspreise) and cost-of-living index (Lebenshaltung insgesamt) is *Zahlen zur Geldentwertung in Deutschland von 1914 bis 1923.*

Two phases of the inflation. Figure 1 plots the time series of the wholesale price index and the cost-of-living index. Germany's inflation has its roots in WWI, when the gold standard was abandoned and the government increasingly financed the deficit by discounting government securities at the Reichsbank (Feldman, 1993). During WWI, the wholesale price index increased by a factor of 2.45. This rate of inflation was slightly higher than in the U.K., where prices increased by a factor of 2.3, but lower than in France, where prices increased by a factor of 3.3. At the end of the war, German inflation and public finances were not in significantly worse condition than France's (Graham, 1931).

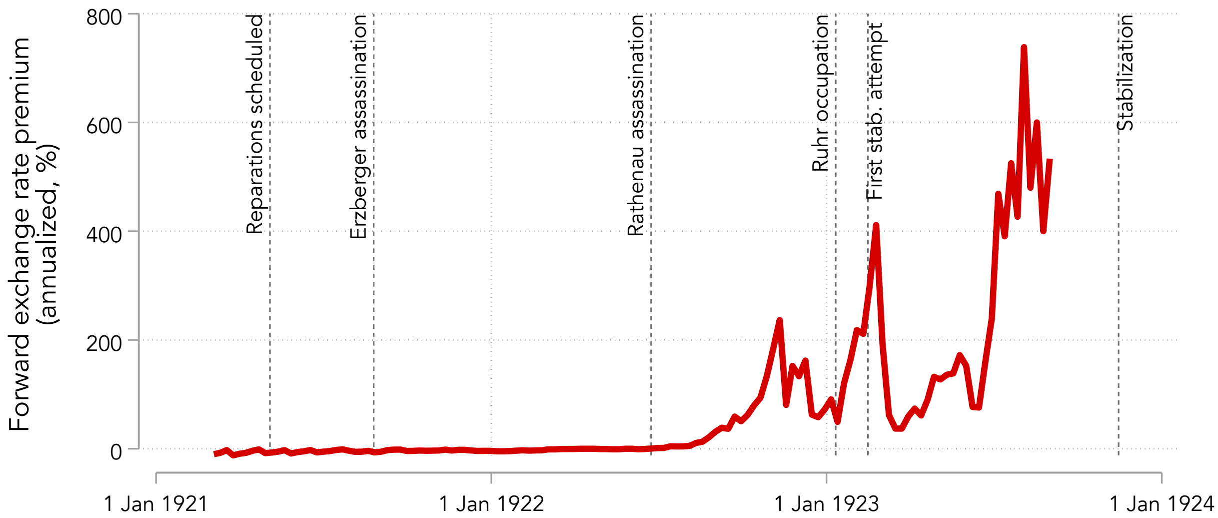
There are two broad phases of the postwar inflation. The first phase is from the WWI Armistice in November 1918 to the summer of 1922. Panel (a) of Figure 1 shows that inflation accelerated in the second half of 1919, after the signing of the Treaty of Versailles in June 1919. The Treaty assigned sole blame for the war on the Central Powers (the "War Guilt Clause") and imposed large and uncertain reparations on Germany. Lopez and Mitchener (2020) present evidence that policy uncertainty was important in generating high inflation. From the end of 1918 to the end of 1919, the wholesale price index increased by a factor of 3.3. The price level stabilized during 1920 with the Erzberger fiscal reforms and the successful suppression of the "Kapp Putsch," a right-wing coup attempt, in March 1920. The price level then rose again in May 1921 after the Reparations Commission determined Germany's exact reparations bill and imposed an ultimatum of a substantial upfront payment in 1921.

The second phase of the inflation runs from July 1922 to stabilization in November 1923, shown in panel (b) of Figure 1. This phase was ushered in by three events that undermined confidence in Germany's ability to meet reparations (Kindleberger, 1985). First, in early June 1922, the French government insisted on the original reparations schedule, rather than a reduced schedule. Second, hopes of an international loan to stabilize the mark were disappointed by the Reparations Commissions Banker's Committee. Third, on June 24, the foreign minister Walther Rathenau was assassinated by an ultra-nationalist terrorist group. That day the mark depreciated by 7% against the dollar. Germany then suspended and formally demanded a 2.5 year postponement of reparations in July 1922. From July 1922, monthly inflation exceeded 50%, marking the start of the hyperinflation phase. Inflation rose further after the invasion of the Ruhr by France and Belgium in January 1923 in response to arrears on the delivery of reparations in kind. The occupation was met with passive resistance, which the government financed by discounting treasury bills, further fuelling inflation. Inflation was finally stabilized in November 1923 through a combination of monetary and fiscal reforms.

Inflation expectations. Narrative accounts suggests inflation expectations were anchored only increased gradually in the first phase of the inflation (Kindleberger, 1985).[9] Expectations of inflation then shifted decisively in the summer of 1922, and expectations of further depreciation became widespread (Feldman, 1993).

[9] Ferguson (1995) reports that Keynes lost £20,000 speculating on the mark (about £500,000 today). He was later reported to have said that "everyone in Europe and American bought mark notes... the argument has been the same... Germany is a great and strong country; some day she will recover; when that happens the mark will recover also, which will bring a very large profit. So little do bankers and servant girls understand of history and economics."

Figure 2: *Inflation Expectations Implied by Forward Exchange Rates.*



Notes: Forward and spot exchange rate data are from Einzig (1937), which records the data from the weekly circular of the Anglo-Portuguese Colonial and Overseas Bank, Ltd. The annualized forward premium is based on one-month forward contracts and is calculated as $12\frac{F-S}{S}$, where S_t is the spot exchange rate in marks per sterling and F_t is the forward exchange rate. A higher value implies that the forward price of sterling (in terms of marks) is at a premium compared to the spot price.

This narrative is supported by the behavior of the forward exchange rate. Figure 2 plots the annualized mark/sterling forward premium based on one-month forward contracts. From covered-interest parity and abstracting from a risk-premium, the forward premium is given by $\frac{F_t}{S_t} = \frac{1+i_t}{1+i_t^*}$, where i_t is the mark interest rate and i_t^* is the pound sterling interest rate. Taking an approximation and applying the Fisher equation yields $\frac{F_t-S_t}{S_t} \approx i_t - i_t^* = \mathbb{E}_t\pi_{t+1} - \mathbb{E}_t\pi_{t+1}^* + r_t - r_t^*$, where π_t is the rate of inflation and r_t the real interest rate. Assuming that most variation in interest rates is due to expectations about inflation in Germany ($\mathbb{E}_t\pi_{t+1}$), the forward premium provides a proxy of inflation expectations.[10]

Before June 1922, the mark forward rate was at a premium relative to the spot rate, suggesting that the forward market did not imply a large increase in Germany's inflation. Therefore, high inflation came as a surprise relative to expectations in the first phase of the inflation.[11] While this is perhaps surprising *ex post*, inflation had been low from

[10]Frenkel (1977) also makes this assumption and uses the same forward-premium data to construct a measure of inflation expectations to estimate money demand during the German hyperinflation.

[11]Another piece of evidence for anchored inflation expectations is that firms were able to issue long-term fixed rate bonds in 1919-20, as we discuss below (see Figure C.21). Moreover, in 1922 many borrowers repaid loans early to take advantage of the depreciated mark because they (wrongly) expected the mark to strengthen again (Hughes, 1988).

Germany's unification in 1871 until WWI, at an average rate of 0.7% per year.[12] The last hyperinflation occurred over a century earlier during the French revolution (Sargent and Velde, 1995).

The forward price of sterling moved decisively from a discount to a premium the week of the Rathenau assassination in late June 1922, suggesting that inflation expectations became unanchored (Holtfrerich, 1986). After the political turmoil during the summer of 1922, the forward traded at an increasingly large premium.

Real activity during the inflation. The postwar inflation was associated with a booming economy through the third quarter of 1922, followed by a severe bust starting at the end of 1922.[13] Figure 3 plots an index of real GDP per capita for Germany starting in 1918. For comparison, we also plot an index of average real GDP per capita growth for other major industrial economies, weighted by GDP. While the U.S., U.K., and other industrial economies underwent deflation and declining output to maintain or return to pre-war gold parities, Germany's real GDP per capita rose by 20% from 1919 to 1922. Further, unemployment was low from the end of WWI until the last months of 1922 (see Figure C.4). Germany's inflationary boom slows with the hyperinflation in the second half of 1922 and decisively reverses in early 1923, following the invasion of the Ruhr and the resulting passive resistance. In 1923, Germany saw a large fall in real GDP, and unemployment rose to nearly 30% at the height of the hyperinflation and in the run-up to the stabilization.

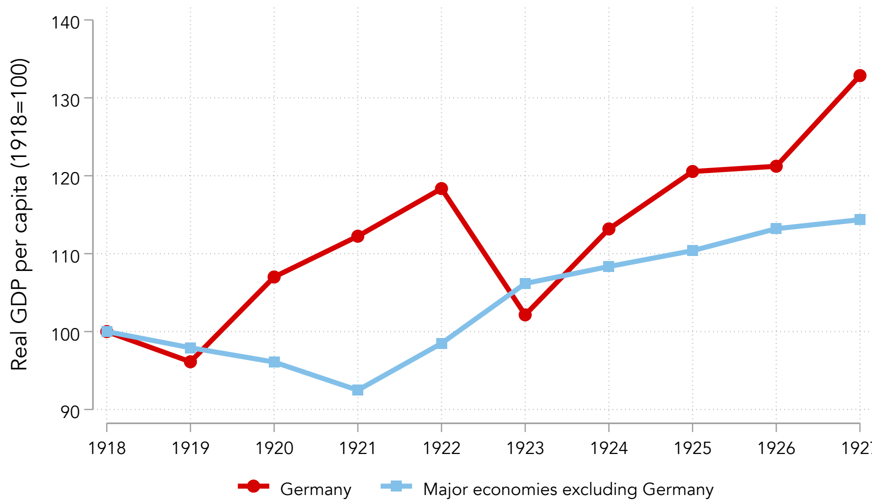
4.2 Aggregate Evidence on the Debt-Inflation Channel

Inflation and firm bankruptcies. In the presence of nominal debt contracts, unexpected inflation will increase the net worth of levered nonfinancial firms and reduce the likelihood of bankruptcy. Figure 4 plots the relation between the number of firm bankruptcies in a quarter and inflation over the past four quarters. There is a striking negative relation between inflation and firm bankruptcies. Bankruptcies fall with rising inflation in 1919, then rise with falling inflation in 1920, before falling as inflation rises from the second half of 1921. The relation is also convex. It is steep during the first phase of the postwar inflation for 1919Q1 to 1922Q2, but flatter in the hyperinflation phase from 1922Q3 to

[12]Inflation had been low in all major economies for multiple decades under the Gold Standard before WWI Eichengreen (1995).

[13]As emphasized by Graham (1931): "that business in Germany was booming during most of the inflation period is a universally admitted fact." Graham (1931) further argued that inflation contributed to the boom.

Figure 3: *Real GDP in Germany and Other Major Economies, 1918-27.*



Notes: This figure shows real GDP per capita for Germany and an index of other major economies. The series are indexed to 100 in 1918. The data are from Jordà et al. (2017) and Barro and Ursúa (2008). "Other major economies excluding Germany" is an index of average real GDP growth per capita, weighted by lagged nominal GDP in U.S. dollars. The index is constructed using 15 countries with continuous coverage in the Jordà et al. (2017) database between 1914 and 1927 (Australia, Belgium, Canada, Denmark, Finland, France, Italy, Japan, Norway, Portugal, Spain, Sweden, Switzerland, the U.K., and the U.S.).

1923Q4.[14] Once annual inflation is high, further increases in inflation are not associated with additional defaults. It is worth noting that bankruptcies remained low even in 1923, when output declined significantly.

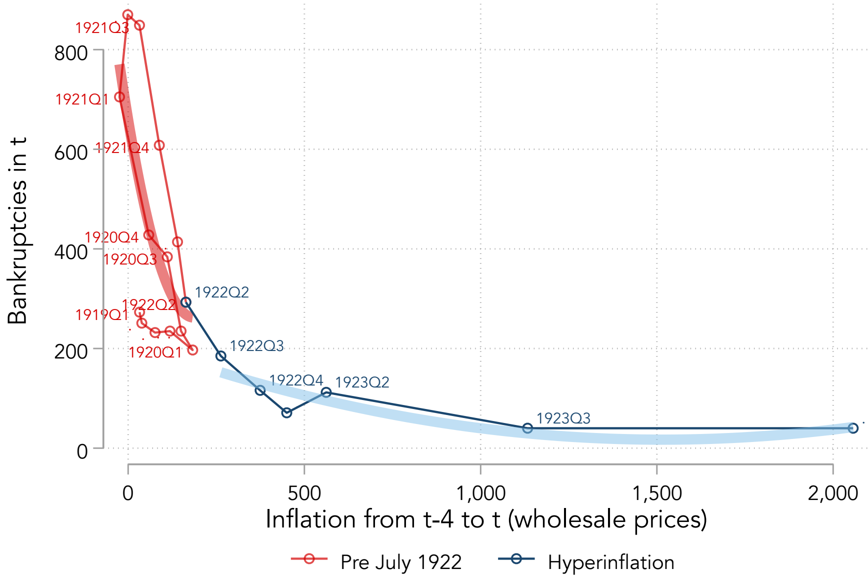
The pattern is robust to different ways of measuring bankruptcies and inflation. Figure C.5 confirms the above patterns for the bankruptcy rate, rather than the level of bankruptcies. The bankruptcy rate falls from 1.5% in 1920 to close to zero in 1923.[15] Further, while Figure 4 uses the level of annual inflation on the x-axis, Figure C.6 in the Appendix reveals a similar pattern when using the "accelerationist" version that uses the change in inflation.

Inflation eroded real firm debt burdens. Our hypothesis is that the negative inflation-bankruptcy relation emerges because inflation erodes firms' nominal liabilities. Figure 5 provides direct evidence that the inflation reduced firm leverage. Panel (a) compares the distribution of firm book leverage in 1919 and 1924 in the *Saling's* firm-level data. Book leverage is defined as liabilities-to-assets. We choose 1919 as the start year, as it marks the

[14]See Table C.1 in the appendix for the corresponding regression estimates.

[15]We plot the number of firms in bankruptcy in Figure 4, rather than the bankruptcy rate, because the total number of registered firms used in the denominator of the bankruptcy rate is only available annually.

Figure 4: *Inflation and Firm Bankruptcies.*



Notes: This figure plots the number of firm bankruptcies in quarter t against realized inflation over the past four quarters from $t-4$ to t. 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*. The thick lines represent quadratic fits, computed separately for each of the two stages of inflation.

beginning of the postwar inflation. We choose 1924 as the endpoint to utilize the more reliable Goldmark balance sheets, which firms were required to report by January 1924, shortly after the stabilization.

Figure 5(a) shows that the distribution of leverage shifts significantly to the left during the German inflation. The leverage ratio falls by 25 percentage points for the average firm in the sample. Figure C.2(a) in the Appendix plots the median of firm liabilities, deflated by wholesale prices, by quarter.[16] It shows that real debt declines substantially during the first inflation acceleration in 1919. Debt in real terms then falls again once inflation accelerates in 1921, before falling sharply from mid 1922, once hyperinflation takes hold. The large decline in debt from the summer of 1922 onward also suggests that firms were not able to take on new debt once expectations of inflation become unanchored.[17]

Panel (b) of Figure 5 analyzes firm leverage from the perspective of interest expenses. Specifically, it shows the evolution in the share of interest expenses in firms' total non-

[16]As discussed in section 3, systematic measurement error of balance sheet items during the hyperinflation is less of a concern for nominal items such as debt.

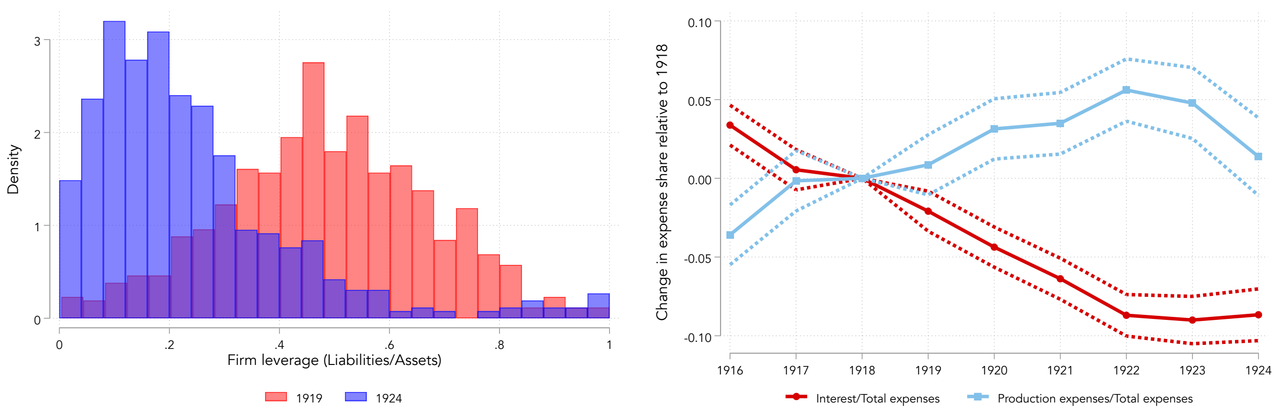
[17]As we discuss in section 5 and Appendix A, credit conditions were not particularly tight for most of the first phase of the inflation, but credit availability tightened sharply starting from late 1921 onward.

depreciation expenses. We calculate the within-firm change using the estimated year fixed effects from a firm-level regression with firm and year fixed effects. Firms do not always break out interest expenses from other expenses in the income statements reported in the *Saling's* data, so this measure is a lower bound on interest expenses. Figure 5(b) shows a clear decline in the share of interest expenses to total expenses during the inflation. The interest expense share declines by about 10 percentage points. The erosion of real debt thus directly boosted firms' interest coverage ratios and benefited their liquidity positions.

