The Debt-Inflation Channel of the German Hyperinflation

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

February 20, 2023

Abstract

Unexpected inflation can redistribute wealth from creditors to debtors. In the presence of financing frictions, such redistribution can impact the allocation of real activity. We use the German inflation of 1919-1923 to study how a large inflationary shock is transmitted to the real economy via a *debt-inflation* channel. In line with inflation reducing real debt burdens and relaxing financial constraints, we document a tight negative and convex relation between firm bankruptcies and inflation in aggregate data. Using newly digitized firm-level data, we further document a significant decline in leverage and interest expenses during the inflation. We show that firms that have more nominal liabilities at the onset of the inflation become more valuable in the stock market, face lower interest payments, and increase their overall employment once the inflation starts. The results are consistent with substantial real effects of the inflation through a financial channel that operates even when prices and wages are fully flexible.

*Brunnermeier: Princeton University, markus@princeton.edu; Correia: Federal Reserve Board, sergio.a.correia@frb.gov; Luck: Federal Reserve Bank of New York, stephan.luck@ny.frb.org; Verner: MIT Sloan, everner@mit.edu; Zimmermann: University of Cologne tom.zimmermann@uni-koeln.de. The authors would like to thank Joseph Abadi, Martin Beraja, Gabriel Chodorow-Reich, Marco Del Negro, Keshav Dogra, Yuriy Gorodnichenko, Carl-Ludwig Holtfrerich, Harold James, David Lopez-Salido, David Thesmar, and seminar participants at MIT, SAFE, Toulouse School of Economics, and Banca d'Italia for useful comments. We thank Viktoria Brueck, Lara Fronert, Natalia Fischl-Lanzoni, Tom Jarosch, Edwin Diebold, Vinnie Le, Lev Luskin, Christian Meyer, and Jenna Wang for outstanding research assistance. The project has received support from the Deutsche Forschungsgemeinschaft (DFG) under Germany's Excellence Strategy EXC2126/139083886, Princeton's BCF, and the MIT Research Support Committee's Ferry Fund. The opinions expressed in this paper do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System.

Electronic copy available at: https://ssrn.com/abstract=4303537

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

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

1 Introduction

The German inflation of 1919-1923 is a key event in monetary history (Bresciani-Turroni, 1937; Cagan, 1956; Sargent, 1982). From a value of 4.2 marks per dollar on the eve of World War I, the mark depreciated to 4.2 *trillion* marks per dollar by November 1923. Generations of researchers have examined this episode to understand the fundamental causes of inflation, as well as its macroeconomic, distributional, and broader societal effects.

In this paper, we use the German inflation as a laboratory to study how a large inflationary shock is transmitted to the real economy through a *debt-inflation* channel. With long-term nominal debt contracts, unexpected inflation can redistribute wealth from creditors to debtors (Keynes, 1923). If firms are financially constrained, such wealth redistribution can affect *real* economic activity and potentially have aggregate effects, even when wages and prices are fully flexible (Fisher, 1933; Gomes et al., 2016). The German hyperinflation provides an appealing setting to study this financial channel because the enormous increase in the price level puts the effects of inflation on nominal balance sheets into sharp relief. Further, we compare the debt-inflation channel with the traditional New Keynesian channel based on nominal rigidities by presenting new evidence on price and wage setting during the inflation.

We begin by describing the macroeconomic environment surrounding the German inflation, revisiting existing evidence and providing novel facts from newly digitized data.[1] The post-war 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, and economic growth was strong. Inflation was largely unexpected based on data on the forward exchange premium and anecdotal evidence of foreign speculators betting on an appreciation of the

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

[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.

Electronic copy available at: https://ssrn.com/abstract=4303537

German mark. 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.

The second phase of the post-war inflation is the hyperinflation from July 1922 to the stabilization in November 1923. This phase begins after the assassination of foreign minister Rathenau and concurrent political turmoil over WWI reparations. 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. Newly digitized product level data underlying the cost-of-living index, as well as data on industry-level wages, reveal that prices and wages are effectively flexible by the time the second phase of the inflation starts.

What are the macro-financial implications of the inflation? Using time-series variation, 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 tumult 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 over within a few years, debts have already been wiped out, making bankruptcy increasingly unlikely.

To better understand the negative bankruptcy-inflation relation, we document that inflation is associated with a massive fall in leverage. We find that the ratio of nominal liabilities to assets falls by around 25 percentage points for the average firm, representing a 50% decline. Interest expenses as a share of total expenses also fall by 6 percentage points, representing a 60% decline from 1918 through 1923. On the other hand, salaries as a share of total firm expenses remain constant. These trends are consistent with the longer maturity of financial liabilities relative to wage liabilities. As inflation accelerates, nominal financial liabilities such as long-term debt and pensions are wiped out, while wages become increasingly flexible and race to keep up with inflation. Indeed, we

Electronic copy available at: https://ssrn.com/abstract=4303537

show that the frequency of wage and price adjustment rises with inflation. We find that while wages are adjusted on average every 9 months for lower levels of inflation, they are adjusted every 60 days or less once inflation exceeds 100% and every 30 days or less once inflation becomes hyper. Further, we find that once inflation exceeds 50%, retail prices are reset at least every 30 days, and when inflation becomes hyper, retail prices adjusted every 7 days or less. Financial frictions thus potentially matter more than nominal rigidities in understanding the transmission of large inflationary shocks to the real economy.

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

To answer these questions and provide a more convincing identification of the debt-inflation channel, we examine the impact of inflation in the cross-section of firms. We construct a new firm-level database by digitizing a financial manual with firm-level information on balance sheets, income statements, and employment for about 700 joint-stock firms in Germany. We merge these data with newly digitized monthly stock prices. Information on employment and stock prices is particularly valuable, as accounting statements poentially provide a distorted representation of firm financial conditions during the hyperinflation phase, especially in 1923.[3]

The debt-inflation channel has real effects 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, a 10 percentage point increase in leverage is associated with a 3.5% higher employment during the inflation. The expansionary effect on employment occurs throughout the inflation, but is strongest in the first phase of inflation up to 1922. The hyperinflationary phase of 1922-23 has limited additional stimulative real effects on high leverage firms, consistent with the convex relation between bankruptcies and inflation in the aggregate. Moreover, there is some evidence of a reversal of employment after the stabilization for these firms, possibly because they overexpanded during the boom (Garber, 1982).

[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.

Electronic copy available at: https://ssrn.com/abstract=4303537

We provide several pieces of evidence to support the interpretation that the real effects on employment are driven by the debt-inflation channel. First, we show that high-leverage firms see a larger increase in their book equity and a larger decline in book leverage. Second, these firms experience higher stock market returns, especially in the hyperinflation phase of 1922-23 when erosion of real debt was most salient to investors. On average, high leverage firms have 11% higher annual risk-adjusted returns relative to low leverage firms during the inflation. In line with the value of nominal debt claims declining and firms that have a naturally high exposure to such nominal debt claims being adversely affected, we find that the equities of banks underperform non-financial equities. Third, high leverage firms see larger reductions in the share of interest expenses in total expenses, but an increase in the share of salary and material expenses.

Finally, fourth, the debt-inflation channel should especially benefit firms with a higher proportion of long-term debt. Around 50% of the non-financial firms in our sample have a long-term bond outstanding as of 1919. All bonds were fixed rate. The majority of the bonds were issued before WW1 and the median final maturity date is in 1940 and thus 17 years after the end of the Hyperinflation. Exploiting these additional details on the maturity structure of firms' liabilities, we apply a triple difference-in-differences specification and show 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 in total debt. Overall, the firm-level evidence suggests that the largely unexpected inflation thus redistributed wealth from debt to equity owners 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. 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. Thus, the debt-inflation channel appears to matter, above and beyond, the New Keynesian nominal rigidity channel, especially since wages and prices are flexible once inflation surpasses 100%. The estimates are also robust to the inclusion of other firm-level controls such as initial size, the share of fixed assets, and profitability. In addition, while credit availability tightened especially in the later phase of the inflation, the results are robust to controlling for proxies of credit supply.

Electronic copy available at: https://ssrn.com/abstract=4303537

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.

We also contribute to studies on the impact of inflation on the performance of firms with high and low leverage. Prior research has primarily focused on the 1970s Great Inflation in the U.S and finds mixed evidence for the hypothesis that equity valuation of firms with leverage benefit from inflation (see, for example, Summers, 1981; French et al., 1983; Ritter and Warr, 2002).[6] While inflation during the 1970s was high by U.S. historical standards, it was orders of magnitudes lower than the German inflation, even before the hyperinflation stage. Therefore, studying the German inflation allows us to identify a channel that has been challenging to isolate during episodes of moderate inflation when other shocks may obscure the effects of inflation. Moreover, the absence of a central bank policy response allows us to examine the impact of an inflationary shock that was not met with a large increase in interest rates.

Our findings on the frequency of wage and price adjustment also inform the literature on price setting. The evidence that the frequency of wage and price adjustment rises with inflation is consistent with the early accounts in Pazos (1972) and Simonsen (1983). More recently, Alvarez et al. (2018) theoretically and empirically show that both the frequency of price changes and price dispersion is increasing in inflation if inflation is high but is not affected otherwise (see also Nakamura et al. (2018)). Alvarez et al. (2018) calibrate that the high dispersion in relative prices generates large welfare costs during hyperinflation.