Figure 5(b) also plots the evolution of production expenses to total expenses. Production expenses are defined as revenue minus EBITDA. Production expenses as a share of total expenses rise during the inflation. This is consistent with firms reallocating expenses from interest payments to payments to materials and employment to boost production.

Figure 5: *Hyperinflation Led to Collapse in Leverage and Interest Expenses.*

(a) *Distribution of leverage in 1919 and 1924.* **(b)** *Evolution of expense shares over time.*



Notes: Panel (a) shows the distribution of firm book leverage at the start of the postwar inflation in 1919 and in the aftermath of the hyperinflation in 1924. Leverage is defined as $^{Assets - Equity}/_{Assets}$. Panel (b) plots the evolution of interest expenses and production expenses, both as a share of total expenses, during the inflation. Specifically, it plots the sequence of estimated year fixed effects $\{\hat{\gamma}_t\}$ from firm-level two-way fixed effects regression regression of the form: Expense Share$_{it} = \alpha_i + \gamma_t + \epsilon_{it}$, for interest expenses to total expenses and production expenses to total expenses as the dependent variables. Expenses are from the previous twelve months for fiscal year ending in a reported year. This regressions captures the change in the expense share within firm. Errors bands represent 95% confidence intervals based on standard errors clustered at the firm level.

4.3 Price and Wage Flexibility during the Inflation

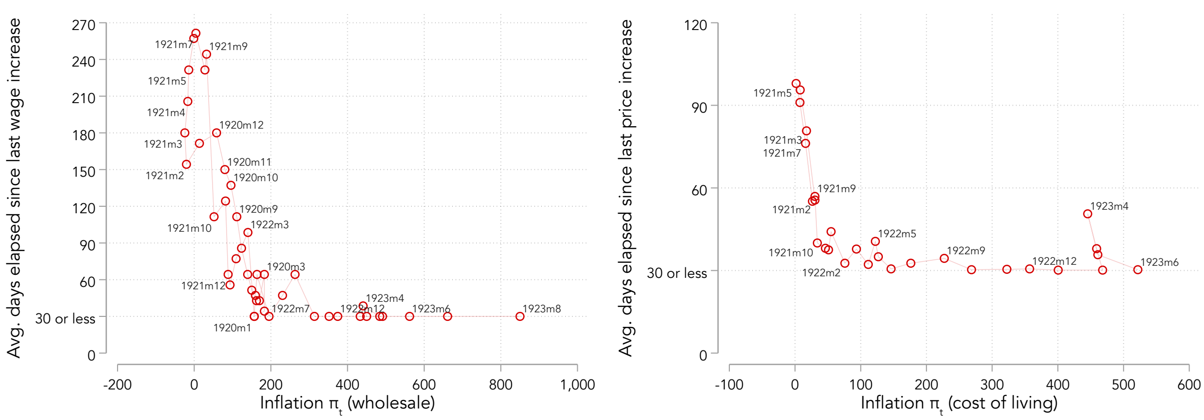
Inflation reduced real debt burdens from fixed nominal debt contracts. How did wage and price setting respond? Real wages, an implicit nonfinancial liability for firms, may also have declined if wages were sticky and slow to respond to inflation, further benefiting firms. At the same time, wages can be renegotiated *ex post* and can therefore have significantly shorter effective maturity than debt contracts. Similarly, prices, which matter for firm revenues, can also be adjusted after a shock to inflation.

We first analyze the frequency of wage adjustment during the inflation. The "Stinnes-Legien" agreement from November 1918 enshrined a set of workers' rights long coveted by the German labor movement, including the recognition of trade unions as the official representatives of the workforce. This allowed for industry-level union bargaining. We therefore collect industry-level wages for seven industries from 1920 through 1923.

Panel (a) in Figure 6 examines the frequency of wage adjustment during the inflation. It plots the number of days since wages were last increased, averaged across the seven industries, against wholesale price inflation.[18] As inflation accelerated, wages were adjusted with increasing frequency. At low levels of inflation, wages were adjusted, on average, every 9 months. This frequency increased to every 60 days or less once inflation exceeded 100% and every 30 days or less during hyperinflation.[19]

Figure 6: *Interval between Price Adjustment Falls during the Inflation: Evidence from Wages and Cost-of-Living Index Prices.*

(a) *Frequency of wage adjustments and inflation.* **(b)** *Frequency of price adjustments and inflation.*



Notes: This figure plots the duration of unchanged wages and of prices of products underlying the cost-of-living index. Wages and 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 price level in month t and month $t-12$, times 100.

The increasing flexibility of wages informs the evolution of real wages. Relative to

[18] Figure C.7 plots the average number of days elapsed since wages were last increased separately for each of the seven industries.

[19] Narrative evidence suggests that wages were adjusted weekly once the inflation reached hyperinflation (Feldman, 1993). We obtain union-bargained wages only at the monthly frequency and thus can only provide an upper bound on the time elapsed since the last wage increase.

pre-war levels, real wages declined during the inflation. Given that the Stinnes-Legien agreement primarily benefited blue-collar and low-skilled workers, the decline in real wages is more pronounced for higher-skilled salaried workers (see Appendix Figure C.10 for state employees from 1914 through 1923). However, most of the decline in real wages had already occurred by the end of 1920. During 1920-23, real wages fluctuate substantially, but there is no clear evidence of a downward trend. This is consistent with wages becoming flexible and racing to keep up with prices once inflation becomes high.

Inflation also led to a shortening in the duration of retail prices. Figure 6 panel (b) presents a similar analysis for the frequency in the adjustment of goods prices. The analysis is based on the prices of goods underlying the cost-of-living index. The data are at the city-product-month level for 18 major cities and 12 retail products such as sugar, pork, and milk. The price quoted for each city is the average of 4 samples taken over the course of a month for each city. An important caveat is that because data are not quoted prices but averages of quoted prices, they may overstate the frequency at which individual quoted prices were adjusted upwards.[20]

Figure 6(b) relates the average days elapsed since the last price increase against the level of inflation. There is a negative relation between inflation and the duration of price adjustment. For cost-of-living inflation around 0%, prices are adjusted every 80 to 100 days. However, once inflation exceeds 50%, product prices are adjusted at least once every 30 to 40 days. By early 1922, before the hyperinflation phase, prices of most goods in all cities are adjusted upwards every 30 to 60 days. By the hyperinflation, prices are adjusted even every 7 days or less (see Appendix Figure C.8).

Overall, Figure 6 indicates that prices and wages became increasingly flexible with rising inflation. The reduction in the time elapsed between price and wage adjustments with rising inflation is consistent with menu cost models (Gagnon, 2009; Alvarez et al., 2019). There was thus likely limited stickiness in the aggregate price and wage levels once the inflationary shocks became large (Golosov and Lucas, 2007; Caballero and Engel, 2007).[21] Revenues and wage expenses of nonfinancial firms increased at a similar pace as overall inflation once inflation became high. In contrast, the debt-inflation channel may still be active even for large shocks to the price level, as long-term financial contracts cannot be renegotiated.

[20]Note that this caveat does not apply to wages. Further, to partially address this concern, we also hand-collected the daily prices of two widely circulated newspapers. These represent actual quoted prices, but only for two goods. We find similar results on the frequency of price adjustment for these newspaper prices, as shown in Figure C.9.

[21]Nevertheless, menu costs could have induced large economic costs through price dispersion, as calibrated by Alvarez et al. (2019) using micro-data on prices in Argentina's 1989-90 hyperinflation.

5 Firm Level Evidence on the Debt-Inflation Channel

The analysis of aggregate data in section 4 shows that the increase in the price level reduced the real value of nominal debt claims and interest payments, which in turn led to a drastic decline in firm bankruptcies. The aggregate data thus suggest that inflation relaxed firms' financial constraints and thus potentially stimulated economic activity through the debt-inflation channel. A concern with interpreting patterns in aggregate data, however, is that other unobserved shocks that are correlated with inflation may have reduced bankruptcies, leading to a spurious negative relation. Moreover, while the inflation may have redistributed from debt-holders to equity-holders, this redistribution may not necessarily have affected real economic activity.

In this section, we address these concerns by analyzing cross-sectional variation using firm-level data. We ask: do firms with higher leverage experience differential outcomes during the inflation? We exploit that firms with relatively higher leverage naturally have a higher nominal balance sheet exposure to unexpected increases in the price level. This analysis allows us to tighten the empirical link between inflation and real economic outcomes through the debt-inflation channel.

5.1 Main Result: Leverage and Firm-level Employment

Empirical specification and identification. We test whether firms with high leverage increase their overall level of economic activity relative to firms with low leverage during the inflation. We proxy a firm's real economic activity by its total number of employees. Studying employment as the outcome variable is especially informative, as balance sheets become less reliable during the hyperinflation. Hence, the reported number of employees dominates alternative indicators of real economic activity constructed from financial statements, such as capital expenditure.

We examine the evolution of firm outcomes across firms with high and low leverage through the lens of a standard dynamic difference-in-differences model. We estimate variants of the following specification:

$$\ln(Employment_{it}) = \alpha_i + \delta_{st} + \sum_{k \neq 1918} \beta_k Leverage_{i,1918-19} \mathbf{1}_{k=t} + \sum_{k \neq 1918} X_i \Gamma_k \mathbf{1}_{k=t} + \epsilon_{it} \quad (1)$$

where $Employment_{it}$ is the number of employees at firm i in year t. $Leverage_{i,1918-1919}$ is a measure of firm i's leverage at the start of the inflation. Furthermore, α_i is a firm fixed effect, δ_{st} is an industry-time fixed effect, and X_i is a set of firm-level control variables.[22] All controls are constructed by averaging across 1918 and 1919 and have year-specific coefficients. The sequence of estimates $\{\hat{\beta}_k\}$ captures the evolution of employment for high leverage firms, relative to low leverage firms, with 1918 as the benchmark year. Our main estimation period is 1916-1923; we consider longer samples below.

We measure a firm's balance sheet exposure to inflation by its leverage ratio at the onset of the inflation. Intuitively, firms with relatively more nominal liabilities—to the extent these are not short-term and constantly repriced, floating rate, or indexed to the price level—benefit more from unexpected increases in the price level. In a frictionless economy in which the Modigliani-Miller theorem holds, equity-holders would benefit from unexpected inflation, but the resulting changes in a firm's capital structure would have no impact on firm real investment or employment decisions. However, if firms are financing constrained, unanticipated inflation can relax financing constraints for levered firms, leading them to increase investment and employment.

We define leverage either as the ratio of a total liabilities to total assets or a financial debt to total assets. The latter measure incorporates both short- and long-term financial debt such as trade credit, bank debt, and bonds. The former measure also includes other nominal liabilities such as accrued wages, unpaid taxes, and pensions. Most debt contracts, especially long-term debt contracts, were fixed-rate.[23] Long-term debt was common, and firms often issued fixed-rate bonds with a maturity from 10 to 50 years. Further, when calculating a firm's leverage we average over the respective ratio reported in 1918 and 1919.[24]

The identifying assumption behind our empirical strategy is that of parallel trends: In the absence of differences in leverage, firms with high and low leverage would have evolved in parallel during the inflation. Identification does not require that leverage be

[22] The industry classification corresponds approximately to two-digit SIC industries.

[23] While no detailed information on the contractual structure of bank debt is available, it is technically possible that short-term bank debt was floating-rate and indexed to the Reichsbank's discount rate. However, the Reichsbank's discount rate remained unchanged at 5 percent between summer 1914 and July 1922. The lack of a policy response hence implied that any floating-rate debt claims were effectively fixed rate. The Reichsbank eventually gradually increased its discount rate to 18 percent by April 1923 and then to 90 percent in summer 1923.

[24] We prefer the average for two reasons. First, as seen in Figure 1 inflation starts to pick up towards the later months of 1919, implying that the treatment date is slightly different than the available as-of dates of the firm balance sheet data. Most balance sheet data are available for December 31 of a given year; thus, the end of 1918 balance sheets may be outdated by mid-1919. Second, using the average of both years also alleviates the concern that the 1918 end-of-year balance sheets may be affected by the Armistice and the political instability around the revolution in November 1918 and arguably less reliable and more noisy. Table C.3 in the Appendix shows that results are similar when using leverage either as reported in 1918 or in 1919, as opposed to their average.

randomly assigned, but it assumes that leverage at the onset of the inflation is uncorrelated with other shocks to employment during the inflation, conditional on controls. This identifying assumption would be violated if, for example, highly levered firms were also exposed to positive demand shocks or faced better investment opportunities. We take a series of steps to alleviate concerns about such threats to identification.

First, we study what factors explain the variation in firm leverage. Table C.2 shows that the main factors in explaining cross-firm variation in leverage are firm size and industry. The positive correlation between leverage and size is consistent with a size-dependent borrowing constraint, perhaps due to a lower probability of default for large firms (Rajan and Zingales, 1995; Gopinath et al., 2017). After controlling for these variables, leverage is uncorrelated with EBIT margin, return on assets, and the share of fixed assets in total assets. Moreover, there is considerable unexplained variation, consistent with the evidence that debt ratios often vary widely even for similar firms (Myers, 1984; Graham and Leary, 2011). Historical accounts suggest that firms did not borrow in 1918-19 in anticipation of the inflation, as the inflation was unexpected (Lindenlaub, 1985; Balderston, 1991).

Second, the cross-section provides a stronger test than the aggregate time series, as we can control for aggregate and industry-specific shocks impacting firms. Industry-year fixed effects, δ_{st}, absorb aggregate shocks such as the Ruhr invasion as well as industry-specific shocks that might be correlated with leverage. For example, inflation led to a flight from the mark toward durable assets, which disproportionately benefited firms in industries producing these assets (Graham, 1931). Related to this, the depreciation benefited exporting firms, so industry-year fixed effects control for industry-level differences in exposure to the exchange rate channel. Further, price and wage rigidity may vary across industries and be correlated with leverage. For example, D'Acunto et al. (2018) find that U.S. public firms with more flexible prices have higher financial leverage. In this context, union-bargained wage setting was common but industry-specific. Industry-year fixed effects absorb effects of industry-specific rigidity in wages or prices.

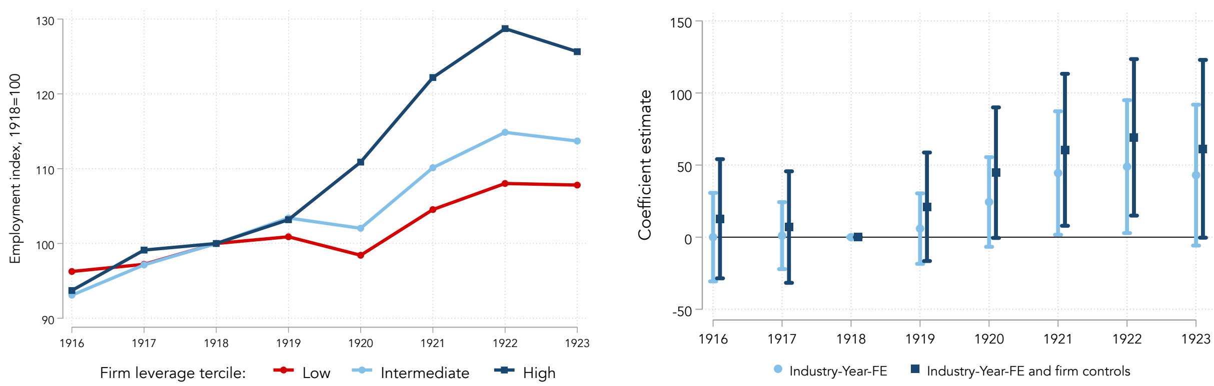
Third, we include a range of controls to capture differences in firms' investment opportunities that may be correlated with leverage. Our baseline analysis controls for size, fixed assets-to-total assets, return on assets, and profit margin, all as of 1918-1919.

Fourth, below we present additional tests to further alleviate concerns about specific threats to identification such as differential cyclicality or exposure to credit supply shocks. Finally, we study pre- and post-trends and show that the impact of leverage on employment is concentrated in the inflation period, with the largest effects occurring between 1919 and 1922.

Results. We start by illustrating the basic result in the raw data. We sort firms into terciles based on their 1918-1919 average liabilities-to-assets ratio and compute the average evolution of employment for each group of firms.[25] Panel (a) of Figure 7 shows the results. Most firms see strong employment growth from 1918 through 1923. This is in line with evidence from section 4 that the inflation was associated with increased economic activity through 1922. The strongest employment gains during the inflation occur for high leverage firms, followed by intermediate leverage firms. Employment at firms in the top tercile of the leverage distribution grows by approximately 30% from 1918 through 1922. In contrast, firms in the lowest tercile only experience an 8% increase in employment. The figure also shows that employment growth was similar across high, intermediate, and low leverage firms in the years before the inflation.

Figure 7: *Employment Dynamics across Low and High Leverage Firms.*

(a) *Employment by tercile of liabilities to assets.* **(b)** *Results from estimating equation* (1).



Notes: Panel (a) presents the average growth of employment for firms in the bottom, middle, and top terciles of leverage. Leverage is defined as the average ratio of liabilities to assets over 1918-1919. Employment is indexed to 100 in 1918 for each group. Panel (b) presents the sequence of estimates $\{\beta_k\}$ from estimating equation (1). Firm-level control variables are omitted for the light-blue coefficient estimates but included for the dark-blue estimates. Firm-level control variables are firm size (log of assets), the share of fixed assets to total assets, return on assets, and profit margin (EBIT-to-revenue), all as of 1918-19. Errors bars represent 95% confidence intervals based on standard errors clustered at the firm level.

Panel (b) in Figure 7 presents the results from estimating (1) using ${}^{Liabilities}/{}_{Assets_{i,1918-19}}$ as the measure of leverage.[26] Firms with higher leverage see stronger employment growth in 1919-1922 relative to firms with lower leverage. The estimates are similar

[25]Figure C.11 show that the results are similar using financial debt to assets (averaged over 1918-1919) and liabilities to assets averaged over 1917- 1919 (instead of 1918-1919). As an alternative way to visualize the results, Figure C.12 plots binned scatterplots of employment growth for various years relative to 1918 against initial firm leverage.

[26]Appendix Figure C.20 shows that the findings are similar when using the ratio of financial debt to assets.

when including industry-year fixed effects and firm-level controls interacted with year fixed effects. In line with the evidence of panel (a), panel (b) of Figure 7 reveals that employment at high leverage firms remains elevated through 1923. Altogether, we interpret the patterns from panel (b) of Figure 7 as an indication that the inflation starting in 1919 transmitted to the real economy at least partially via a debt-inflation channel.

Table 2: *Firm Leverage and Employment.*

Dependent Variable	ln(Employment)					
	(1)	(2)	(3)	(4)	(5)	(6)
Liabilities/Assets$_{i,1918-1919}$ $\times \mathbf{1}_{t\geq 1920}$	45.7***	36.6**	44.2**			
	(16.1)	(17.0)	(20.4)			
Debt/Assets$_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$				44.0***	39.5**	40.1**
				(16.2)	(16.6)	(19.9)
Observations	1912	1864	1726	1912	1864	1726
Number of Firms	357	351	322	357	351	322
R^2	0.97	0.97	0.97	0.97	0.97	0.97
Year FE	✓			✓		
Firm FE	✓	✓	✓	✓	✓	✓
Industry-Year-FE		✓	✓		✓	✓
Controls $\times$ $\mathbf{1}_{t\geq 1920}$			✓			✓

Notes: This table reports results from a model estimating equation (2) for log employment (times 100) as the dependent variable. Firm-level controls consist of firm size (log of assets), the share of fixed assets to total assets, return on assets, and profit margin (EBIT-to-revenue). The estimation period is from 1916 through 1923. Standard errors in parentheses are clustered at the firm level. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 2 reports results for employment from a difference-in-differences specification of the form:

$$\ln(Employment_{it}) = \alpha_i + \delta_{st} + \beta(Leverage_{i,1918-1919}\,\mathbf{1}_{t\geq 1920}) + X_i\Gamma + \epsilon_{it}, \qquad (2)$$

where $Leverage_{i,1918-1919}$ is either the ratio of total liabilities to assets or financial debt to assets, and $\mathbf{1}_{t\geq 1920}$ is a dummy that takes the value one after 1920. The estimation period is 1916 to 1923. The estimated coefficient on $Leverage_{i,1918-1919}$ interacted with $\mathbf{1}_{t\geq 1920}$ is positive and statistically significant at the 5% level or lower, irrespective of how we proxy firm leverage. Further, as above, the effects of leverage on employment during the inflation is robust to the inclusion of firm-level control variables and granular industry-year fixed effects.

The magnitude of the effect is economically meaningful. Increasing a firm's leverage ratio by 10 percentage points implies 3.5-4.5% higher average level of employment between 1920 and 1923 compared to the average level from 1916 through 1919. Applying the estimated coefficient (37%) to the average *ex ante* leverage of 47% implies a partial equilibrium aggregate increase in employment of 17% from the debt-inflation channel. This is similar to the average firm increase in employment from 1919 to 1922 of 17.5%. We stress that this calculation abstracts from general equilibrium effects. For example, if more exposed firms expand at the expense of less exposed firms, this would dampen the aggregate effect. Further, losses to creditors could be contractionary by depressing credit supply, as we discuss further below, or they could be expansionary by boosting the labor supply of households who hold debt claims, as in our model in appendix B.

5.1.1 Robustness and additional results

Credit supply shifts. Our hypothesis is that high leverage firms benefit from the inflation through an increase in their net worth and a relaxation of financing constraints. A related channel that may differentially affect high and low leverage firms is a shift in credit supply caused by inflation. Financing was available in much of the first phase of the inflation when additional inflation was not expected. However, credit supply contracted in 1922 with increased expectations of depreciation.[27]

The bias introduced by the credit supply channel in the estimation of (1) could be either positive or negative, as it is not clear whether high or low leverage firms are most exposed to a credit supply contraction. Controlling for size, industry, and profit margin partially addresses this concern, as these are common proxies of exposure to credit supply (e.g., Gertler and Gilchrist, 1994). Furthermore, our evidence below that the effect of leverage is strongest for firms with longer maturity debt also points to the importance of the firm balance sheet channel.

As additional robustness, we add controls that more directly proxy for differential exposure to shifts in bank credit supply. First, we collect information on firm-bank relationships in 1919. We follow Doerr et al. (2018) and measure firm-bank relationships based on information on the banks that paid out a firm's dividends (*Zahlstellen*). With this information, we control for bank-time fixed effects, distinguishing between seven major banks, other banks, and firms without banking relationships. This essentially compares two firms with different leverage but connected to the same bank, thereby holding fixed bank-specific changes in credit supply.[28] Second, we control for the distance to Berlin, as firms located closer to Berlin may have had better access to Reichsbank credit during the

[27]See Appendix A for a detailed discussion of the impact of the inflation on banks and credit conditions.

[28]We note that this only controls for credit-supply shocks that are bank specific. It would not capture credit-supply changes that affect firms differently based on their unobservables.

inflation. The estimated effect of leverage on employment is quantitatively similar with these controls (see Appendix Table C.4 and Figure C.13).

Investment opportunities. Higher leverage could be correlated with future investment opportunities, leading to an upward bias in the estimate of the debt-inflation channel. Given that investment opportunities are unobserved, it is challenging to perfectly address the concern that investment opportunities in 1919-1922 are correlated with leverage. In Appendix Table C.4 and Figure C.13, we present two tests that control for proxies of investment opportunities. First, we add controls for lagged investment in 1916, 1917, and 1918 to capture the idea that a firm with high future investment opportunities may have a high recent rate of investment. Second, we control for future profitability, proxied by return on assets and EBIT-to-revenue in 1920, 1921, and 1922. This second test is likely to "overcontrol," as changes in profitability could be outcomes of firms expanding in response to relaxed financing constraints. In our model in Appendix B, the debt-inflation channel increases firm profitability. In this case, controlling for future profitability leads to a downward bias in the effect of leverage on employment. Nevertheless, the basic result is reasonably similar when including these controls.

It is worth noting that the concern that leverage is positively correlated with investment opportunities goes against basic capital structure theories. Agency theories of capital structure predict that managers of firms with high future investment opportunities should choose lower leverage because these firms are more concerned about debt overhang restricting profitable investments (Jensen and Meckling, 1976; Myers, 1977; Stulz, 1990).

Cyclicality. A related concern is that firms with high leverage at the onset of the inflation could be more exposed to business cycle risk. One version of this concern is that high leverage firms have more cyclical employment. To address this concern, in Figure C.16 we collect additional data on firm employment through 1933 and show that firms with high leverage as of 1918-19 do not see a larger increase in employment in the late 1920s boom or a larger employment decline during the Great Depression (our data do not allow us to examine earlier cycles). Leverage at the onset of the inflation therefore does not appear to capture general cyclicality. In addition, one would expect industry-year fixed effects to capture a significant portion of cross-firm differences in cyclicality.

Another version of this concern is that the economic expansion during 1919-1922 may have differentially affected high leverage firms through a demand channel. For example, Giroud and Mueller (2017) find that high leverage firms in the non-tradable sector reduced employment more than low leverage firms following household demand shocks in the 2008 Great Recession. These effects should matter less for firms that produce tradable goods, as these firms are exposed to both domestic and global demand. In contrast, the debt-inflation channel should still affect tradable sector firms. Appendix Table C.4 shows that the results are similar when restricting the sample to firms in the tradable sector, defined as firms in mining and manufacturing industries.

Longer-run effects. The main analysis in the paper focuses on the impact of the inflation on highly levered firms during the inflation period from 1919 to 1923. A natural question is whether the debt-inflation channel has longer-run effects. In this context, there is a measurement challenge in estimating longer-term effects, as the number of firms reporting employment declines substantially between 1924 and 1926, before increasing again in 1927.[29] This leads to attrition that could bias the results. We thus present two sets of analyses. First, we report results from estimating our baseline specification (1) on the raw data for a longer sample. Second, since most of the firms that report employment in 1923 but not in 1924-26 report again in 1927, we linearly interpolate employment for these firms. This has the drawback of not capturing any temporary changes in employment in 1924-26, but it allows for a clearer visualization of longer-term trends.

Figure C.14 presents the results from these two exercises. The estimation on the raw data reveals a dip in 1924-1925 and partial recovery in 1926. However, once we interpolate employment for firms with missing employment in 1924-26, the dip is much less pronounced. On balance, the evidence points toward persistent employment gains from the inflation for high leverage firms.[30]

5.2 Additional Evidence Supporting the Debt-Inflation Channel

We next provide evidence on the mechanisms through which the inflation affected levered firms. First, we ask, do more levered firms pay less in interest expenses and have more resources available to spend on production expenses such as salaries and raw materials? Second, are the effects stronger for firms with a higher proportion of long-term debt? Third, do firms with higher leverage see a larger increase in their book equity values and a higher valuation in the stock market?

[29]The number of firms reporting employment is 342 in 1923, 280 in 1924, 127 in 1925, 135 in 1926, and 358 in 1927.

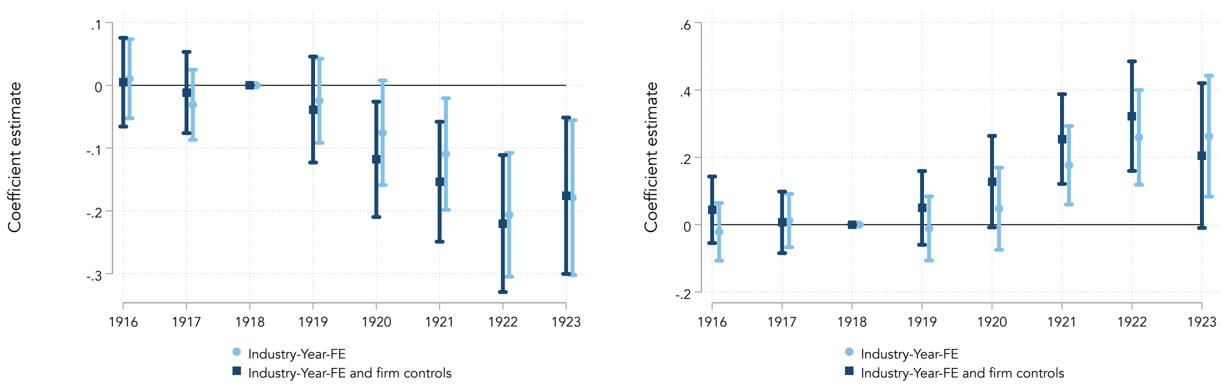
[30]A related concern is that the baseline results may be affected by the unbalanced nature of the panel data on employment. Figure C.15 addresses this concern by estimating (1) on full and balanced panels for both raw and interpolated employment. The patterns are similar across different samples during the 1916-1924 period.

Interest expenses and production expenses. First, we study the dynamics of interest expenses and production expenses at the firm level. Recall from Figure 5b that the average share of interest expenses to total expenses falls during the inflation. We now ask whether this fall is more pronounced for high leverage firms. The decline in interest expenses would provide liquidity for firms to pay production expenses broadly defined as expenses for labor, raw materials, consumable manufacturing supplies, and general overhead (i.e., total non-depreciation expenses net of taxes and interest expenses).

Similar to our analysis of firm-level employment, we estimate equation (1) using either the ratio of interest expenses and total expenses or the ratio of production expenses and total expenses as the dependent variable. Figure 8 shows the results. Firms with a higher share of nominal liabilities relative to total assets at the onset of the inflation dedicate fewer resources to servicing their debt claims, as the real burden of debt service declined. The effect is persistent and builds throughout the inflation. A similar pattern arises when using the financial debt-to-assets ratio as the measure of leverage (see Appendix Figure C.20). The decline in interest expenses allows a financially constrained firm to spend more of its revenue on expenses to boost production. Indeed, we find that more levered firms start spending relatively more of their total expenses on production expenses.

Figure 8: *Firm Leverage, Interest Expenses, and Production Expenses and Salaries.*

(a) *Interest Expenses.* **(b)** *Production Expenses.*



Notes: This figure plots the sequence of estimates $\{\beta_k\}$ from estimating a version of equation (1) with the the ratio of interest expenses to total expenses (panel (a)) or the ratio of production expenses to total expenses (panel (b)) as the dependent variable. Firm-level control variables are firm size (log of assets), the share of fixed assets to total assets, return on assets, and profit margin (EBIT-to-revenue), all as of 1918-19. Error bars represent 95% confidence intervals based on standard errors clustered at the firm level.

We also estimate a model similar to equation (2) using interest expenses and production expenses as the outcome variables. Table 3 reports the results. Our findings confirm the patterns in Figure 8 and indicate that more levered firms paid less interest as a share of their total expenses after the inflation started in 1919. For instance, we find that a 10 percentage point increase in initial leverage is associated with 1.2 to 2 percentage points lower interest payments as a share of total expenses from 1920 onward. At the same time, a firm with a 10 percentage point higher leverage ratio spends around 2 percentage points more of its total expenses on production expenses. Altogether, these findings are in line with highly levered firms benefiting from the inflation by decreasing the amount of resources that need to be spent on interest payments, allowing these firms to hire more employees and spend more funds on salaries, raw materials, and other production inputs.

Table 3: *Firm Leverage, Interest Expenses, and Production Expenses.*

Dependent Variable	Interest Expenses/Tot. Expenses				Production/Tot. Expenses			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liabilities/Assets$_{i,1918-1919}$ $\times \mathbf{1}_{t\geq 1920}$	-0.12***	-0.15***			0.17***	0.20***		
	(0.037)	(0.037)			(0.048)	(0.053)		
Debt/Assets$_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$			-0.16***	-0.19***			0.21***	0.23***
			(0.036)	(0.036)			(0.050)	(0.054)
Observations	3461	3224	3461	3224	3461	3224	3461	3224
Number of Firms	551	502	551	502	551	502	551	502
R^2	0.71	0.74	0.71	0.74	0.68	0.70	0.69	0.70
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Industry-Year-FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls $\times \mathbf{1}_{t\geq 1920}$		✓		✓		✓		✓

Notes: This table reports results from estimating (2), with either firm *i*'s share of interest expenses of total expenses (columns 1-4) or the share of production expenses of total expenses (columns 5-8). $Leverage_{i,1918-1919}$ is either firm *i*'s ratio of financial debt or total liabilities to total assets averaged over 1918-1919. Firm-level controls consist of firm size (log of assets), the share of fixed assets to total assets, return on assets, and profit margin, all as of 1918-1919. The estimation period is from 1916 through 1923. Standard errors in parentheses are clustered at the firm level. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Impact on firms with longer maturity debt. The debt-inflation channel should be especially strong for firms with a higher proportion of long-term debt (see, for example, Gomes et al., 2016). As inflation rises and increases *expected* inflation, firms that have secured long-term financing are less exposed to a repricing of new loans. As a finer test, we therefore examine whether, within firms that are more levered, firms with more long-term debt benefit relatively more.

Nonfinancial German firms relied extensively on fixed-rate long-term bond financing. We collect detailed information on the contractual loan terms of all bonds issued by firms in our sample as of 1918 and 1919. These loan terms are detailed in Table 4. All bonds in the sample pay a fixed coupon, and the coupon rates are almost all between

400 and 500 basis points of par. After origination, the loan terms typically specified an interest-only period lasting 5 years, on average, during which no amortization took place. Once repayment started, bonds would be typically amortized evenly until a specified final repayment date. Notably, bonds were of very long maturity. For instance, for bonds outstanding in 1918 and 1919, the median origination year was 1906 and the median final maturity year was 1940. Figure C.21 in the Appendix also shows that most bonds were originated before WWI, and a final maturity date after 1950 was not uncommon.

Table 4: *Interest Rates, Volume, and Maturity Structure of Bonds Outstanding in 1918 and 1919.*

	Mean	p5	p25	Median	p75	p95
Panel A: Interest rates and volume						
Interest rate (ppt)	4	4	4.25	4.5	4.5	5
Volume (in thousand RM)	3961	500	1000	2000	5000	13000
Panel B: Origination and maturity						
Origination year	1906	1895	1901	1906	1911	1919
Repayment start year	1910	1897	1905	1910	1916	1922
Repayment end year	1941	1926	1933	1940	1947	1961

Notes: This table provides information on all outstanding bonds issued by firms in our sample. Data are obtained from *Saling's Börsen-Jahrbuch* published in 1919 and 1920 (covering 1918 and 1919). The table is based on a sample of $N = 417$ firms. 51% of firms in the sample report information on at least one bond.

To test whether the impact of the debt-inflation channel is stronger for firms with relatively more long-term bond financing, we interact a firm's debt-to-assets ratio with a set of four dummies that indicate the quartile of the firms' ratio of long-term-debt to total debt. Here, we use the ratio of debt-to-assets rather than the ratio of liabilities-to-assets, as interest expenses are more naturally connected to financial debt rather than other non-debt nominal liabilities. Specifically, we estimate triple-difference specifications of the following form:

$$y_{it} = \alpha_i + \delta_{st} + \sum_q \beta_q \, Q_{i,q} \, \left(\frac{Debt}{Assets}\right)_{i,1918-19} \mathbf{1}_{t \geq 1920} + \Gamma \, X_i \, \mathbf{1}_{t \geq 1920} + \epsilon_{it}, \tag{3}$$

where $Q_{i,s}$ is an indicator for each quartile q of the distribution of long-term debt to total debt.