The remainder of the paper is structured as follows. Section 2 provides a conceptual framework

[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 Weimar Germany's inflation, include Cagan (1956), Sargent (1982), and Dornbusch and Fischer (1986). Section 4 and Appendix A.1 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.

[6]These papers do not examine whether inflation has real effects on firm investment or employment.

Electronic copy available at: https://ssrn.com/abstract=4303537

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 big inflation can affect the real economy. The discussion in this section is based on intuition from a simple model in Appendix A.2. 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, especially when debt is of longer maturity and fixed interest rate. 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 a firm will default and go into bankruptcy. This mechanism is at the heart of the model in Gomes et al. (2016), where unanticipated inflation reduces leverage, alleviates debt overhang, and reduces the share of firms in costly bankruptcy, thereby increasing aggregate 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, if a firm faces financing constraints, the reduction in real debt burdens increases net worth and allosw the firm to expand employment, investment, and production. For example, if a firm's debt is limited to be a fixed proportion of assets (e.g., Kiyotaki and Moore, 1997) or cash flows (e.g., Lian and Ma, 2021), a one-time unexpected inflation relaxes this financing constraint.

Electronic copy available at: https://ssrn.com/abstract=4303537

The inflation thus generates a boom in employment, investment, and production, especially for more levered firms. We illustrate this mechanism in our model in appendix A.2. 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 increases their net worth, relaxes financing constraints, and boosts production.

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. Inflation has real effects through a debt-inflation channel if firms are financing-constrained and if debt contracts are nominal and long-term with fixed interest rate. If instead debt is floating or indexed to inflation or denominated in foreign currency, then inflation does not necessarily increase firms' net worth or output. At the same time, 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 A.2). On the other hand, if inflation reduces the net worth of banks exposed to duration mismatch, then the reduction in credit supply can depress firm activity.[7]

The debt-inflation channel of the inflation is relevant in absence of nominal rigidities, traditionally assumed in macroeconomic models of inflation (e.g. Galí, 2015). In our model in appendix A.2, we introduce a nominal rigidity by assuming a fixed cost of wage adjustment. 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 work together to boost employment output. However, at high levels of inflation, wage setters pay the fixed menu cost of updating wages, and wages become flexible. Thus, for high levels of inflation, inflation only has real effects through the debt-inflation channel. Golosov and Lucas (2007) emphasize that menu costs imply small real effects of money-induced inflation, yet inflation could nonetheless have substantial real effects through the debt-inflation channel. The German inflation provides an

[7]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).

Electronic copy available at: https://ssrn.com/abstract=4303537

appealing setting to test these hypotheses, as the high level of inflation led prices and wages to become highly flexible.

Hypothesis III: The Nominal Rigidity Channel of Inflation. *If workers face a menu cost in adjusting wages, small increases in inflation have a large effect on output 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 an expansionary effect through the debt-inflation channel.*

3 Data

3.1 Aggregate, Industry-level, and Regional Data

We obtain aggregate, industry-level, and regional data by digitizing contemporary publications of various government agencies. Our main source is a publication from the government agency for statistical analysis, the *Reichsamt für Statistik*, which is called *Zahlen zur Geldentwertung in Deutschland von 1914 bis 1923* and was published in 1925. This publication provides data on the daily exchange rate of the mark to the dollar, 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.[8] 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*) and which contains information on monthly industry-level and regional unemployment.

[8]These data are in part digitally available via https://histat.gesis.org/.

Electronic copy available at: https://ssrn.com/abstract=4303537

3.2 Firm-Level Data

We construct a firm-level dataset with annual information on balance sheets and income statements from *Saling's Börsenjahrbuch*, an investor manual.[9] Figure 1 provides an example of the balance sheet and income statement from the 1920 issue of *Saling's* for Siemens & Halske AG, a large electrical engineering firm. We digitize these financial statements using optical character recognition (OCR) using the methods discussed in Correia and Luck (2022) and then hand-check the OCR output, with particular attention to cases where accounting identities fail to hold. Further, the source also provides loan terms for long-term bonds which we hand-collect for selected years. The data are available for over 700 nonfinancial firms and 60 banks each year for the period 1915 to 1933. In this paper, we focus on the sample of nonfinancial firms and exclude banks and insurance companies. Table 1 provides summary statistics for key firm-level variables. Appendix Figure A.3.1 plots the number of firms reporting balance sheets by quarter and currency of reporting from 1918 to 1927.

An important point to note when using data from *Saling's Börsenjahrbuch* is that balance sheets can provide a misleading account of firms' financial situations during hyperinflation.[10] "Inflation accounting" did not exist at the time, and dealing with inflation was a major challenge for firms, especially in 1922-23. 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."[11] Similarly, Hoffmann and Walker (2020) provide examples of firms 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. We are therefore cautious in drawing inferences based on financial statements from 1922 and especially 1923. Figure A.3.2 shows that violations of the balance sheet accounting identity spikes to nearly 40% in 1923, from around 5%

[9]The *Saling's* documents are made available by the University of Mannheim. See https://digi.bib.uni-mannheim.de for the scanned originals.

[10]Income statements can also be distorted due to the addition of nominal values at difference 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 in total expenses, which are less likely to be distorted by inflation as long as different expenses occur at similar times in the year.

[11]See Sweeney (1934) for a detailed discussion of how inflation distorted balance sheets during the 1920s hyperinflations in Europe.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure 1: *Example of Newly Digitized Firm-Level Data from Saling's Börsenjahrbuch and Berliner Börsen Zeitung.*

(a) *Siemens & Halske AG's financial statement from Saling's, 1920.*

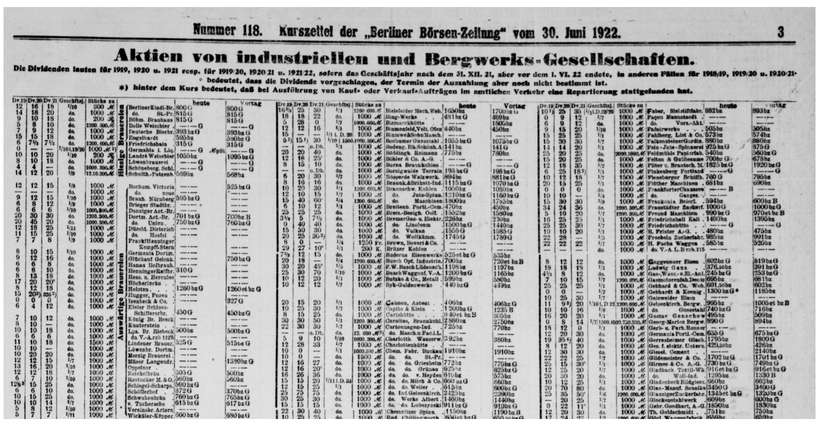
Siemens & Halske Aktiengesellschaft.

Sitz in *Berlin*, Schönebergerstr. 1—4.

Gewinn 1918/19: Vortrag 1 262 845, Geschäftsgewinn 14 473 277; zus. 15 736 122 ℳ. — *Ab*: Handl.-Unk. der Zentral-Verwalt. 1 809 501, Anleihe-Zinsen 1 950 230, Abschreib. auf Gebäude 518 949, *bleibt Reingew.* 11 457 441 ℳ.

Bilanz ult. Juli 1919: *Aktiva*: Kassa 1 427 135, Guth. bei Banken 40 185 254, Staatspap. 24 115 914, sonst. Wertp. 2 632 183, Sicherheiten 4 769 803, Hyp. 1 839 033, Wechsel 1 198 716, dauernde Beteilig. 87 055 706, Grundstücke 11 249 294, Gebäude 11 698 570, Geräte u. Werkz. 1, Werkz.-Masch. 1, Betriebs-Masch., Heizungs- u. Beleucht.-Anl. 1, Rohmaterial 9 323 913, Fabrikate 40 523 242, Unternehm. od. Beteilig. an solchen 2 418 988, (Bürgsch. 10 998 201), Schuldner (einschl. Gewinn von Siemens-Schuckertwerk) 75 558 193 ℳ. — *Passiva*: A.-K. 63 000 000, R.-F. 13 500 000, Sond.-R.-F. 19 000 000 (Rückl. 2 000 000), 4% Anleihe v. 1898 14 287 500, do. (konv.) v. 1900 7 410 500, 4½ % Anleihe v. 1912 20 000 000, do. v. 1919: 20 000 000, Hyp. 1 289 400, Spar- u. Depos.-K. 27 789 254, Pens.-, Witwen- u. Waisen-K. für Beamte 1 307 295, do. für Arb. 4 372 306, Wohlf.-Dispos.-F. 6 304 261 (Rückl. 500 000), Interims-K. 10 717 900, Gläubiger 68 932 131, Anzahl. 26 462 578, ausgel. Oblig. 204 970, Oblig.-Zinsen 336 815, (Bürgsch. 10 998 201), Div. 7 560 000, do. rückst. 423 600, Tant. d. A.-R. 331 935, Vortrag 1 065 506 ℳ. — S. b. 313 995 954 ℳ.

(b) *Stock prices of industrial firms from Berliner Börsen Zeitung, 1922.*



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

Aktien von industriellen und Bergwerks-Gesellschaften.

Die Dividenden lauten für 1919, 1920 u. 1921 resp. für 1919/20, 1920/21 u. 1921/22, sofern das Geschäftsjahr nach dem 31. XII. 21, aber vor dem 1. VI. 22 endete, in anderen Fällen für 1918/19, 1919/20 u. 1920/21.
° bedeutet, dass die Dividende vorgeschlagen, der Termin der Auszahlung aber noch nicht bestimmt ist.
*) hinter dem Kurs bedeutet, daß bei Ausführung von Kauf- oder Verkauf-Aufträgen im amtlichen Verkehr eine Repartierung stattgefunden hat.

Notes: Panel (a) shows an example of financial statements for the firm Siemens & Halske AG from the 1920 issue of *Saling's Börsenjahrbuch*. Panel (b) shows an excerpt of stock prices and dividends from *Berliner Börsen Zeitung*.

in other years.[12]

In response to the distortion of paper mark balance sheets caused by the hyperinflation, the regulation on Goldmark accounts (Verordnung über Goldbilanzen) was passed in December 1923. It required firms to prepare new opening balance sheets for financial years beginning on or after January 1, 1924 in Goldmarks.[13] This preparation required a full revaluation of all assets and liabilities (see, e.g., Sommerfeld, 1924).

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

[12]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.

[13]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.

Electronic copy available at: https://ssrn.com/abstract=4303537

items before and after the introduction of Goldmark balance sheets to understand how hyperinflation distorted accounting.[14] 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] Figure A.3.4 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.

Our analysis uses two approaches to overcome the inflation-induced measurement challenge. First, we primarily rely on accounting variables before the hyperinflation (before 1922) and after the 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 has the obvious drawback of not being informative about the timing of the effects.

Second, we examine variables that are not subject to accounting issues throughout the inflation: employment and stock prices. Employment is self-reported by firms in *Saling* for about one-third of the firms in the sample. Aggregating employment growth across firms in *Saling* captures the aggregate fluctuations in employment reasonably well. Figure A.3.5 compares average employment growth in *Saling* with the change in the aggregate unemployment rate (on an inverted scale). The two variables co-move reasonably closely. Employment growth among firms in *Saling* 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.

Finally, monthly stock and bond prices for nonfinancial firms and banks are hand-collected from *Berliner Börsen Zeitung* (BBZ), a financial newspaper.[16] We also collect dividends to construct total returns. Figure 1b provides an example of data from *Berliner Börsen Zeitung*. Figure A.3.18

[14] Sweeney (1934) uses the Goldmark balance sheets as the "truth" to illustrate the misleading nature of the paper mark balance sheets during the hyperinflation. However, it should be noted that even the revalued Goldmark balance sheets likely undervalue real assets, as uncertainty about the costs of stabilization and whether it would succeed led to conservative valuations (Graham, 1931, p. 242).

[15] Sweeney (1934) also notes that current assets and current liabilities more likely to be correct in a case study comparing paper mark and revalued gold mark balance sheet for one firm. Measurement error is most severe for less liquid, long-term assets, such as fixed assets and book equity.

[16] Braggion et al. (2022) also utilize stock returns from *Berliner Börsen Zeitung*.

Electronic copy available at: https://ssrn.com/abstract=4303537

shows that equal-weighted stock price indexes constructed from the BBZ data closely track corresponding indexes published by *Wirtschaft und Statistik*, providing a reassuring validation of our hand-collected stock market data.

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

	N	Mean	Std. dev.	10th	90th
$\text{Liabilities/Assets}_{i,1918-1919}$	798	0.47	0.18	0.23	0.69
$\Delta_{1919-1924}\text{Liabilities/Assets}_i$	656	-0.25	0.20	-0.47	0.00
$\text{Debt/Assets}_{i,1918-1919}$	800	0.37	0.18	0.13	0.59
$\ln(\text{Assets})_{i,1918-1919}$	800	15.01	1.26	13.48	16.77
$\text{Fixed Assets/Assets}_{i,1918-1919}$	800	0.36	0.24	0.08	0.74
$\text{ROA}_{i,1918-1919}$	744	0.10	0.06	0.03	0.18
$\text{EBIT margin}_{i,1918-1919}$	758	0.36	0.22	0.10	0.68
$\text{Employment}_{i,1919}$	240	4,151.54	9,307.68	400.00	9,959.50
$\Delta\ln(\text{Employment})_{i,t}$	1,358	3.50	21.90	-2.90	19.24

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

4 Aggregate Evidence on the Debt-Inflation Channel

4.1 Background and Aggregate Evidence on Weimar Germany's Inflation

We start with a brief discussion on the background of Weimar Germany's inflation. Appendix A.1 provides further details on the historical background and a chronology of critical events.

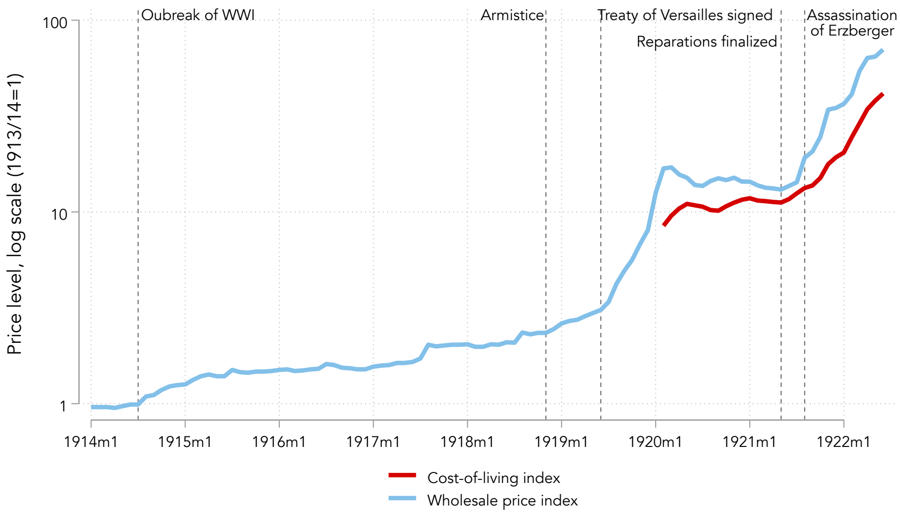
Two phases of the inflation. Figure 2 plots the time series of the wholesale price index and the cost-of-living index. Germany's inflation has its roots in WWI, when the gold standard was abandoned and the government increasingly financed the deficit by discounting government securities at the Reichsbank (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, and lower than in France, where wholesale 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).

In the post-war period, there are two broad phases of the inflation. The first phase is from

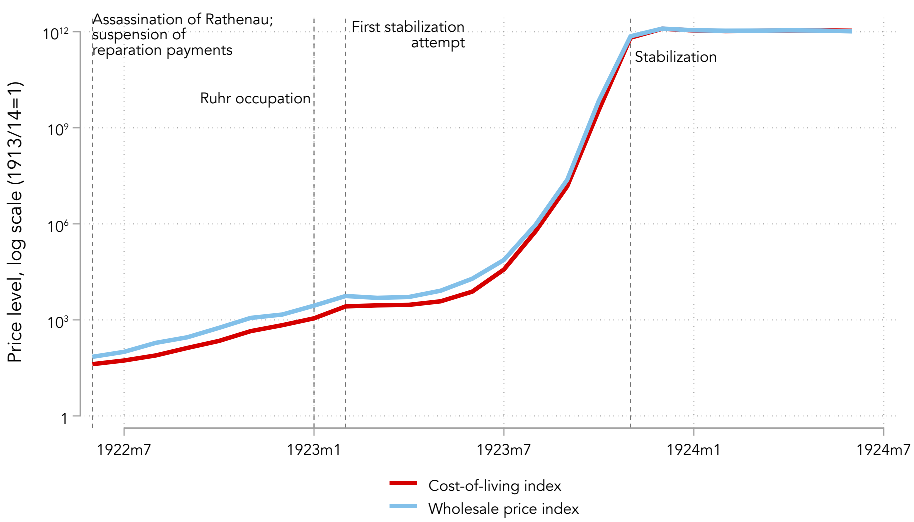
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure 2: *The Price Level during Germany's Inflation.*

(a) *Wartime inflation and first phase of the post-war inflation, January 1914 to June 1922.*



(b) *Second phase of the inflation and the post-stabilization period, June 1922 to December 1924.*