The results are presented in Table 5. Firms with a high share of long-term debt experienced the largest reduction in the share of interest payments of total expenses.

The effect is close to zero for firms in the lowest quartile of the long-term debt and builds monotonically for firms in higher quartiles of the long-term debt distribution. For example, a 10 percentage point increase in the debt-to-assets ratio implies that firms in the second, third, and fourth quartiles of the long-term debt share experience a reduction of interest payments of about 1.4%, 1.8%, and 3.1%, respectively. At the same time, the effect of leverage on the production expense share is largest for firms with more long-term debt.

Table 5: *Firm Leverage, Long-term Debt, Interest Expenses, and Employment.*

Dependent Variable	$\frac{\text{Int. Expenses}}{\text{Tot. Expenses}}$		$\frac{\text{Prod. Expenses}}{\text{Tot. Expenses}}$		ln(Employment)	
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Debt/Assets}_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$	-0.0063	-0.023	0.16	0.17	25.2	29.5
	(0.045)	(0.057)	(0.11)	(0.12)	(26.1)	(32.1)
$Q_2 \times \text{Debt/Assets}_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$	-0.093	-0.12	-0.029	-0.032	17.5	-17.2
	(0.073)	(0.080)	(0.14)	(0.15)	(52.1)	(50.4)
$Q_3 \times \text{Debt/Assets}_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$	-0.12	-0.16*	0.048	0.11	13.4	14.4
	(0.086)	(0.090)	(0.15)	(0.15)	(33.6)	(37.3)
$Q_4 \times \text{Debt/Assets}_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$	-0.30***	-0.29***	0.15	0.15	77.1**	109.0*
	(0.087)	(0.085)	(0.14)	(0.14)	(36.2)	(63.7)
Observations	3446	3217	3446	3217	1901	1749
Number of Firms	546	499	546	499	354	324
R^2	0.68	0.74	0.66	0.69	0.97	0.97
Firm FE	✓	✓	✓	✓	✓	✓
Industry-Year-FE	✓	✓	✓	✓	✓	✓
Controls $\times$ $\mathbf{1}_{t\geq 1920}$		✓		✓		✓

Notes: This table reports results from estimating equation (3) for interest expenses as a share of total expenses (columns 1-2), production expenses as a share of total expenses (columns 3-4), and log employment times 100 (columns 5-6) as the dependent variables. Firm-level controls consist of firm size (log of assets), the share of fixed assets to total assets, return on assets, and profit margin, all as of 1918-1919. The estimation period is from 1916 through 1923. Standard errors in parentheses are clustered at the firm level. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

We also ask whether the employment effects are stronger for firms with relatively more long-term debt. Although the results are less precise, we indeed find that not only do more highly levered firms hire more employees after 1920, but the effect is strongest for firms with more long-term debt. The effect of leverage is especially strong for firms in the top quartile of the long-term debt distribution.

Book equity. The reduction in real debt burdens should increase the book equity values of levered firms. On average, the real value of nonfinancial firms' book equity increased by 122% from 1919 to 1924. Table 6 asks whether this increase was larger for highly levered firms. As discussed in section 3, balance sheet outcomes during the hyperinflation (especially in 1923) are subject to systematic measurement error. For this analysis, we therefore focus on the change in balance sheet outcomes from the start of the postwar inflation in 1919 to the aftermath of the inflation in 1924, when the new and more accurate Goldmark balance sheets are available. We present estimates of the following long-difference firm-level regression for book equity to assets and real book equity as the outcome variables:

$$\Delta_{19-24} Y_i = \alpha + \beta Leverage_{i,1918-1919} + X_i \Gamma + \epsilon_i. \tag{4}$$

Panel A of Table 6 documents that firms with higher leverage at the start of the inflation see a larger subsequent increase in equity to assets, or, equivalently, a larger decline in leverage. Moving from a zero to 100% leverage ratio is associated with a decline in leverage of about 60 percentage points. Columns 2 and 4 show that the relation is robust to controlling for firm controls and industry fixed effects. Industry fixed effects absorb differential growth rates across industries, which might be correlated with initial leverage. In columns 3 and 6, we further control for the change in equity to assets from 1916 to 1919 to account for any differential pre-trends in the dependent variable. The results are similar. Panel B of Table 6 shows that firms with higher leverage see faster growth in the real value of book equity from 1919 to 1924. In the revalued book values constructed after the inflation, equity holders of more levered firms thus experienced an increase in equity values. Book equity measures thus suggest that the inflation led to redistribution from debt to equity holders of levered firms.

Market equity returns. Do more levered firms see an increase in their stock market valuations? The decline in interest expenses and increase in real book equity values suggest that the inflation should increase the market equity returns of highly levered firms. Studying market equity values also has the benefit that they are not subject to accounting errors but instead reflect the equity values of firms as perceived by investors in real-time. At the same time, equity investors subject to "money illusion" may also misperceive the impact of inflation on firm value (Modigliani and Cohn, 1979; Ritter and Warr, 2002; Campbell and Vuolteenaho, 2004; Cohen et al., 2005).

Table 7 reports the returns across firms with high and low leverage. We follow the standard asset pricing approach and sort firms into five portfolios by quintiles of lagged leverage each year of the postwar inflation, from 1919 to 1923. We then compute the equal-weighted average log total return for each portfolio, as well as the difference between

Table 6: *Firm Leverage in 1919 and Change in Firm Leverage and Book Equity from 1919 to 1924.*

Panel A: Dependent var.= $\Delta_{19-24}\frac{Equity}{Assets}$						
	(1)	(2)	(3)	(4)	(5)	(6)
Liabilities/Assets$_{i,1918-1919}$	0.62***	0.79***	0.73***			
	(0.043)	(0.063)	(0.063)			
Debt/Assets$_{i,1918-1919}$				0.56***	0.71***	0.65***
				(0.044)	(0.063)	(0.062)
Observations	650	600	551	650	600	551
R^2	0.293	0.353	0.382	0.253	0.308	0.351

Panel B: Dependent var.= $\Delta_{19-24}\ln(Equity)$						
	(1)	(2)	(3)	(4)	(5)	(6)
Liabilities/Assets$_{i,1918-1919}$	98.6***	185.9***	155.8***			
	(26.7)	(33.7)	(30.0)			
Debt/Assets$_{i,1918-1919}$				80.7***	165.1***	145.2***
				(28.5)	(34.8)	(27.1)
Observations	650	600	568	650	600	568
R^2	0.015	0.094	0.135	0.011	0.088	0.134
Industry FE		✓	✓		✓	✓
Firm Controls		✓	✓		✓	✓
Lagged dep. var., 1916-19			✓			✓

Notes: This table presents estimates of equation (4). The dependent variable in panel A is the change in book equity-to-assets from 1919 to 1924. The dependent variable in panel B is the change in log deflated book equity, using the wholesale price index as the deflator. Firm controls are size (log of assets), the share of fixed assets to total assets, return on assets, and profit margin (EBIT-to-revenue), all as of 1918-1919. "Lagged dep. var., 1916-19" refers to a specification that controls for the change in equity-to-assets (panel A) or real equity growth (panel B) from 1916 to 1919. Robust standard errors in parentheses. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

the high-minus-low portfolio. Returns are deflated by wholesale prices. Panel A reports results using the liabilities to assets ratio as a proxy for leverage, and Panel B reports results using the ratio of financial debt to assets.

Table 7 reveals two notable patterns. First, returns are, on average, negative during the inflation, despite the large increase in the book value of equity during this time. Prior research argues that the poor performance of the stock market during Germany's inflation is explained by lower expected future cash flows, including from high expected taxes on firms, high uncertainty, and money illusion on the part of investors. Bresciani-Turroni (1937) argues that investors mistook large nominal capital gains for large real capital gains. Consistent with this, Braggion et al. (2022) present evidence of money illusion

Table 7: *Stock Returns across Portfolios Sorted by Leverage.*

Panel A: Sorting by Liabilities-to-Assets.

Quintile of Liabilities/Assets$_{i,t-1}$	Liabilities/Assets$_{i,t-1}$ Mean	S.E.	$Return_t$ Mean	S.E.
1	0.29	(0.01)	-36.62	(3.93)
2	0.48	(0.00)	-34.45	(3.88)
3	0.58	(0.01)	-30.90	(3.82)
4	0.67	(0.01)	-30.48	(3.62)
5	0.79	(0.01)	-23.92	(3.89)
High-Low	0.51	(0.01)	12.70	(4.63)

Panel B: Sorting by Debt-to-Assets.

Quintile of Debt/Assets$_{i,t-1}$	Debt/Assets$_{i,t-1}$ Mean	S.E.	$Return_t$ Mean	S.E.
1	0.34	(0.01)	-36.11	(3.93)
2	0.49	(0.01)	-35.97	(3.81)
3	0.57	(0.01)	-31.49	(3.71)
4	0.65	(0.01)	-25.79	(3.84)
5	0.77	(0.01)	-26.68	(3.82)
High-Low	0.44	(0.01)	9.43	(4.58)

Notes: This table presents total returns on five portfolios of nonfinancial firms sorted by lagged leverage. Panel A uses firm liabilities-to-assets in year $t-1$ as the measure of leverage, while Panel B uses debt-to-assets. Returns are defined as log total returns (times 100) and are deflated by the wholesale price index. The analysis uses annual data on returns from 1919 to 1923.

among stock market investors during Germany's hyperinflation.

Second, returns are (almost) monotonically increasing across the leverage portfolios. The difference between the high minus low portfolio is large (10-13% annual return) and statistically significant (p-values of 0.6% and 3.6% for panels A and B, respectively). Figure C.22 plots the cumulative return on the high-minus-low leverage portfolio over time. The portfolio has significantly positive returns in 1919, 1922, and 1923. Returns are especially high during 1922-23, when annual inflation surpassed 1000%. The relatively poor performance in 1921 is puzzling given the high rate of inflation in that year (141%). One possible explanation is that investors were slow to realize the benefits of high inflation for highly levered firms, as hypothesized by Modigliani and Cohn (1979).

Table 8 explores the robustness of the relation between leverage and subsequent returns using linear regressions of the form:

$$Return_{it} = \gamma_t + \beta \; Leverage_{it-1} + \epsilon_{it}. \tag{5}$$

We include time fixed effects in all specifications to compare firms within-year.[31] Columns 1 and 4 show that there is a robust, positive, and highly statistically significant relation between both leverage measures and subsequent equity returns during the inflation. Columns 2 and 5 in Table 8 include industry-year fixed effects, and columns 3 and 6 further include lagged firm-level controls. The estimate on $Leverage_{it-1}$ is essentially unchanged with these controls.

Table 8: *Leverage and Stock Returns: Linear Regressions, 1919-1923.*

	(1)	(2)	(3)	(4)	(5)	(6)
Liabilities/Assets$_{i,t-1}$	19.3***	17.0***	22.7***			
	(5.47)	(5.89)	(6.82)			
Debt/Assets$_{i,t-1}$				15.8***	14.1***	20.4***
				(5.11)	(5.27)	(5.72)
Observations	2739	2735	2614	2739	2735	2614
R^2	0.71	0.76	0.76	0.71	0.76	0.76
Year Fixed Effects	✓			✓		
Industry-Year FE		✓	✓		✓	✓
Firm Controls			✓			✓

Notes: This table presents estimates of equation (5). Firm controls are size (log of assets), the share of fixed assets to total assets, return on assets, and profit margin (EBIT-to-revenue) in $t-1$. Robust standard errors in parentheses. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

The relative outperformance of high leverage firms could be driven by higher prices or payouts in the form of dividends, depending on whether firms return the unexpected windfall to shareholders or keep the money inside the firm. Interestingly, we find that dividend yields decline during the inflation and essentially fall to zero by 1923, as shown in Figure C.23. Firms keep the money inside the firm, presumably because firms have better access to stores of value than investors, consistent with the increase in book equity. That firms reduce, rather than increase, payouts is also consistent with the substantial real effects of the reduction in real debt burdens.

Nonfinancial firms with higher leverage fare relatively better during the inflation. By definition, the gain must come at someone else's expense. Thus, we ask: who loses at the same time? Nonfinancial firms' equity should have greater positive net nominal

[31] Results are considerably stronger without a time fixed effect. On the other hand, the estimates are smaller and usually statistically insignificant when fixing leverage in 1918 or 1919. For the result that high leverage firms have higher stock returns, resorting firms each year using lagged leverage is important, especially as most of the excess return for high leverage firms occurs in 1922 and 1923. Note that we avoid using leverage based on balance sheets from 1923, which are subject to measurement error, as we discussed in Section 3. Results are also similar if we use leverage from balance sheets only through 1921.

exposure compared to banks. Nonfinancial firm equity is a levered claim on real assets, while bank equity is a levered claim on nominal assets. Moreover, banks are exposed to duration mismatch. Figure C.3 in the Appendix compares the returns on nonfinancial firms and banks during the inflation. While inflation was associated with negative real returns on both indexes, we find that nonfinancial firms performed better than banks. Altogether, our findings suggest that the inflation redistributed from those that held debt of nonfinancial firms (such as banks) to equity holders, with equity investors in leveraged firms benefiting relatively more.

6 Conclusion

This paper examines how inflation transmits to the real economy through a *debt-inflation* channel via firm balance sheets. We study Weimar Germany's big inflation from 1919 to 1923 using newly digitized macro and firm-level data. Inflation led to a substantial decline in nonfinancial firms' leverage and interest expenses, resulting in a downward sloping and convex relation between inflation and firm bankruptcies. Exploiting variation across firms in initial leverage, we find that high leverage firms saw larger increases in employment, book equity, and market equity valuations during the inflation. These firms also saw larger declines in the share of interest expenses along with an increase in production expenses. At the same time, we find that prices and wages were adjusted at shorter and shorter frequencies with rising inflation, consistent with menu cost models. These results are consistent with the view that the inflation affected real activity through a debt-inflation channel that can be operative even in the absence of nominal rigidities in prices and wages.

Our analysis invites questions of external validity. Previous researchers have studied hyperinflations as extreme events that can provide insights into the workings of inflation more broadly (e.g., Sargent, 1982).[32] The debt-inflation channel may be present during times of more moderate inflation if debt contracts are nominal, long-term, and denominated in domestic currency. However, with other debt contract structures, such as floating or foreign currency debt, inflation would be neutral or even negative for more levered

[32]The insights that can be gleaned from studying the German hyperinflation, as well as the concerns about external validity, were perhaps best summarized by Lionel Robbins's foreword to Bresciani-Turroni (1937)'s study of the German inflation: "When disturbance takes place, it is sometimes possible to snatch good from evil and obtain insight into the working of processes which are normally concealed. No doubt there are dangers here. We must not ignore the possibility that the processes thus revealed are themselves abnormal. . . We must not infer... that propositions which apply to large inflations necessarily apply, without modification, to small inflations. But the dangers are clear: it is not difficult to keep them in mind and guard against them. And the opportunities for fruitful research are enormous."

firms. Moreover, the debt-inflation channel, while still present, may be dominated by other forces during times of lower inflation. For example, if monetary policy responds aggressively to rising inflation by raising interest rates and tightening financial conditions, this can offset the expansionary effects from the reduction in real debt burdens.

Finally, an important caveat is that we have not quantified the full aggregate effect of the inflation through private-sector balance sheets. We focus on firm debt due to data availability, but the debt-inflation channel through household debt could also have been quantitatively important (Doepke and Schneider, 2006; Diamond et al., 2022). Moreover, we have not estimated the effect of inflation through bank balance sheets and credit supply, which presumably offsets the expansionary effect of the debt-inflation channel. We are exploring the impact of the inflation on bank credit supply in ongoing work.

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The Debt-Inflation Channel of the German Hyperinflation

Online Appendix

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- Appendix A: Historical Background
- Appendix B: Model of the Debt-Inflation Channel
- Appendix C: Supplementary Figures and Tables
- Appendix D: Data Appendix

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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

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

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

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

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

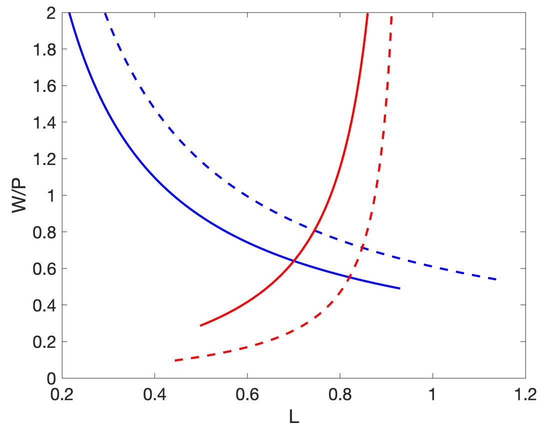
The labor market equilibrium is illustrated in Figure B.9. In response to an increase in the price level P, labor demand shifts outward, as firms financing constraints are relaxed. Moreover, labor supply shifts outward due to the negative wealth effect. The increase in labor supply dampens the increase 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.

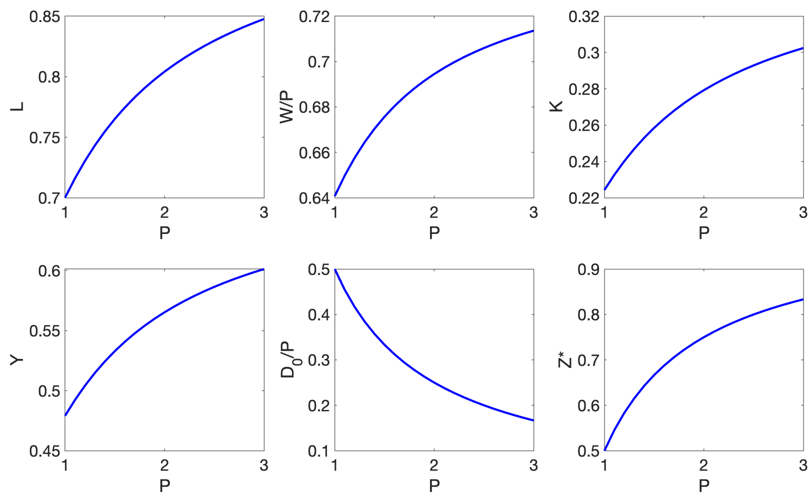
[13] If we instead assume that utility is quasi-linear, $U(C, L) = C - \chi \frac{L^{1+\varphi}}{1+\varphi}$, then labor supply would be $\frac{W}{P} = \frac{\epsilon}{\epsilon-1}\chi L^{\varphi}$, removing the wealth effect.

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.

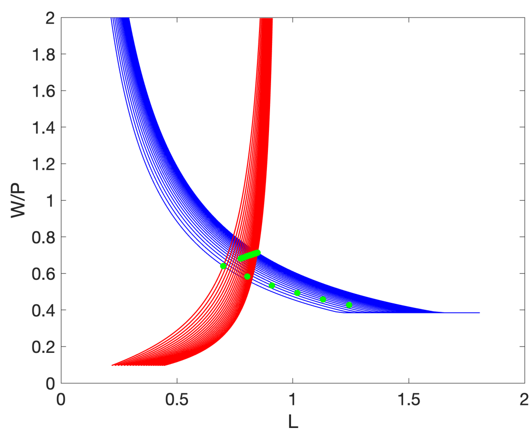
Introducing nominal wage rigidity. We introduce nominally rigidity by assuming that initially, the wage for all workers is set at W_0, which we assume is the equilibrium flexible wage with $P = 1$. Workers can alter their wages W_j, but incur a cost by doing so. Specifically, there is a menu cost of 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.

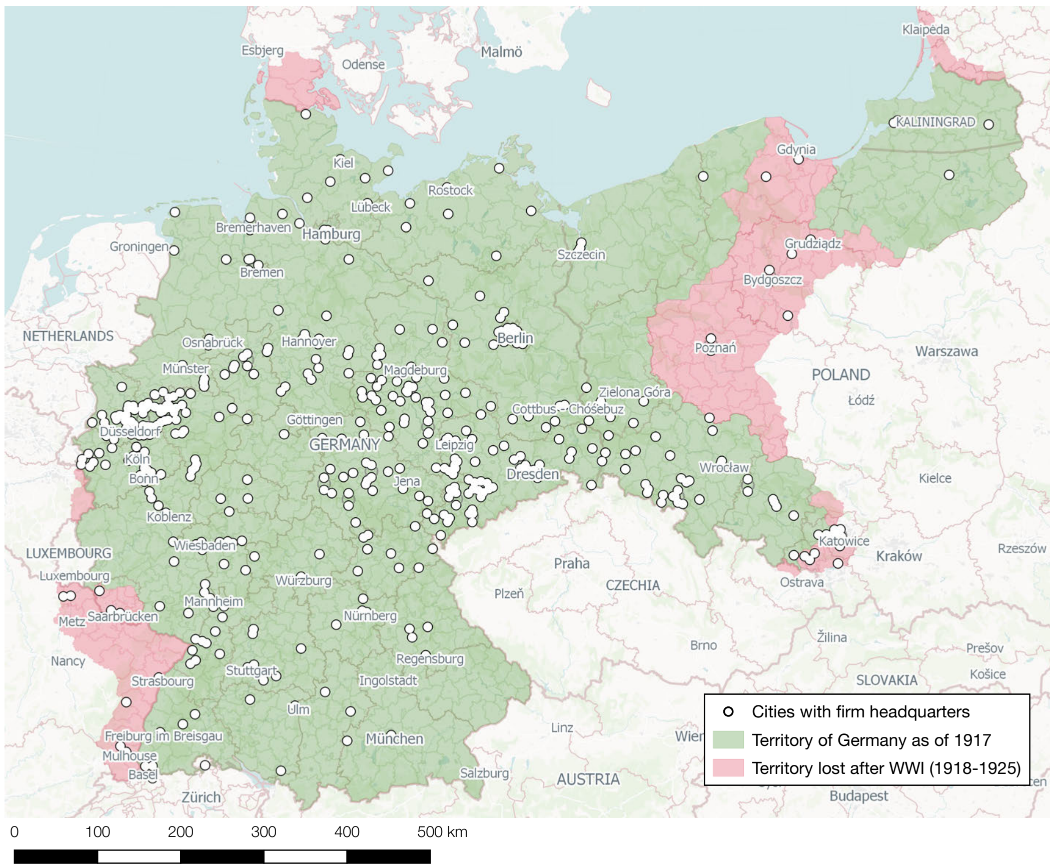
Figure B.10: *Labor Market Equilibria with Nominal Wage Rigidty for Different Levels of P*



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

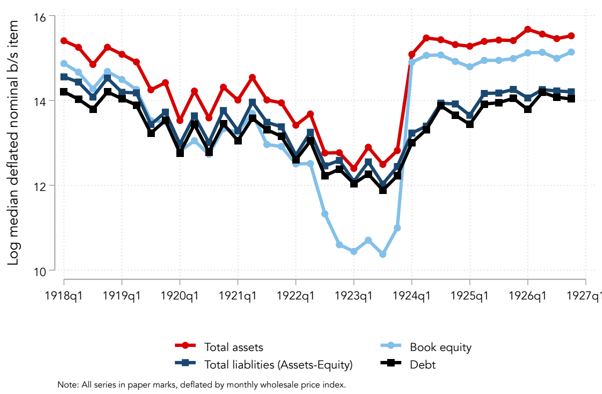
Figure C.1: *Map of Firm Headquarter Locations.*



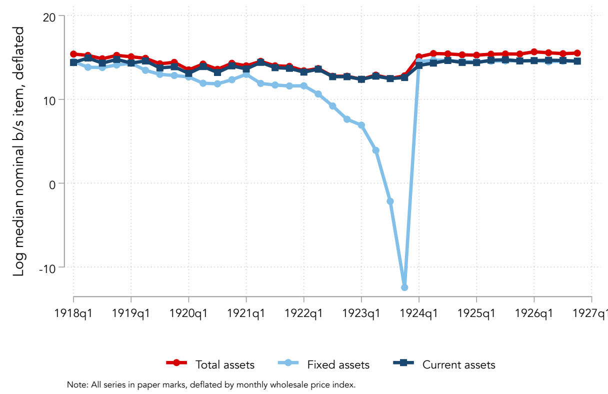
Notes: This map portrays the headquarter locations of all firms in our *Saling's* sample, alongside Germany's territorial extent as of 1917.

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

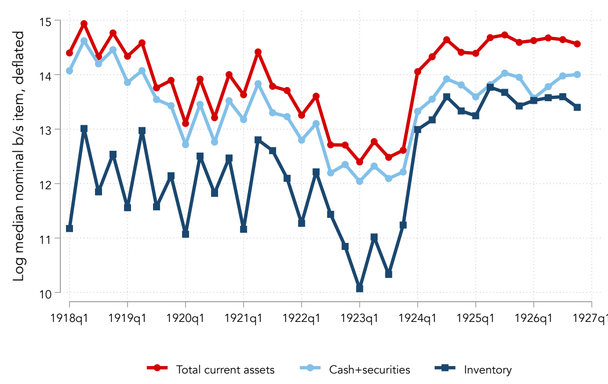
(a) *Evolution of median of liability components in paper marks, deflated.*



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

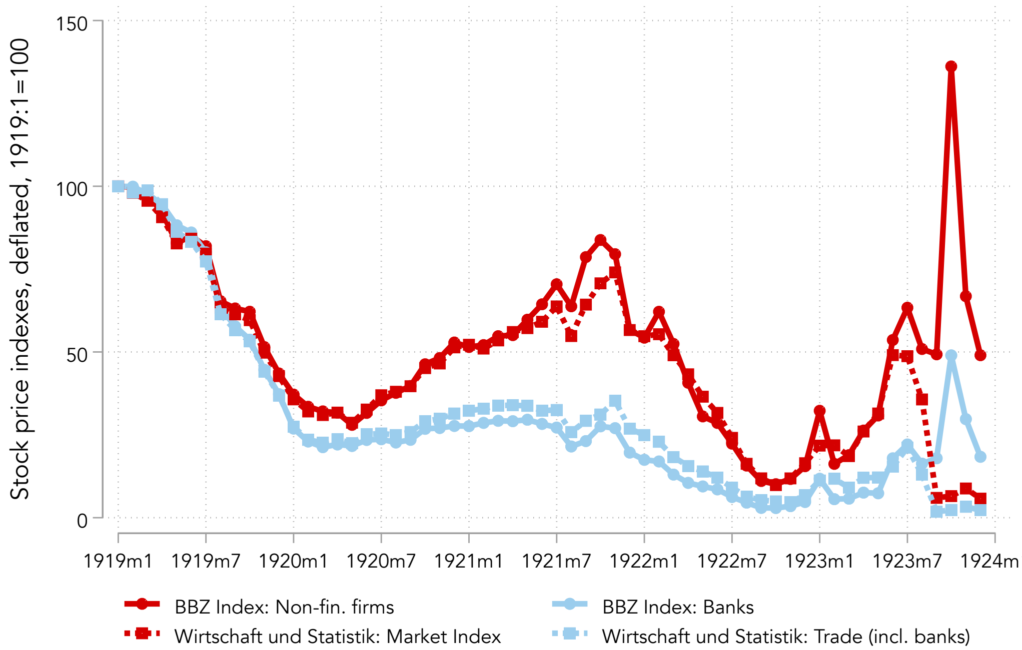


(c) *Evolution of median of current asset components in paper marks, deflated.*



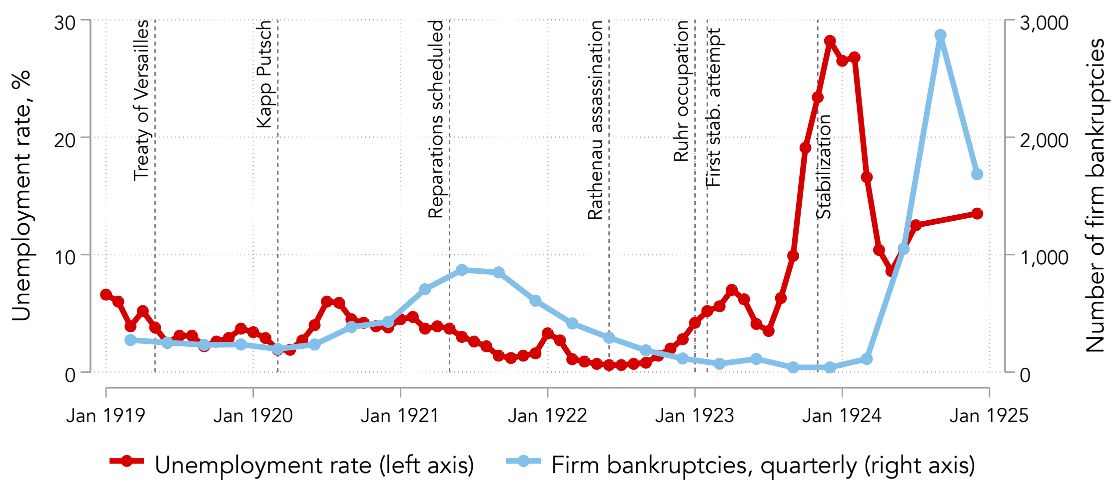
Notes: This figure plots the evolution of the medians of key balance sheet items in paper marks, deflated by the wholesale price index. The large changes in 1924Q1 occur due to the introduction of revalued Goldmark balance sheets.

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.

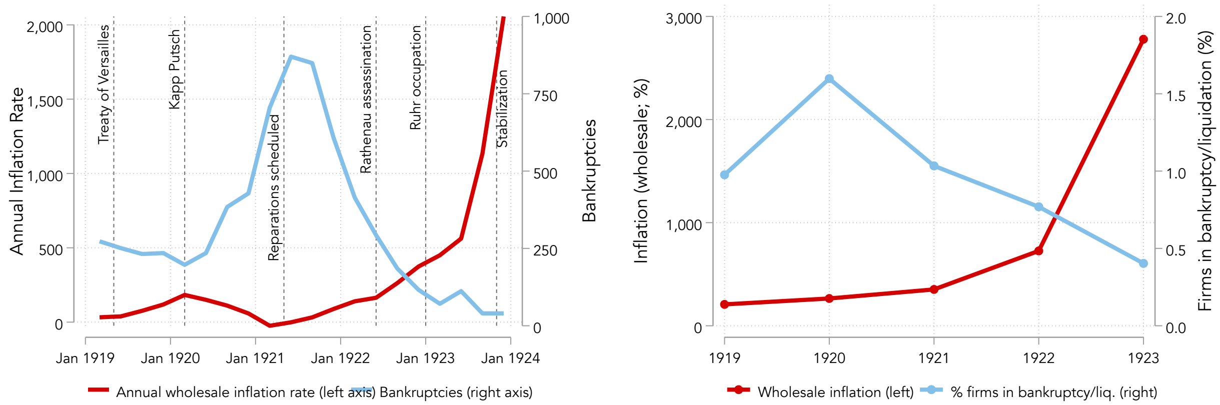
Figure C.4: *Unemployment and Firm Bankruptcies.*



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*.

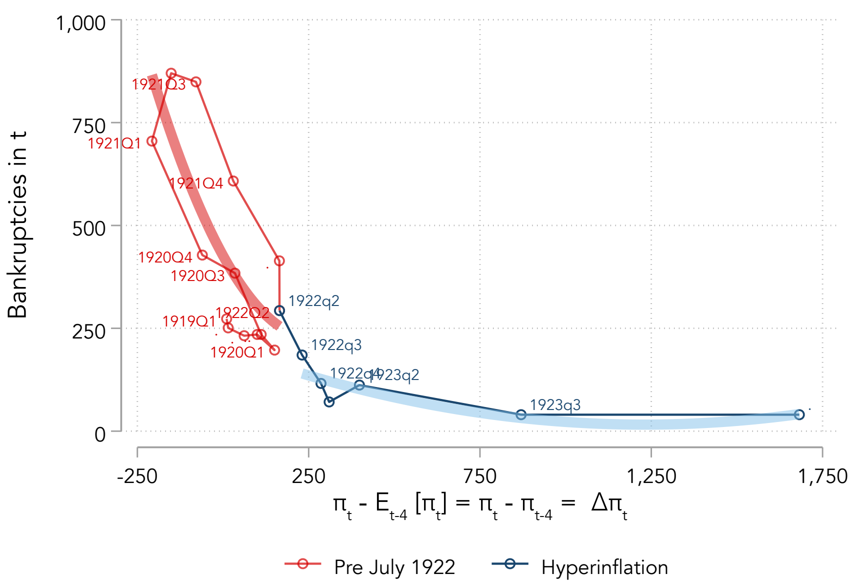
Figure C.5: *Inflation and Firm Bankruptcies.*

(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*.