Notes: 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.*

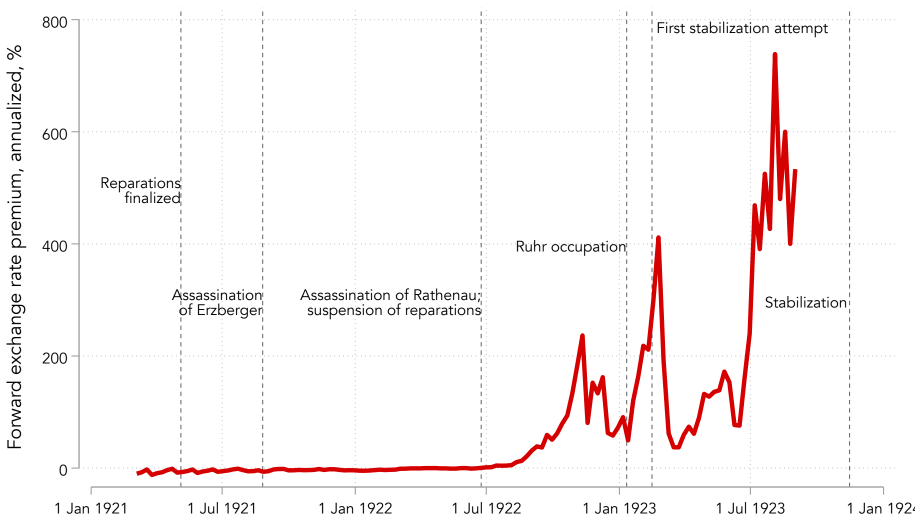
the WWI Armistice in November 1918 to the summer of 1922. Panel (a) of Figure 2 shows that inflation accelerated in the second half of 1919, after the signing of the Treaty of Versailles in June 1919. The Treaty assigned sole blame for the war on the Central Powers (the "War Guilt Clause") and imposed large and uncertain reparations on Germany. From the end of 1918 to end of 1919, the wholesale price index increased by a factor of 3.3. The price level stabilized

Electronic copy available at: https://ssrn.com/abstract=4303537

during 1920 with the Ezberger fiscal reforms and the successful suppression of a right-wing coup attempt in March 1920, the "Kapp Putsch". 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 2. This phase was ushered in by several events that further undermined confidence in Germany's ability to meet reparations. In early June 1922, the French government insisted on the original reparations schedule, rather than a reduced schedule—in part as a response to the upset of the Treaty of Rapallo in which Germany entered into diplomatic relations with the Soviet Union. Hopes of an international loan to stabilize the mark were dashed by the Reparations Commissions banker's committee. 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. Moreover, Germany 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.

Figure 3: *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.

Electronic copy available at: https://ssrn.com/abstract=4303537

Inflation expectations. The summer of 1922 marked a decisive shift in expectations. Figure 3 plots the annualized forward premium based on one-month forward contracts.[17] During the first phase of the inflation, many agents, including foreign speculators, believed that the depreciation would be temporary (e.g., Kindleberger, 1985).[18] However, the forward price of sterling moves decisively from a discount to a premium the week of Rathenau's assassination in late June 1922 (Holtfrerich, 1986). After the political turmoil during the summer of 1922, the forward trades at a larger and larger premium.

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 $\frac{F_t - S_t}{S_t} \approx i_t - i_t^* = \mathbb{E}_t \pi_{t+1} - \mathbb{E}_t \pi_{t+1}^* + r_t - r_t^*$. Assuming that most variation in interest rates is due to expectations about inflation in Germany ($\mathbb{E}_t \pi_{t+1}$), forward exchange rates suggest that markets anticipated lower inflation in Germany up to summer of 1922, followed by higher inflation afterwards.[19] In short, inflation expectations become unanchored in the summer of 1922. Inflation expectations and realized 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. This led to a large increase in money printing, which further fuelled inflation.

Stabilization. Inflation was stabilized in November 1923. The stabilization had several key ingredients. First, a monetary reform led to the introduction of the Rentenbank, backed by "fictitious" claims on industry and land. The Rentenbank would issue a new currency, the Rentenmark, at an exchange rate of one trillion paper marks per Rentenmark. Second, the reform imposed limits on the Rentenbank and Reichsbank's ability to discount government bills. Third, the Rentenmark exchange rate was stabilized at 4.2 Rentenmarks per dollar. Fourth, the

[17] The annualized forward premium is calculated as $\frac{12(F_t - S_t)}{S_t}$, where S_t is the spot exchange rate in marks per sterling and F_t is the forward exchange rate.

[18] 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."

[19] 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.

Electronic copy available at: https://ssrn.com/abstract=4303537

stabilization was associated with a massive fiscal reform, including large reduction in public servants. Sargent (1982) argues the fiscal reform was crucial for ending the inflation, while Dornbusch (1985) also emphasizes the important role of the exchange rate stabilization.

Real activity during the inflation. The post-war inflation was associated with a booming economy through the end of 1922.[20] Figure 4 plots an index of real GDP per capita for Germany starting in 1918. For comparison, we also plot an index of weighted real GDP per capita growth for other major industrial economies. The figure shows that 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 A.3.6). Germany's inflationary boom ended in early 1923, around the time of the invasion of the Ruhr and the resulting passive resistance. Starting in 1923, Germany underwent a large fall in industrial production, 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

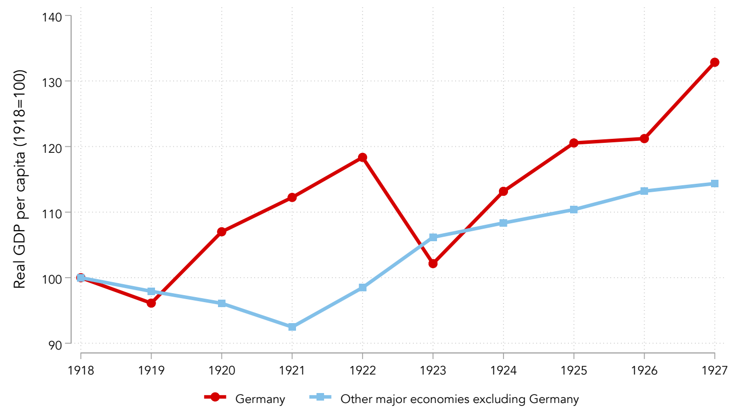
Inflation and firm bankruptcies. Cagan (1956) argued that "hyperinflations provide a unique opportunity to study monetary phenomena. The astronomical increases in prices and money dwarf the changes in real income and other real factors. . . Relations between monetary factors can be studied, therefore, in what almost amounts to complete isolation from the real sector of the economy."

While the increase in nominal quantities indeed dwarf the changes in real income, inflation may nevertheless have important real effects through redistributive financial channels (Fisher, 1933; Gomes et al., 2016). The equity holders of firms with nominal debt will benefit from unexpected inflation. These redistributive effects can operate and affect real activity even when prices are fully flexible, breaking monetary neutrality. This contrasts with New Keynesian and classical monetary

[20] As emphasized by Graham (1931): "that business in Germany was booming during most of the inflation period is a universally admitted fact." Furthermore, Graham (1931) argued that inflation contributed to the boom: "domestic production [in Germany] seems, on the whole, to have been substantially greater than would presumably have been achieved under a stable monetary standard.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure 4: *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, Switzerland, Denmark, Spain, Finland, France, U.K., Italy, Japan, Norway, Portugal, Sweden, and the U.S.).

models without financial constraints, as discussed in section 2.

One implication of long-term nominal debt contracts is that unexpected inflation will tend to reduce the likelihood of bankruptcy for nonfinancial firms. To test this, Figure 5 plots the relation between the monthly number of firm bankruptcies and inflation.

Figure 5 reveals 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 1923Q4.[21] Once annual inflation is high, further increases in inflation are not associated with additional defaults.[22]

The pattern is robust to different ways of measuring bankruptcies and inflation. Figure A.3.8 which confirms the above patterns for the rate rather than the level of bankruptcies, which falls from 1.5% in 1920 to close to zero in 1923.[23] Further, while Figure 5 shows realized annual

[21] See also Table A.3.1 in the appendix for the corresponding regression estimates.

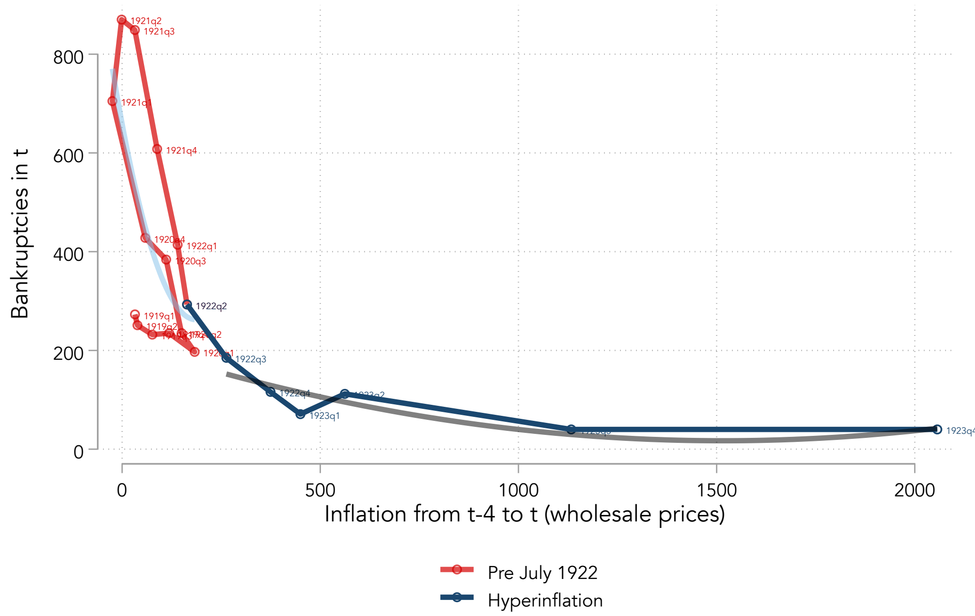
[22] Graham (1931) noted that large fall in bankruptcies, writing that "as the rate of depreciation became accelerated, it was next to impossible for a business concern to fail" (p. 278).