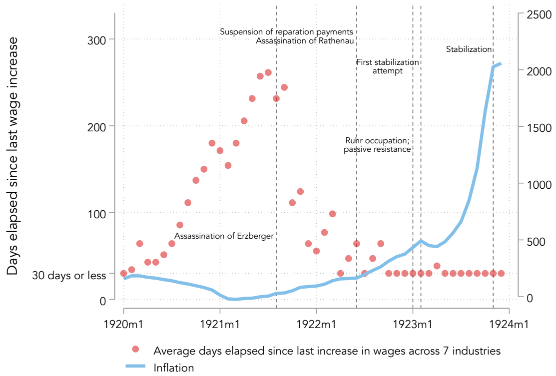
Figure C.6: *Inflation and Firm Bankruptcies: Robustness using the Acceleration in Inflation.*



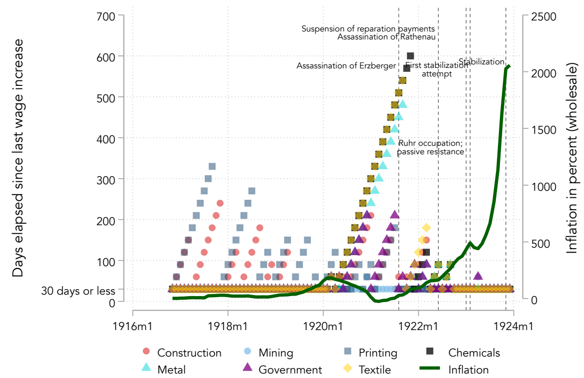
Notes: This figure plots the number of firm bankruptcies in quarter t against inflation over the past four quarters net of expected inflation over the same period. Expected inflation is assumed to be inflation over the past year from quarter $t-8$ to $t-4$. Inflation is calculated as the log change (times 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.*



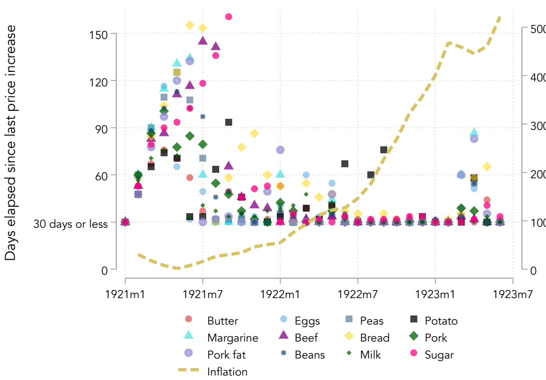
(b) *Wage adjustments, by industry.*



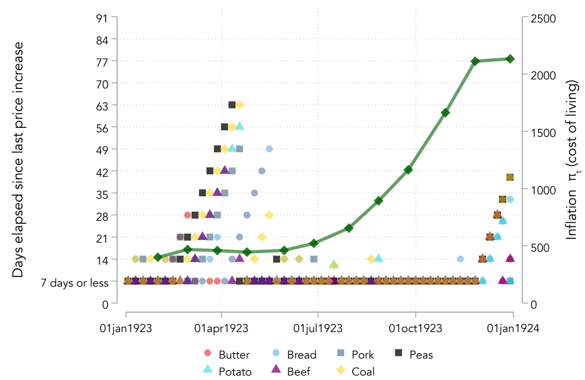
Notes: This figure plots the duration of unchanged wages over time. Wages are as reported in *Zahlen zur Geldentwertung in Deutschland von 1914 bis 1923* and *Wirtschaft und Statistik* (various issues). Inflation is defined as the difference between the log of the wholesale price level in month t and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

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

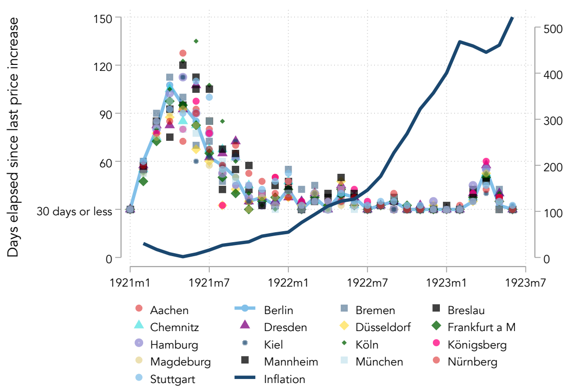
(a) *Frequency of price adjustments by type of good.*



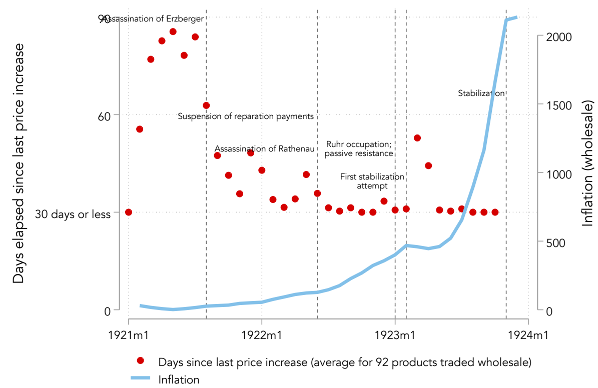
(b) *Price adjustment by product for Berlin in 1923.*



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

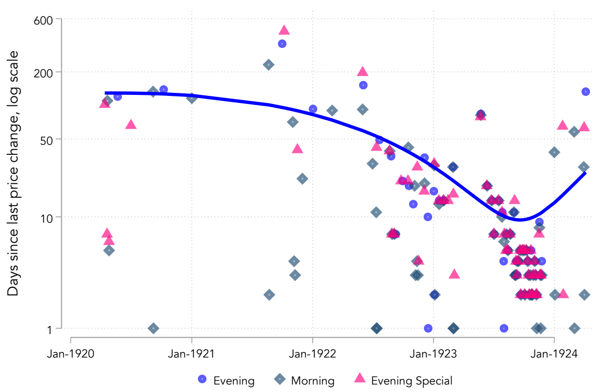


(d) *Price adjustments for 95 wholesale-traded products.*

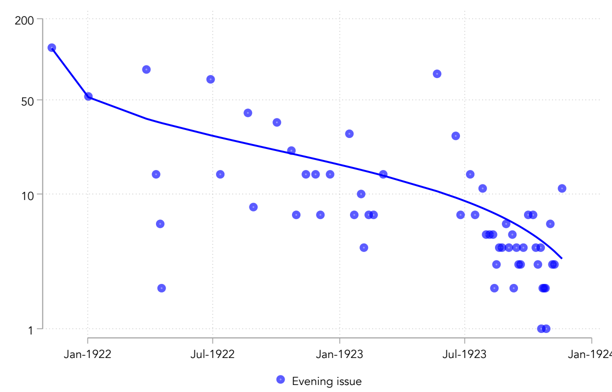


Notes: This figure plots the duration of retail product prices, for products underlying the cost-of-living index. Retail prices are as reported in *Zahlen zur Geldentwertung in Deutschland von 1914 bis 1923* and *Wirtschaft und Statistik* (various issues). Inflation is defined as the difference between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

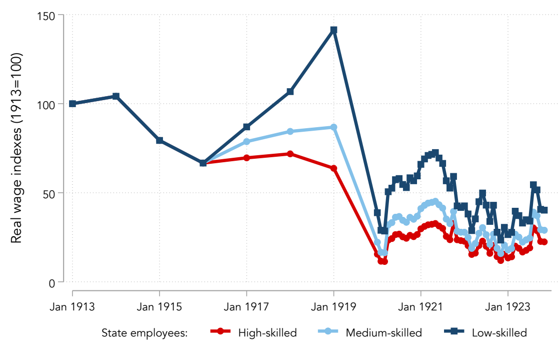


(b) *Daily newspaper prices, Berliner Tageblatt und Handels-Zeitung.*

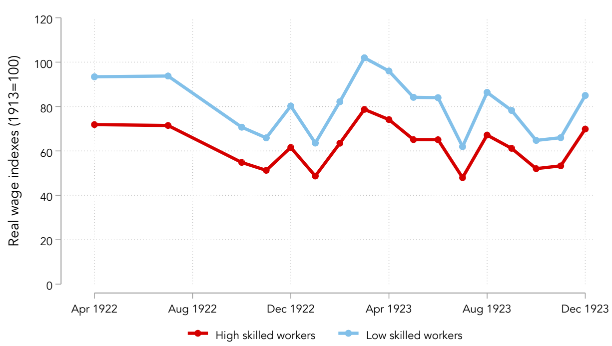
Notes: This figure plots the duration of unchanged prices for various issues of two German newspapers, the *Berliner Börzen Zeitung* and the *Berliner Tageblatt und Handels-Zeitung*. Daily newspaper prices are hand-collected from scans of the newspapers.

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

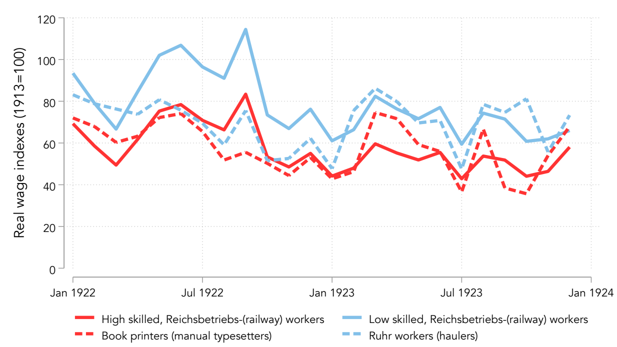
(a) *Real wages of state employees*



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



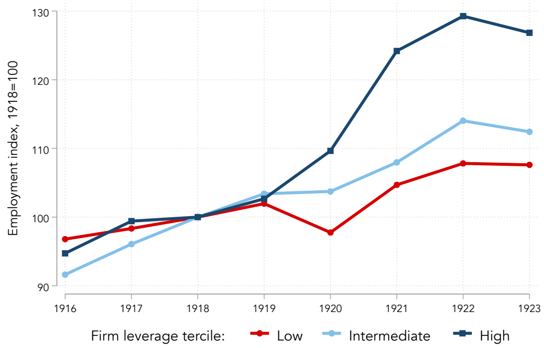
(c) *Real wages of public railroad workers, Ruhr workers, and book printers*



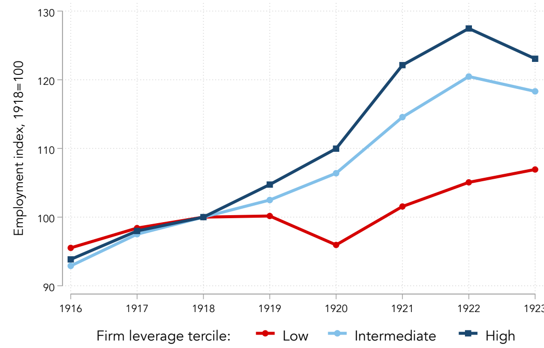
Notes: This figure plots the evolution of real wages for various groups of workers and industries. Wage data are from *Wirtschaft und Statistik*. Real wages are deflated by wholesale prices.

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*

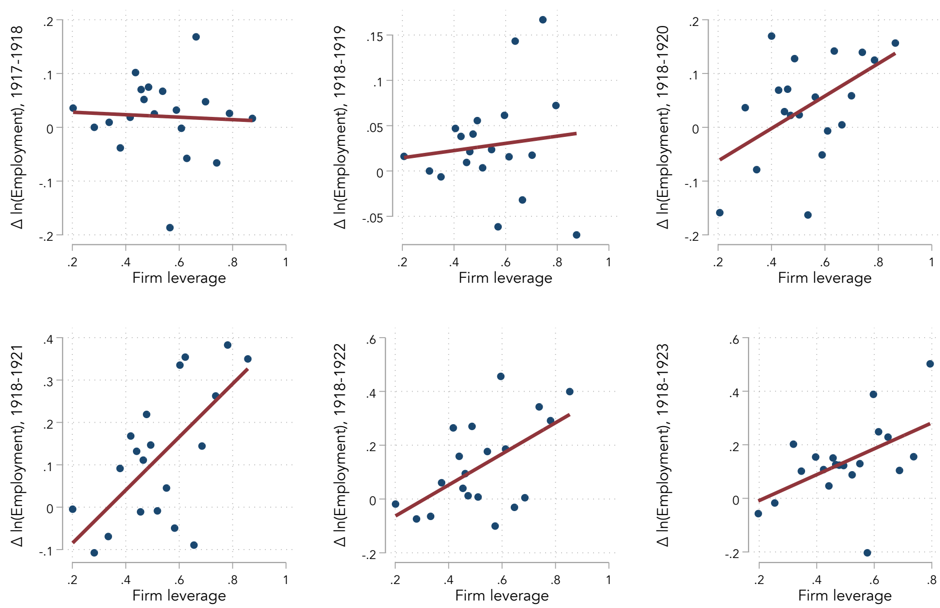


(b) *Sorting firms by average financial debt to assets over 1918-1919*



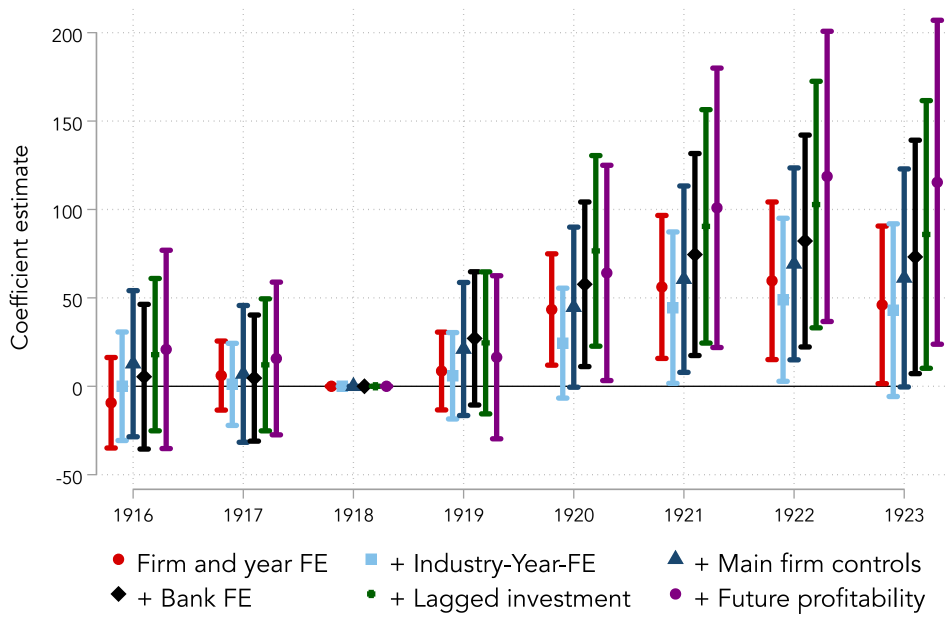
Notes: This figure presents the average evolution of employment for firms in the bottom, middle, and top terciles of leverage. Leverage is defined as the average of liabilities-to-assets over 1917 to 1919 (panel a) or financial debt to assets (panel b). Employment is indexed to 100 in 1918 for each group.

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



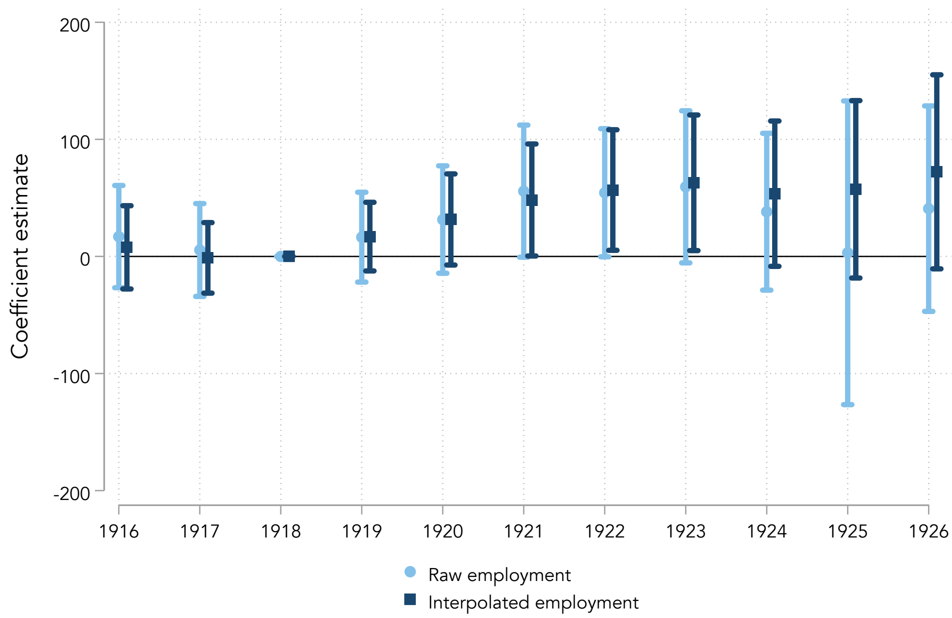
Notes: This figure plots binned bivariate means of firm-level employment growth (defined as the change in log employment, multiplied by 100) in each year from 1917 to 1923, relative to 1918. Firm leverage is defined as $\frac{Liabilities}{Assets}$, averaged over 1918 and 1919.

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



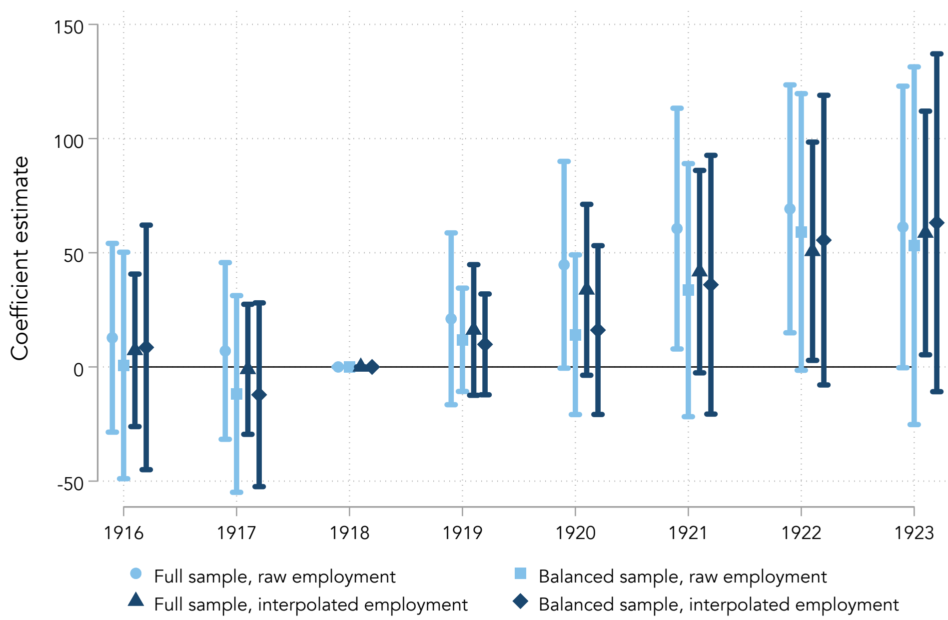
Notes: This figure is similar to Figure 7, but it reports estimates for various other control sets. "Firm and year FE" are from estimates of (1) with only firm and year fixed effects. "+ Industry-Year FE" are from a specification that adds industry-year fixed effects. "+ Main firm controls" further include 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.*



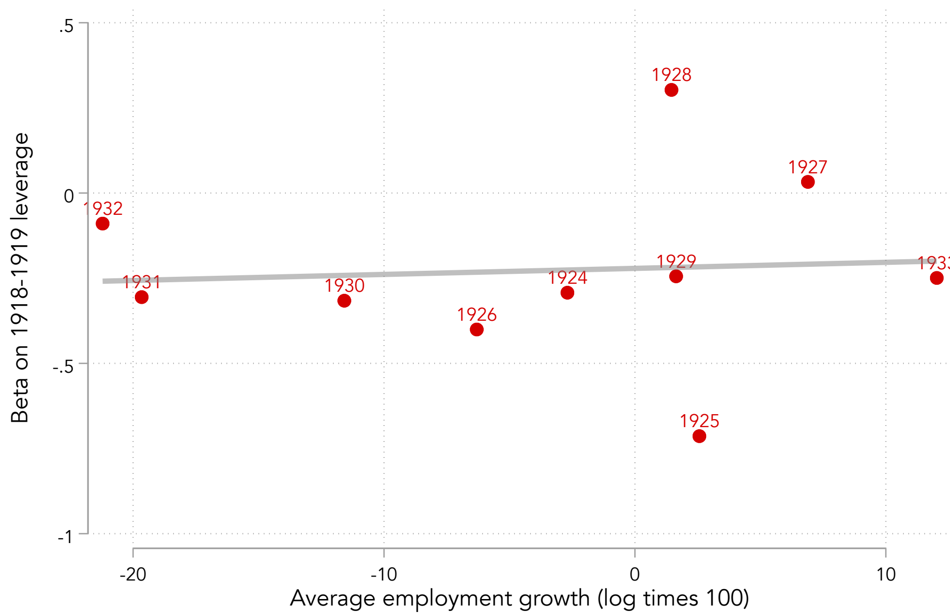
Notes: This figure is similar to Figure 7, but it reports estimates for a longer panel of employment data that extends to 1926. Estimates from "Raw employment" use the raw employment data reported in *Saling's*. Estimates from "Interpolated employment" use interpolated employment as the dependent variable. 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.*



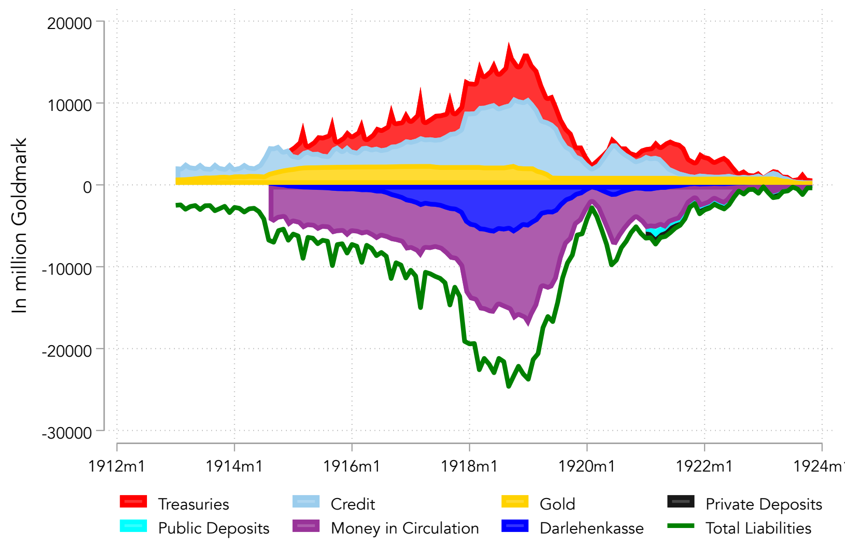
Notes: This figure shows that firms with higher leverage as of 1918-1919 do not have higher business cycle exposure in the post-inflation period (1924-1933). The figure correlates average annual firm employment growth with the beta from a regression of firm employment growth on firm leverage:

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

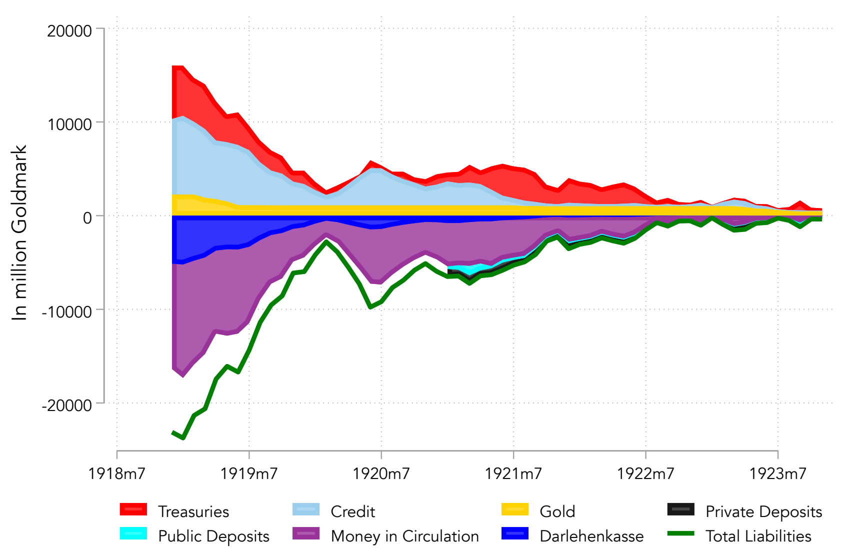
where leverage is defined as $\frac{Liabilities}{Assets}$ averaged over 1918 and 1919, γ_s^t is an industry fixed effect, and X_i are firm controls. The regression is estimated each year from 1924 to 1933. This exercise tests whether high leverage firms have higher employment growth during years of high 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*



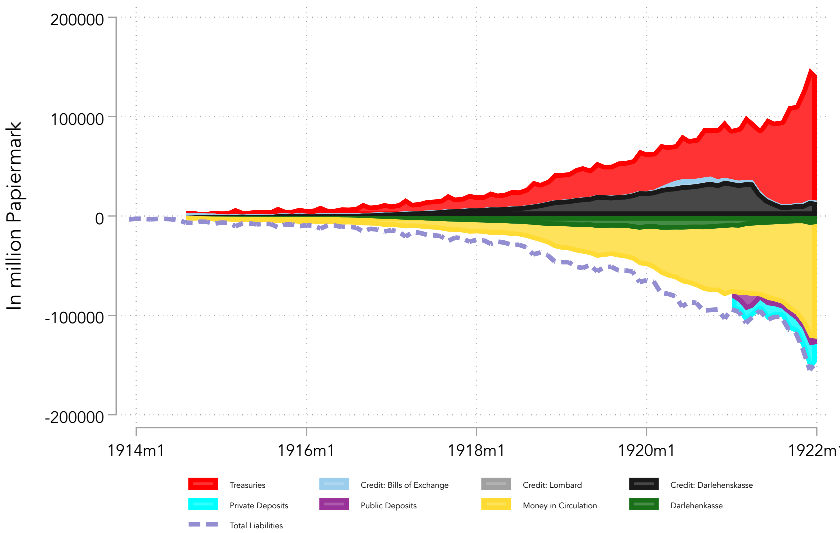
(b) *1919-1923*



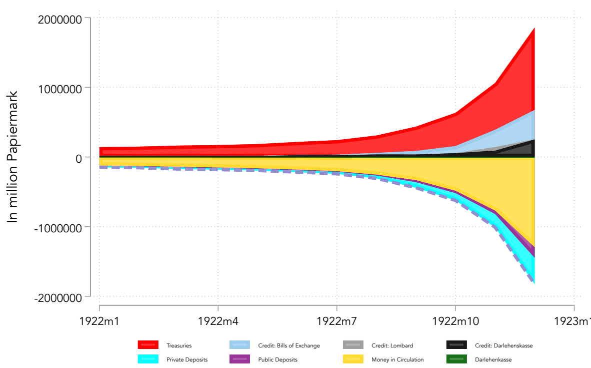
Notes: Data are from *Zahlen zur Geldentwertung*.

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

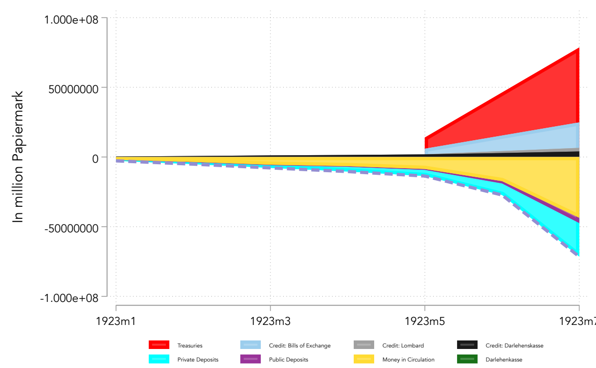
(a) *1914-1921*



(b) *1922*



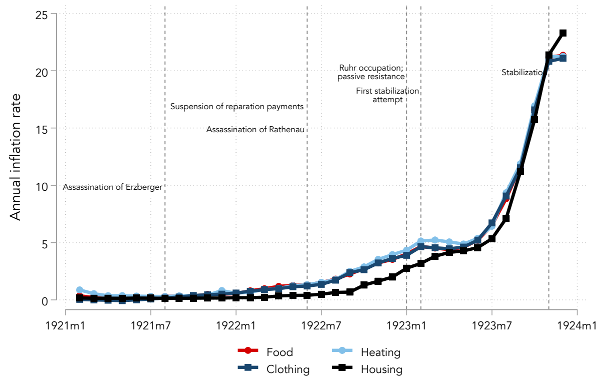
(c) *1923*



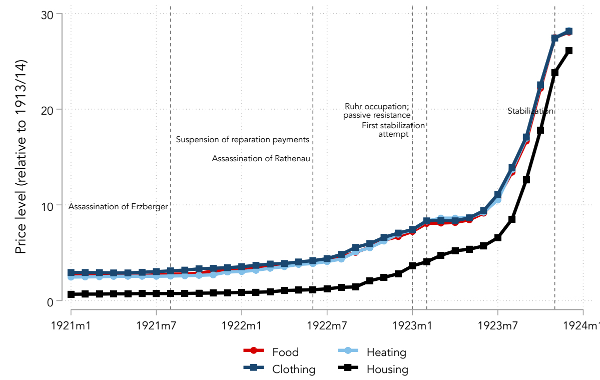
Notes: Data are as reported in *Zahlen zur Geldentwertung*.

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

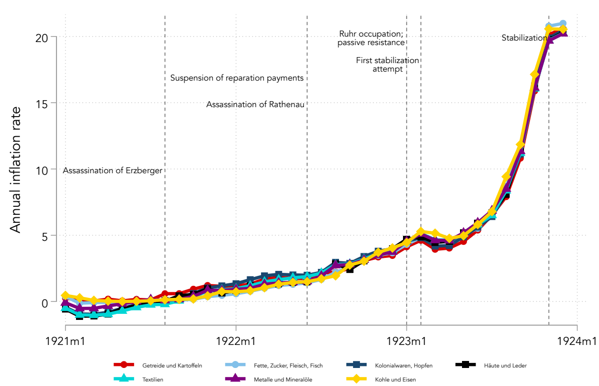
(a) *Cost of living inflation.*



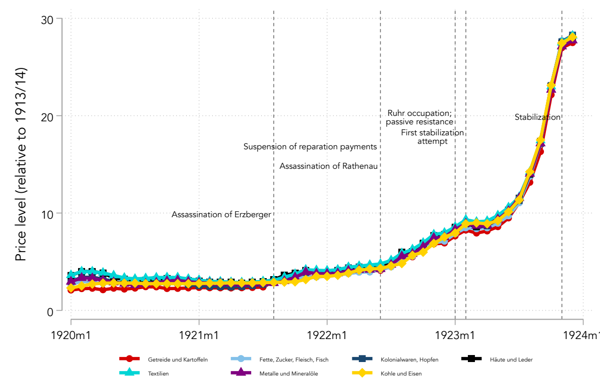
(b) *Cost of living price level.*



(c) *Wholesale goods inflation.*



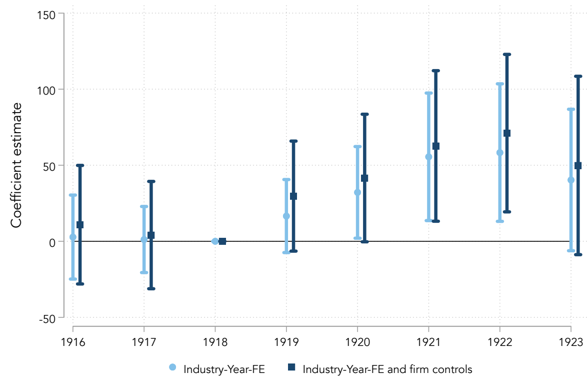
(d) *Wholesale goods price level.*



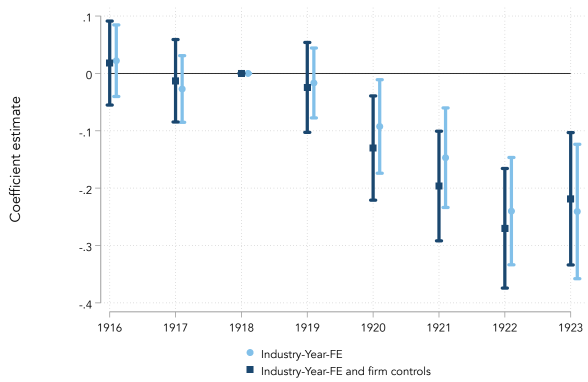
Notes: Data are from *Zahlen zur Geldentwertung*.

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

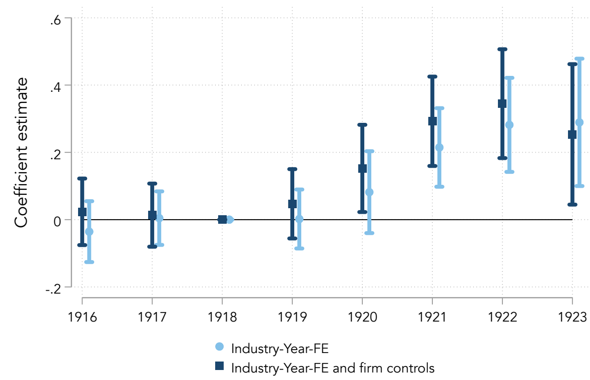
(a) *Employment.*



(b) *Interest Expenses.*



(c) *Production Expenses.*

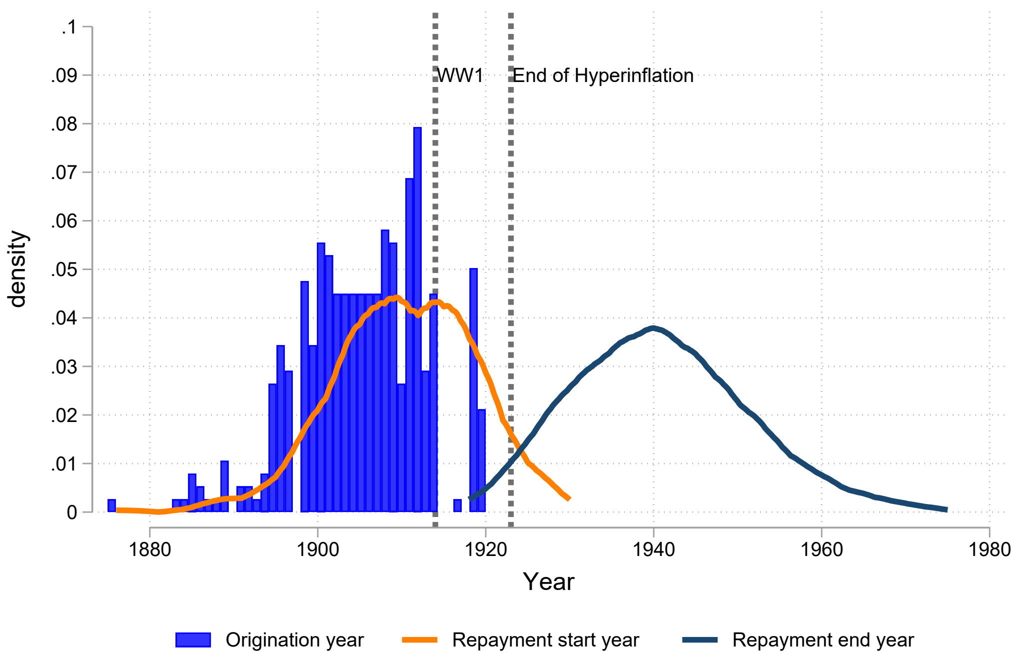


Notes: The figure plots the sequence of estimates $\{\beta_k\}$ from estimating the following model:

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

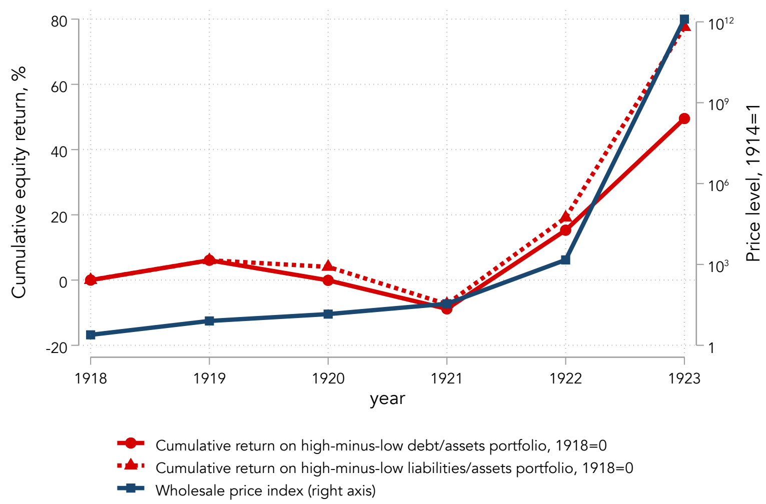
where y_{it} is either log employment, the ratio of interest expenses to total expenses, or the ratio of materials and salary expenses to total expenses. Further, α_i is a set of firm fixed effect, γ_{st} a set of industry-year fixed effects, $Debt/Assets_{i,1919}$ is firm i's financial debt-to-assets 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.*