[23] Figure A.3.8 shows the inflation-bankruptcy relation using the share of firms in bankruptcy, rather than the number of firms. The total number of registered firms is only available annually, so we use the number of firms in bankruptcy

Electronic copy available at: https://ssrn.com/abstract=4303537

inflation, Figure A.3.7 in the Appendix confirms a similar pattern when using the "accelerationist" version that uses unexpected inflation, $\pi_t - E_{t-1}[\pi_t]$, where inflation expectations are assumed to be adaptive so that expected inflation is assumed to be last periods inflation, $E_{t-1}[\pi_t] = \pi_{t-1}$.

Figure 5: *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*.

Inflation eroded real firm debt burdens. Our hypothesis is that the negative inflation-bankruptcy relation emerges because inflation erodes firms' long-term nominal liabilities. Figure 6 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 because it is likely to be less influenced by the end of the WWI than 1918. We choose 1924 as the endpoint to utilize the more reliable Goldmark balance sheets, which most firms reported in January 1924, shortly after the stabilization.

Figure 6(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

in Figure 5 to be able to use quarterly data.

Electronic copy available at: https://ssrn.com/abstract=4303537

sample. Figure A.3.4(a) in the Appendix plots the median of firm liabilities, deflated by wholesale prices, by quarter.[24] It shows that real debt declines sharply 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.[25]

Panel (b) of Figure 6 analyzes firm leverage from the perspective of interest expenses. Specifically, it shows the evolution of the share of interest expenses in firms' total non-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* data, so this measure is a lower bound on interest expenses. Figure 6(b) shows a clear decline in the share of interest expenses in total expenses during the inflation. The interest expense share declines by about 6 percentage points. The erosion of real debt thus directly boosts firm's interest coverage ratios and benefits their liquidity.

Figure 6(b) also plots the evolution of salaries and material expenses to total expenses. Salaries and material expenses as a share of total expenses essentially remain constant. This is consistent with wages becoming flexible and racing to keep up with inflation, as we document below, as well as with firms boosting employment and production. Wage liabilities are of shorter effective duration than nominal debt liabilities and hence adjust more quickly to rising inflation.[26]

4.3 The Classic Phillips Curve

Both in narrative accounts and in the data, Germany's inflation was associated with a booming economy through 1922. Rising output and prices suggest a money-financed demand boom.[27]

[24] 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.

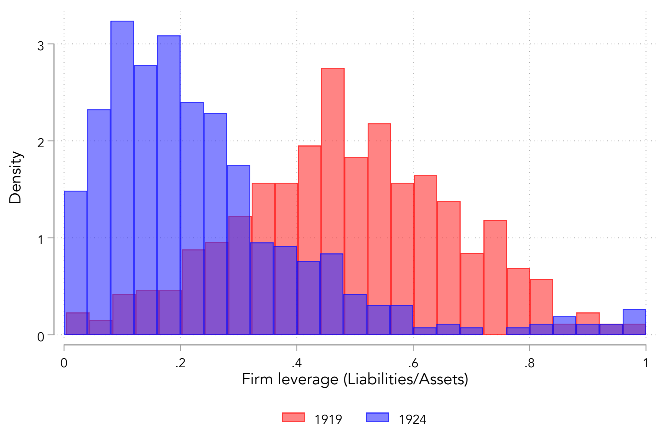
[25] In July 1922, *The Economist* reported "an extreme shortness of money," as credit demand was high while credit supply was extremely limited (*The Economist*, July 8, 1922).

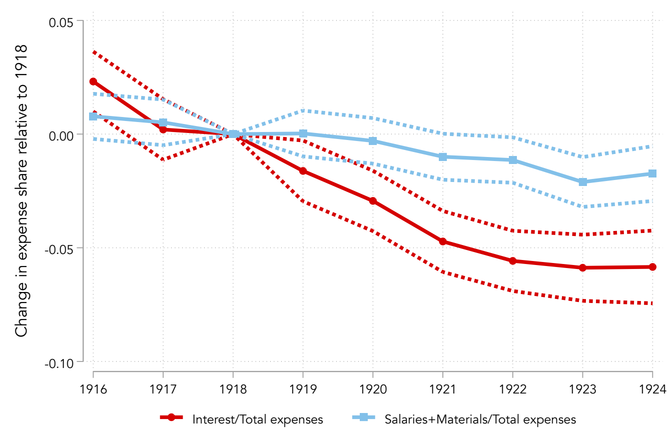
[26] Consistent with our findings, Bresciani-Turroni (1937) documents that real wages declined in the first phase of the inflation up to 1922. From the latter half of 1922, real wages kept pace with inflation. As a result, Bresciani-Turroni (1937) discusses evidence from a survey of textile firms that the share of wages in total costs declined between 1913 and 1923. However, he does not provide annual evidence of when the decline in labor cost share occurred or compare it to the decline in interest expenses.

[27] In the standard New Keynesian model, divine coincididence allows monetary policy to perfectly stabilize demand shocks. Under such monetary policy, only supply shocks would emerge in the data, obscuring the presence of a Phillips

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure 6: *Hyperinflation Led to Collapse in Leverage and Interest Expenses.*





Notes: Panel (a) shows the distribution of firm book leverage at the start of the post-war inflation in 1919 and in the aftermath of the hyperinflation in 1924. Leverage is defined as $\frac{Assets-Equity}{Assets}$. Panel (b) shows that interest expenses as a share of total expenses declined during the hyperinflation. Specifically, it plots the sequence of estimated year fixed effects from firm-level two-way fixed effects regression regression of the form:

$$\text{expense share}_{it} = \alpha_i + \gamma_t + \epsilon_{it}$$

for interest to total expenses and salaries to total expenses as the dependent variable. This regressions captures the change in the expense share within firm.

We next investigate whether there is a negative relation between unemployment and inflation during Germany's inflation. The traditional "level-level" (Ball and Mazumder, 2019) variant of the Phillips curve is given by:

$$\pi_t = -\kappa(u_{t-1} - u_{t-1}^n) + \nu_t. \tag{1}$$

We use beginning of period unemployment, following previous empirical work (Ball and Mazumder, 2019; Hazell et al., 2021). The formulation in (1) ignores inflation expectations, which are crucial for inflation dynamics, especially during high inflation. A modern version of the Phillips curve that incorporates inflation expectations is the New Keynesian Phillips Curve:

$$\pi_t = \beta E_t \pi_{t+1} - \kappa(u_{t-1} - u_{t-1}^n) + \nu_t.$$

curve (McLeay and Tenreyro, 2020). In the case of the German hyperinflation, monetary policy was passive and clearly did not respond to rising inflation.

Electronic copy available at: https://ssrn.com/abstract=4303537

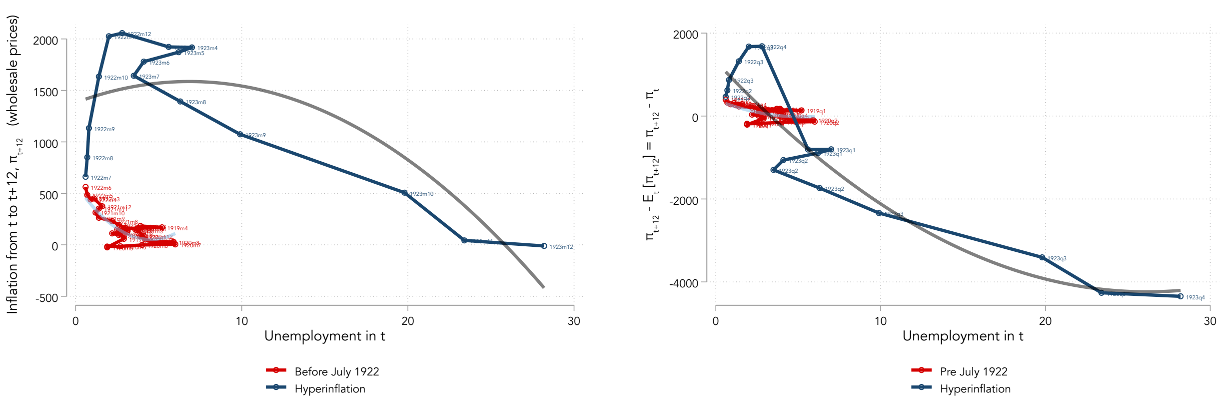
A common empirical variant assumes that expectations are adaptive and that the expectation of next year's (discounted) inflation is last period's inflation ($\beta E_t \pi_{t+1} = \pi_{t-1}$). Further, assuming a constant natural rate of unemployment yields the "accelerationist" Phillips curve

$$\pi_t - \pi_{t-1} = -\kappa(u_{t-1} - u^n) + \nu_t. \tag{2}$$

Figure 7 presents the graphical versions of (1) and (2) using monthly data. Table A.3.2 in the appendix reports the corresponding regression estimates. Inflation is computed as the change in the price level over the next twelve months. Unemployment is the unemployment rate in the current month. We also plot quadratic fits separately for the two phases of the inflation, 1919:1-1922:6 and 1922:7-1923:12.[28] Figure 7 reveals that there is a downward sloping relation between unemployment and subsequent inflation, especially during the first phase of the inflation before July 1922. The classic Phillips curve is also non-linear. As unemployment declines as inflation rises, the Phillips curve steepens.

Figure 7: *The Phillips Curve during Germany's Inflation*

(a) *Level-level Phillips Curve, 1919:1-1923:12.* **(b)** *Accelerationist Phillips Curve, 1919:1-1923:12.*



Notes: Panel (a) shows the level-level Phillips curve, given by the level of inflation from month t to $t+12$ against the level of the unemployment rate in month t. Panel (b) shows the accelerationist Phillips curve, given by inflation from t to $t+12$, net of inflation from $t-12$ to t, against the level of the unemployment rate in month t. Both panels use monthly data from the entire post-war inflation period, 1919:1-1923:12. Quadratic fits are estimated separately for 1919:1-1922:6 (before July 1922) and 1922:7-1923:12 (hyperinflation). Inflation of wholesale prices is from *Zahlen zur Geldentwertung*. Monthly unemployment in the German industries is from the *Reichsarbeitsblatt*.

We note two challenges in estimating a Phillips curve relation in this context. First, supply shocks that increase unemployment and inflation, captured by ν_t, will tend to bias estimation

[28] Figure A.3.9 zooms in on the first phase of the inflation, 1919:1-1922:6.

Electronic copy available at: https://ssrn.com/abstract=4303537

of κ. The Ruhr crisis starting in January 1923 led to a fall in output, rise in unemployment, and rising inflation, as the government ran large money-financed deficits to support striking workers. Excluding data from 1923 yields a more well-behaved downward sloping and non-linear relation between inflation and unemployment.

Second, estimating a Phillips curve in this historical setting of high inflation is challenging because it is difficult to measure inflation expectations. Failure to control for inflation expectations can lead to severe bias in the estimate of κ. For example, a sequence of unexpected inflation surprises that are correlated with unemployment rate leads to an upward bias (in absolute value) in the slope of the Phillips curve. We find that the Phillips curve relation is highly sensitive to the exact specification for inflation expectations. For example, during the first phase of the inflation (1919:1-1922:6), the slope of the level-level Phillips curve (Figure 7(a)) is about twice the slope of the accelerationist Phillips curve (Figure 7(b)). Moreover, the Phillips curve is sensitive to specification choice, such as the timing of inflation and unemployment.

Leaving aside these methodological caveats, an important question is which mechanisms generate the negative inflation-unemployment relation documented in Figure 7. Traditional New Keynesian theories hypothesize that a negative relation between inflation and unemployment emerges as a consequence of demand shocks that transmit to real activity through nominal rigidities, such as frictions in adjusting wages and prices. As we outlined in section 2, a negative unemployment-inflation relation could also arise in the absence of nominal rigidities, purely through the debt-inflation channel. In the latter case, the relevant friction is no wage or price rigidity but "sticky" long-term nominal debt. While it is difficult to distinguish these hypotheses using only data on inflation and unemployment, Figure 7 supports the view that the inflation was expansionary from 1919 through 1922. To better understand whether this is driven by New Keynesian or debt-inflation channels, we next analyze the behavior of wages and prices, before turning to firm-level data for more direct evidence on the debt-inflation channel.

4.4 Wage and Price Flexibility during the Inflation

We next study the frequency at which wages and prices adjust throughout the inflation. Wages and prices became increasingly flexible with rising inflation, and there was a reduction in the time

Electronic copy available at: https://ssrn.com/abstract=4303537

elapsed between price adjustments as inflation accelerated.[29]

We first analyze wages. The "Stinnes-Legien" agreement from November 1918 enshrined a set of workers' rights long coveted by the German labor movement, including recognizing trade unions as the official representatives of the workforce. This allowed for union bargaining at the industry-level. We collect the industry-level wages for seven industries from 1920 through 1923. Panels (a) and (b) in Figure 8 examine the frequency of wage adjustment during the inflation. Panel (a) plots the number of days since wages were last increased, averaged across the seven industries, against inflation in wholesale prices. As inflation accelerated, wages were adjusted with increasing frequency. While wages are adjusted on average every 9 months for lower levels of inflation, wages were adjusted every 60 days or less once inflation is larger than 100%, and every 30 days or less once inflation becomes hyper. Panel (b) in Figure 8 plots the days elapsed since the last wage change across seven different industries from 1920 to 1923. It shows that, as inflation accelerated in 1922, the gap between wage adjustments declined. By the hyperinflation in July 1922, wages were adjusted at least monthly.[30]

The increasing flexibility of wages also informs the evolution of real wages. Relative to 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 is more pronounced for higher-skilled salaried workers that were less likely to have union representation and thus in a worse position to renegotiate wages when inflation picked up (see Appendix Figure A.3.12 for state employees from 1914 through 1923). However, most of the decline 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 wages racing to keep up with prices once inflation becomes high, as predicted by menu cost models of nominal rigidity.

Inflation also led retail prices to be adjusted at shorter and shorter intervals. Figure 8 panels (c) and (d) present similar figures for the frequency in the adjustment of goods prices, based on prices of goods underlying the cost-of-living index. The underlying data we obtain are at the city-product-month level for 18 major cities and 12 retail products such as sugar, pork, and milk.[31]

[29] This is sometimes referred to as the Pazos-Simonsen mechanism (Pazos, 1972; Simonsen, 1983).

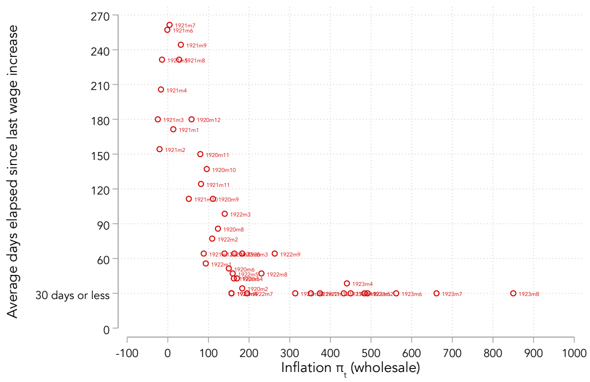
[30] Narrative evidence suggests that wages were adjusted weekly once the inflation became hyper (Feldman, 1993). We obtain union-bargained wages only at the monthly frequency and thus can only provide an upper bound on the time elapsed since the last wage increase.

[31] The price quoted for each city is the average of 4 samples taken over the course of a month for each city. Thus,

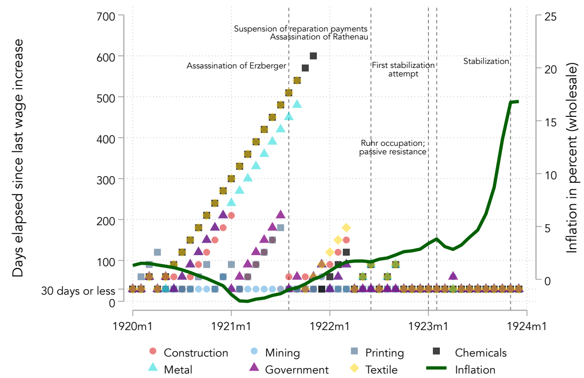
Electronic copy available at: https://ssrn.com/abstract=4303537

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

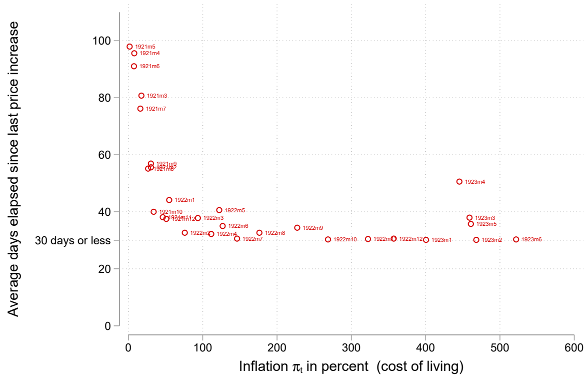
(a) *Frequency of wage adjustments and inflation.*



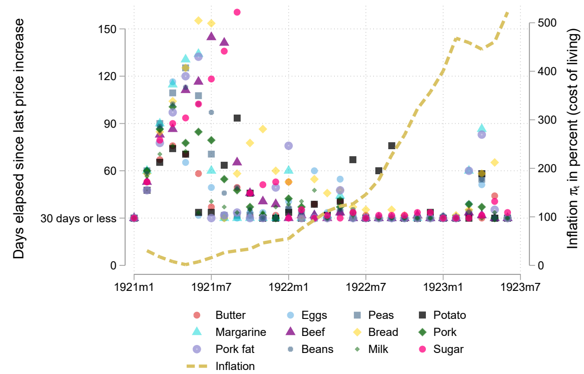
(b) *Frequency of wage adjustments by industry.*



(c) *Frequency of price adjustments and inflation.*



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



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.