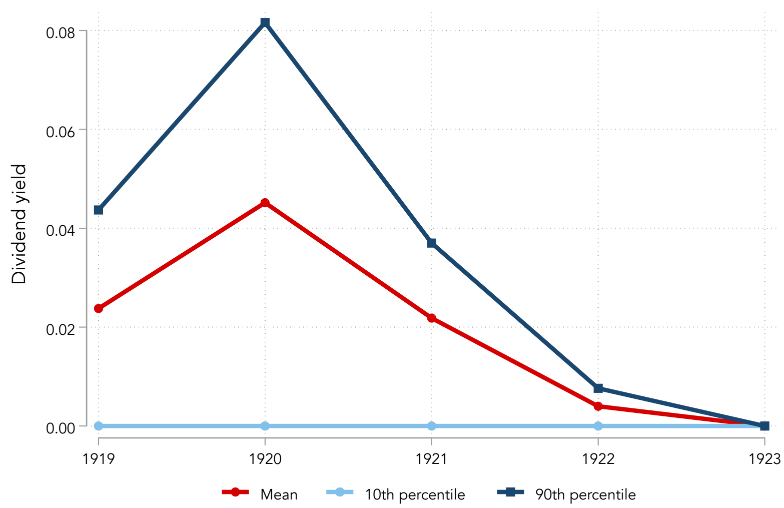
Notes: This figure shows the origination year, repayment start year, and final maturity for outstanding bonds reported by nonfinancial firms in 1918 and 1919. Data obtained from *Saling's Börsenjahrbuch* published in 1919 and 1920. $N = 417$. 51% of firms in the sample report information on at least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

	Leverage$_{i,1918-1919}$					
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Total Assets)$_{i,1918-1919}$	0.061***					0.065***
	(0.0049)					(0.0059)
Fixed Assets/Total Assets$_{i,1918-1919}$		-0.15***				-0.076**
		(0.031)				(0.036)
EBIT margin$_{i,1918-1919}$			0.092***			-0.0085
			(0.030)			(0.031)
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:

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

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

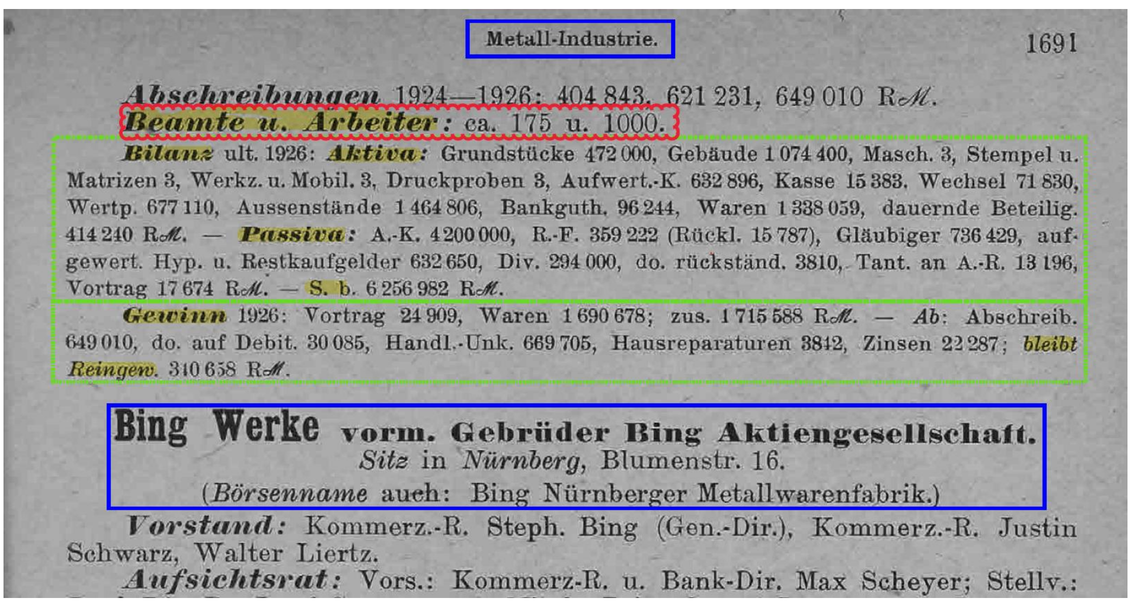
Notes: This table is similar to Table 2 but adds additional controls for proxies of credit supply. Panels A and B present estimates of (2) using liabilities-to-assets and debt-to-assets as of 1918-19 as the leverage variable, respectively. Column 1 corresponds to columns 1 and 4 in Table 2. Column 2 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 $\frac{Fixed\,Assets_{it} - Fixed\,Assets_{it-1}}{Total\,Assets_{it-1}}$. 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 Rℳ.
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 Rℳ. — *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 Rℳ. — S. b. 6 256 982 Rℳ.
Gewinn 1926: Vortrag 24 909, Waren 1 690 678; zus. 1 715 588 Rℳ. — *Ab:* Abschreib. 649 010, do. auf Debit. 30 085, Handl.-Unk. 669 705, Hausreparaturen 3842, Zinsen 22 287; *bleibt Reingew.* 340 658 Rℳ.

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.

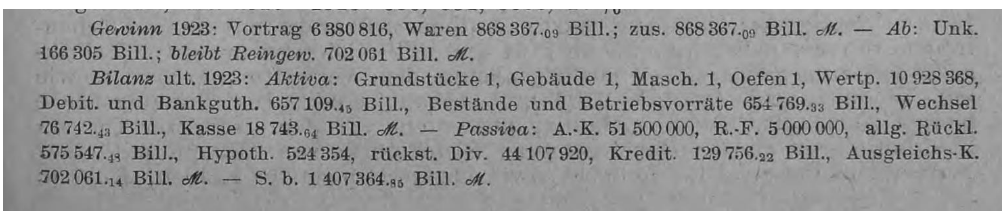
Data quality through the hyperinflation Balance sheet numbers during the hyperinflation years are particularly challenging to digitze. Because of inflation, the numbers

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.$_{48}$ 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.

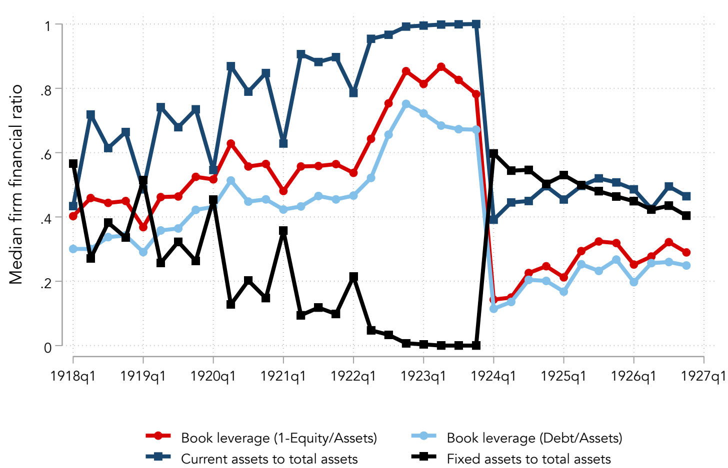
The impact of hyperinflation on the reliability of financial accounts was understood by contemporaries. Some firms began voluntarily reporting balance sheets in Goldmarks

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.*

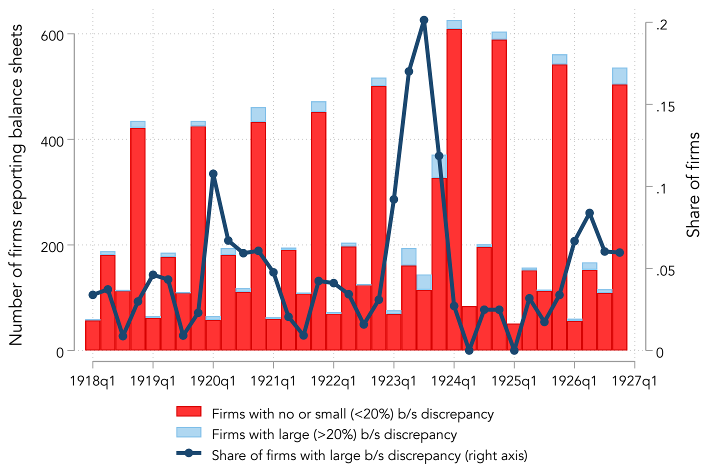


Notes: This figure plots the evolution of the median of key balance sheet ratios in the *Saling's* data over time. The large changes in 1924Q1 occur due to the introduction of revalued Goldmark balance sheets.

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.

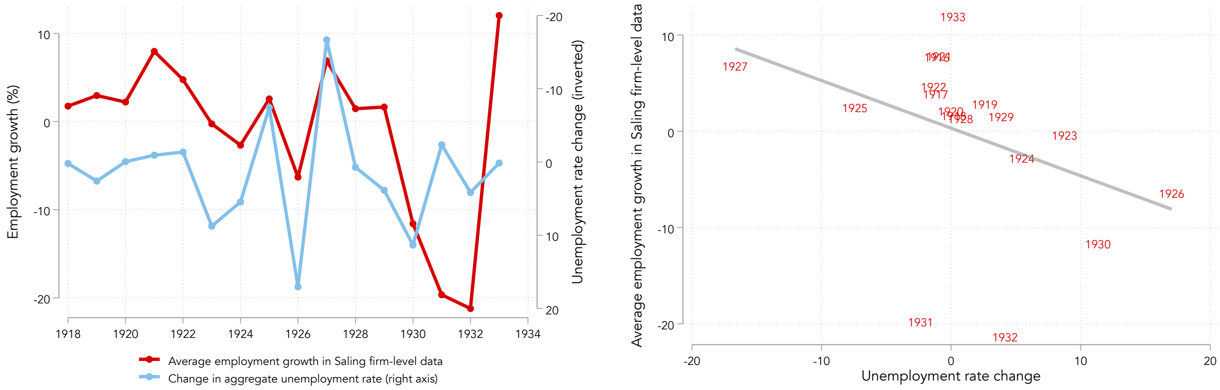
The main analysis in the paper uses the employment data as it is reported in *Saling's*. The panel on firm employment over 1916-1923 is unbalanced and contains some gaps, as sometimes firms do not report in a given year. To address this concern, for robustness, we fill in gaps in employment by linearly 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*.

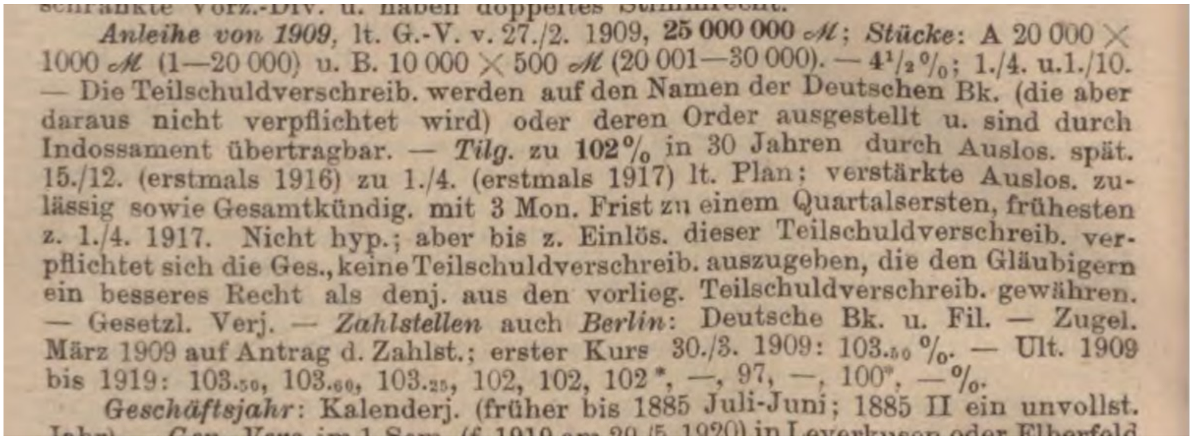
1920 edition of *Saling's*. Data on long-term bonds are reported in a subsection of the description of a firm's financials. The header of each subsection indicates whether a bond is a regular bond ("*Anleihe*") or a mortgage ("*Hypotheken-Anleihe*"). Further details on the contractual terms of each bond 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

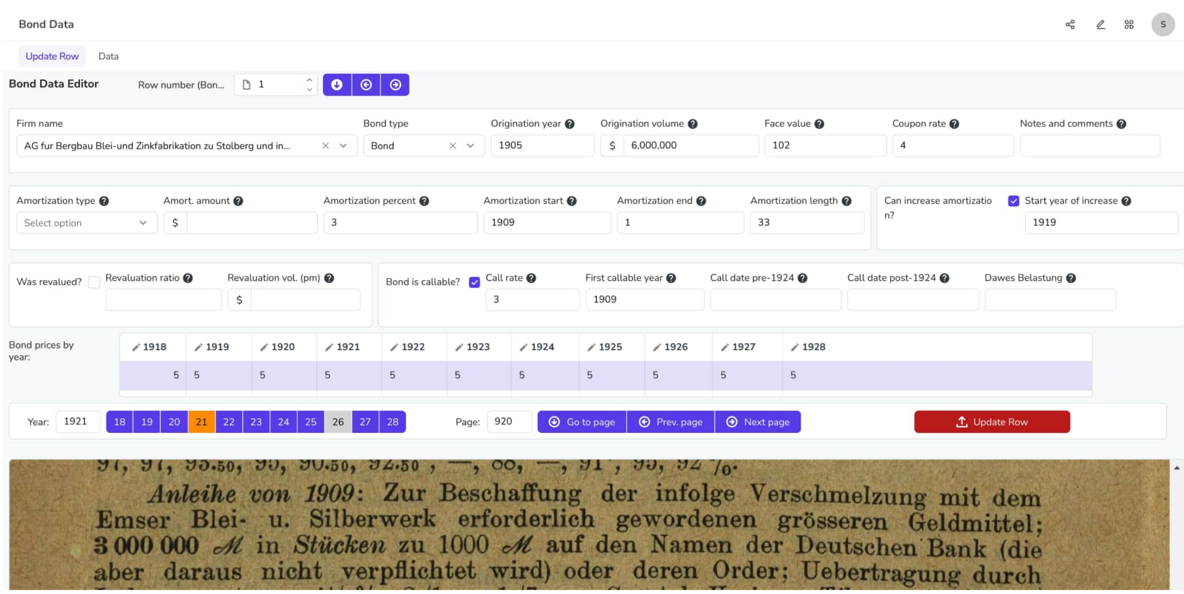
Figure D.6: *Sample bond information from the 1920 edition of* Saling's, *for the firm Bayer AG.*



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). — **$4^1/_2$ %**; 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*, — %.

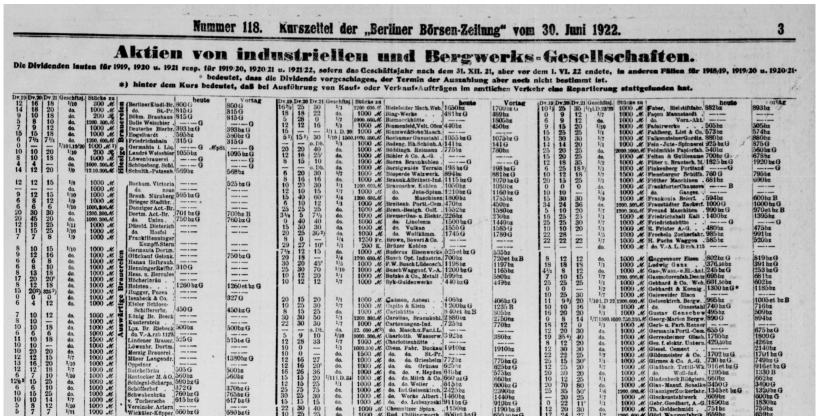
Geschäftsjahr: Kalenderj. (früher bis 1885 Juli-Juni; 1885 II ein unvollst.

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

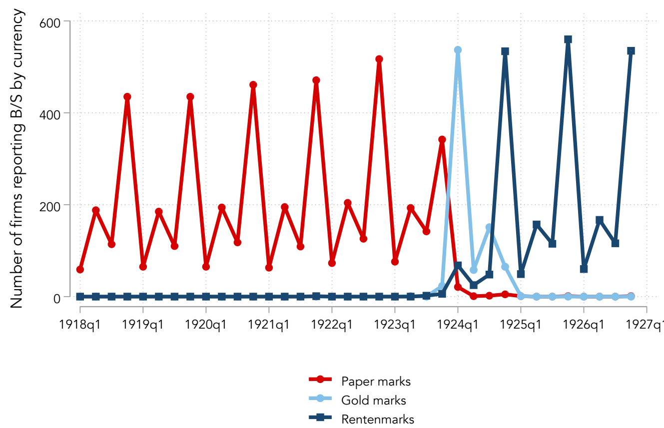
Throughout the data digitization process, we apply several quality checks. A key quality check stems from exploiting simple accounting identities that must hold within balance sheets and income statements. For instance, we flag balance sheets if assets and liabilities are not equal. We also flag income 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 95th 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 2.5th and 97.5th percentiles.

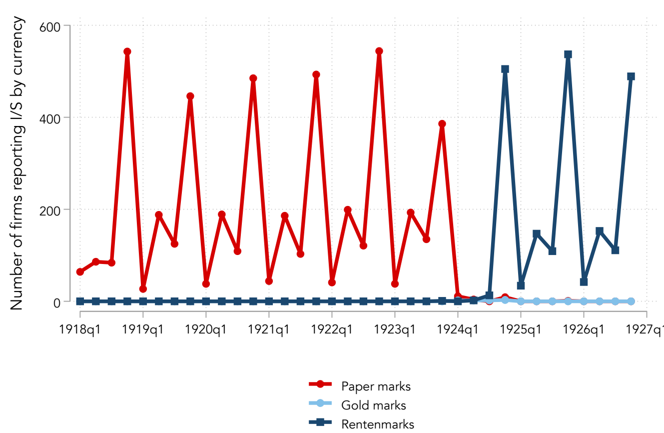
Finally, we drop firms with a headquarter located outside of Germany's post-WWI borders or firms with balance sheets and income statements that are not denominated in paper marks, Reichsmarks, or Goldmarks. We also exclude insurance companies, credit banks, and mortgage banks from our analysis. Figure 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.