Panel (c) relates the average days elapsed since the last price increase against the level of inflation. It shows that once cost-of-living inflation exceeds 50%, product prices in the cost-of-living index are adjusted at least once every 30-40 days. Panel (d) plots the days elapsed since the prices of individual goods in the cost-of-living index are updated. 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 A.3.10). During the first stabilization attempt in February and March 1923, inflation slowed, and the

the fact that the data are not quoted prices but averages of quoted prices implies that they may possibly overstate the frequency at which prices were adjusted upwards.

Electronic copy available at: https://ssrn.com/abstract=4303537

interval of price adjustment increased. But prices were once again adjusted more than monthly by early summer 1923 as inflation accelerated again.[32]

Overall, Figure 8 indicates that wages and prices are essentially flexible by 1922, once inflation is high. Intuitively, menu costs are not sufficient to induce price stickiness for large inflationary shocks (see, e.g., Golosov and Lucas, 2007). Our evidence suggests that during the period of high and hyperinflation, inflation had little potential to affect output positively through New Keynesian channels. Nevertheless, menu costs could have induced large economic costs through price dispersion, as documented by Alvarez et al. (2018) using micro-data on prices in Argentina's 1989-90 hyperinflation.

5 Firm Level Evidence on the Debt-Inflation Channel of the Inflation

The analysis of the time series variation in section 4 suggests that non-financial firms in Germany benefited from the inflation of 1919-1923. 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 helped reduce firms' financial constraints and thus stimulated economic activity via a 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 such as observed in the earlier years of the German inflation. This analysis allows us to tighten the empirical link between inflation and real economic outcomes via the debt-inflation channel.

[32] Consistent with this evidence, the daily prices of two widely circulated newspapers were also adjusted at shorter and shorter intervals during the inflation and hyperinflation, as shown in Figure A.3.11, which is based on new hand-collected data from individual newspapers.

Electronic copy available at: https://ssrn.com/abstract=4303537

5.1 Main Result: Leverage and Firm-level Employment

We start out by testing whether firms with high leverage increase their overall level of economic activity relatively more compared to firms with low leverage. 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 and income statements become relatively 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 measure a firm's 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, only equity-holders would benefit from unexpected inflation and the resulting changes in a firm's capital structure have no impact on firm real investment or employment decisions. However, if firms are financing constrained, the inflation can relax financing constraints for levered firms, leading them to increase investment and employment, as we outlined in section 2.

We define leverage either as the ratio of a firm's total liabilities over total assets or a firm's financial debt over its 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.[33] Note that debt contracts were typically fixed-rate; floating-rate contracts were not common in Germany during this time. Long-term debt was also common and firms often issued fixed-rate bonds with a maturity of 10 and up to 50 years. Further, when calculating a firm's leverage we average over the respective ratio reported in 1918 and 1919.[34]

We start by sorting firms into three terciles based on their 1918-1919 average liabilities-to-assets

[33]We also consider an alternative measure that nets out asset side nominal exposure and is given by $NNP = (Liabilities - Cash - TreasurySecurities - AccountsReceivable) / Assets$. We refer to this measure as a firm's net nominal position. Results are provided in the Appendix.

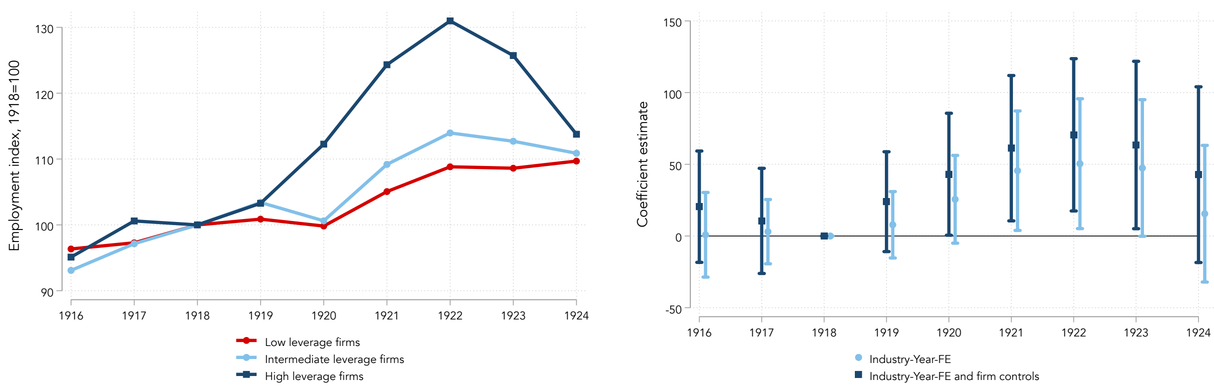
[34]We prefer the average for two reasons. First, as seen in Figure 2 inflation starts to pick up towards the later months of 1919, implying that the treatment date is slightly different than the available as-of dates of the firm balance sheet data. Most balance sheet data are available for December 31 of a given year and 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 A.3.4 in the Appendix shows that results are robust to using either leverage in as reported in 1918 or in 1919 as opposed to their average.

Electronic copy available at: https://ssrn.com/abstract=4303537

ratio.[35] Panel (a) of Figure 9 shows that most firms see strong employment growth from 1918 through 1924, irrespective of their initial leverage. The strongest employment growth occurs in 1921 and 1922. This is in line with evidence from section 4 that shows that the inflation led to overall more economic activity. Further, the strongest employment gains during the inflation occur for high leverage firms, followed by intermediate leverage firms. Employment at firms in the highest tercile of the leverage distribution grows by approximately 30% from 1918 through 1922. In contrast, firms in the lowest tercile only experience a 5% increase in employment. Thus, while overall employment grew, there is substantial heterogeneity across the distribution of firm leverage. This finding indicates that firms with more nominal liabilities benefited from the inflation, possibly becoming less financially constrained and thereby being able to hire more employees.

Figure 9: *Employment Dynamics across Low and High Leverage Firms.*

(a) *Evolution of employment by tercile of liabilities to assets.* **(b)** *Results from estimating equation* (3).



Notes: Panel (a) presents the average evolution 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 the following model:

$$\ln(Employment_{it}) = \alpha_i + \gamma_{st} + \sum_{k\neq 1918} \beta_k Leverage_{i,1918-1919} \mathbf{1}_{k=t} + \sum_{k\neq 1918} X_i \Gamma_k \mathbf{1}_{k=t} + \epsilon_{it},$$

where α_i is a set of firm fixed effect, γ_{st} a set of industry-year fixed effects, where $Leverage_{i,1918-1919}$ is firm i's liabilities-to-assets ratio averaged over 1918 and 1919, and X_i is our set of firm-level control variables. Errors bars represent 95% confidence intervals.

Panel (b) of Figure 9 examines the evolution of employment by firm leverage more formally

[35]As additional robustness, Figure A.3.13 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 A.3.14 plots binned scatterplots of employment growth from 1918 onwards against initial firm leverage.

Electronic copy available at: https://ssrn.com/abstract=4303537

through the lens of a standard dynamic difference-in-differences model that allows us to control for observable characteristics. We present the sequence of estimates of $\{\beta_k\}$ from estimating:

$$\ln(Employment_{it}) = \alpha_i + \delta_{st} + \sum_{k \neq 1918} \beta_k Leverage_{i,1918-1919} \mathbf{1}_{k=t} + \sum_{k \neq 1918} X_i \Gamma_k \mathbf{1}_{k=t} + \epsilon_{it} \qquad (3)$$

where $\ln(Employment_{it})$ is firm i's number of employees (in logs, multiplied by 100) in year t and $Leverage_{i,1918-1919}$ is firm i's liabilities-to-assets ratio averaged over 1918 and 1919.[36] Further, α_i is a firm fixed effect, δ_{st} is an industry-time fixed effect, and X_{it} is a set of firm-level control variables such as size, fixed assets-to-total assets, return on assets, and profit margin.[37] All controls are constructed from averaging across 1918 and 1919 and are interacted with year fixed effects.

The identifying assumption behind our empirical strategy is that the increase in inflation starting in 1919 was largely unexpected and firms in the same industry with higher leverage were not differentially affected by other shocks. That is, in the absence of differential nominal balance sheet exposure to the inflation, firms with high and low leverage would have evolved in parallel during the inflation. This identifying assumption would be violated if, for example, highly levered firms were also exposed to positive demand shocks or faced better investment opportunities.

The cross-section provides a stronger test than the aggregate time series discussed in section 4, 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 controls for industry-level differences in exposure to the exchange rate channel. Further, union-bargained wage setting was quite common but industry-specific. Industry-year fixed effects absorb such effects from industry-specific stickiness of wages or prices. We also control for firm size, fixed assets-to-total assets, the turn on assets, and profit margins (EBIT over revenue), all as of 1918-19. Controlling for size allows us to account for the fact that large and politically connected firms disproportionately benefited from being able to borrow directly from

[36] In the Appendix we provide evidence that the findings are similar when using the ratio of financial debt to assets, see Figure A.3.19.

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

Electronic copy available at: https://ssrn.com/abstract=4303537

the Reichsbank (Feldman, 1993).[38]

Results from estimating (3) are displayed in panel (b) of Figure 9. Firms with higher leverage see stronger employment growth in 1919-1922 relative to firms with lower leverage. The estimates are robust to including industry-year fixed effects and a set of firm-level controls. In line with the evidence of panel (a), panel (b) of Figure 9 reveals that employment at high leverage firms remains elevated through 1923, before a slight reversal in 1924. The timing of the reversal is consistent with narrative accounts of "rationalization" in the aftermath of the inflation, following the period of high growth and investment during the inflation (Garber, 1982). Altogether, we interpret the patterns from panel (b) of Figure 9 as a robust 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)
Liabilties/Assets$_{i,1918-1919}$ $\times \mathbf{1}_{t\geq 1920}$	44.8***	37.0**	43.5**			
	(15.8)	(16.7)	(19.3)			
Debt/Assets$_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$				42.5***	38.8**	38.9**
				(16.2)	(16.7)	(19.6)
Observations	1920	1872	1734	1920	1872	1734
Number of Firms	358	352	323	358	352	323
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:

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

where y_{it} is firm i's number of employees (in logs). $Leverage_{i,1918-1919}$ is either the ratio of firm i's financial debt or total liabilities to total assets. α_i is a set of firm fixed effects, and δ_{st} is a set of industry-time fixed effects. Further, 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 (EBIT-to-revenue). *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Is the relative increase in employment for highly levered firms economically meaningful?

[38] Table A.3.3 reports the correlates of firm leverage in 1919. Firms with higher leverage are larger but have a lower share of fixed assets in total assets. After controlling for these variables, EBIT margin and return on assets are uncorrelated with leverage.

Electronic copy available at: https://ssrn.com/abstract=4303537

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

$$\ln(Employment_{it}) = \alpha_i + \delta_{st} + \beta(Leverage_{i,1918-1919}\mathbf{1}_{t\geq 1920}) + X_i\Gamma + \epsilon_{it}, \tag{4}$$

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. Moreover, the magnitude of the effects are economically meaningful. Increasing a firm's ratio of debt-to-assets by 10 percentage points implies 3.5-4.5% higher average level in employment between 1920 and 1923 compared to the average level from 1916 through 1919. 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.

Robustness to 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, and some firms took advantage of this to take on additional debt.[39] However, credit supply contracted in 1922 with increased expectations of depreciation.[40] Moreover, credit and mortgage banks experienced large losses from making loans and from having to hold significant amounts of paper money for customer withdrawals.[41]

The bias introduced by the credit supply channel in the estimation of (3) could be either

[39] The report of the General Association of German Banks and Bankers for 1923 commented: "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." Banks, in response, were slow to raise interest rates (Bresciani-Turroni, 1937).

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

[41] For example, Bresciani-Turroni (1937) notes that banks ended up making major losses because the "phenomenon of monetary depreciation had not yet been properly understood by the majority of bank directors," as banks were too slow to demand higher interest rates (p. 281). Banks were, in turn, aided by the Reichsbank through a low discount rate, which transferred losses from banks to all holders of currency. 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."

Electronic copy available at: https://ssrn.com/abstract=4303537

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, in Table A.3.5 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 1920.[42] With this, we control for bank-time fixed effects, distinguishing between seven major banks and other banks. This essentially compares two firms with different leverage but connected to the same bank, thereby holding fixed bank-specific changes in credit supply. Second, we control for the distance to Berlin, as firms located closer to Berlin may have had better access to Reichsbank credit during the inflation. The estimated effect of leverage on employment is quantitatively similar with these controls.

5.2 Evidence Supporting the Debt-Inflation Channel

We next provide evidence that allows for a better understanding of the mechanisms through which the inflation affected firms through the debt-inflation channel. First, we ask, do firms with higher leverage benefit from a higher valuation in the stock market? Second, do firms with higher initial leverage see a larger decline in leverage and a larger increase in real book equity? Third, do more levered firms pay less for interest expenses and have more resources available to spend on salaries and materials? And, fourth, are the effects stronger for firms with a higher proportion of long-term debt?

Market equity returns. Do more levered firms see an increase in the market value of their equity? Studying market values 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.[43] This allows us to understand if and when investors in more levered firms benefit from unexpected inflation.

[42]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").

[43]Of course, equity investors subject to "money illusion" may also misperceive the impact of inflation on firm value, as argued by Modigliani and Cohn (1979).

Electronic copy available at: https://ssrn.com/abstract=4303537

Table 3 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 from 1919 to 1923. We then compute the equal-weighted average log total return for each portfolio, as well as the difference between 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 when using the ratio of financial debt to assets.

Table 3: *Stock Returns across Portfolios Sorted by Leverage.*

Panel A: Sorting by Liabilities-to-Assets.

Quintile of $\text{Liabilities/Assets}_{i,t-1}$	$\text{Liabilities/Assets}_{i,t-1}$ Mean	S.E.	$Return_t$ Mean	S.E.
1	0.29	(0.01)	-36.63	(3.93)
2	0.48	(0.00)	-34.47	(3.87)
3	0.58	(0.01)	-30.98	(3.83)
4	0.67	(0.01)	-30.44	(3.62)
5	0.79	(0.01)	-23.81	(3.89)
High-Low	0.51	(0.01)	12.82	(4.65)

Panel B: Sorting by Debt-to-Assets.

Quintile of $\text{Debt/Assets}_{i,t-1}$	$\text{Debt/Assets}_{i,t-1}$ Mean	S.E.	$Return_t$ Mean	S.E.
1	0.34	(0.01)	-36.06	(3.95)
2	0.49	(0.01)	-35.93	(3.80)
3	0.57	(0.01)	-31.99	(3.67)
4	0.65	(0.01)	-25.60	(3.85)
5	0.77	(0.01)	-26.45	(3.83)
High-Low	0.44	(0.01)	9.62	(4.61)

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

Table 3 reveals two notable patterns. First, returns are on average negative during the inflation, consistent with Figure A.3.18 in the Appendix, which shows that the real value of stocks of non-financial firms generally fell during the inflation. 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 the panel A and panel B, respectively).

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure 10 plots the cumulative return on the high-minus-low leverage portfolio over time. The portfolio has significantly positive returns in 1919, 1922, and 1923. The returns are especially high during 1922-23, when annual inflation surpassed 1000%. The relatively poor performance in 1921 is puzzling given the high inflation (141%) in that year. 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). Bresciani-Turroni (1937) argues that high inflation led to wild swings in the stock market during the inflation, in part due to increased speculation. Some investors, for example, reportedly mistook large nominal capital gains for large real capital gains. Consistent with this, Braggion et al. (2022) provide empirical evidence that stock market investors exhibited money illusion during Germany's hyperinflation.

Table 4 explores the robustness of the relation between leverage and subsequent returns using linear regressions of the form:

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

We include time fixed effects in all specifications to compare firms within-year.[44] 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.

A concern is that leverage may be capturing other characteristics that may correlate with better performance during the German inflation. Columns 2 and 5 in Table 4 include industry-year fixed effects, and columns 3 and 6 include lagged firm-level controls. The estimate on $Leverage_{it-1}$ is essentially unchanged with these controls.

Non-financial 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 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 A.3.18 in the Appendix compares the returns on nonfinancial firms and banks during the inflation. While inflation was

[44] 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.

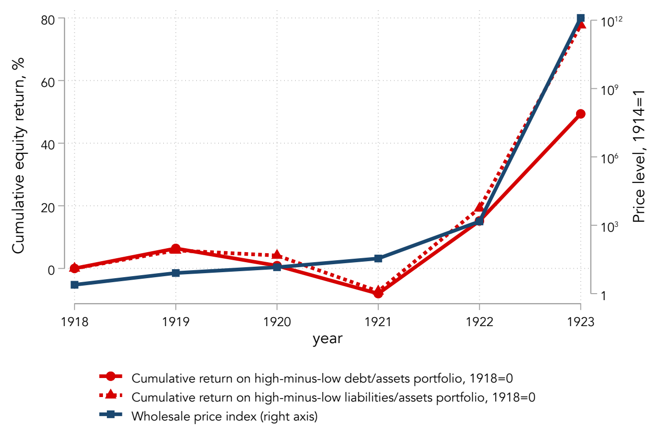
Electronic copy available at: https://ssrn.com/abstract=4303537

Table 4: *Leverage and Stock Returns: Linear Regressions, 1919-1923.*

	(1)	(2)	(3)	(4)	(5)	(6)
Liabilities/Assets$_{i,t-1}$	19.0***	16.7***	19.7***			
	(5.47)	(5.89)	(6.50)			
Debt/Assets$_{i,t-1}$				16.1***	14.5***	16.5***
				(5.10)	(5.25)	(5.48)
Observations	2739	2735	2735	2740	2736	2736
R^2	0.71	0.76	0.76	0.71	0.76	0.76
Year Fixed Effects	✓			✓		
Industry-Year FE		✓	✓		✓	✓
Firm Controls			✓			✓

Notes: Firm controls are log total assets and fixed assets to total assets in $t-1$. Robust standard errors in parentheses. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Figure 10: *High Leverage Firms' Stock Returns Outperformed Low Leverage Firms during the Hyperinflation.*



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. Returns for year t are based on portfolios that are resorted at the end of year $t-1$ based on leverage reported in year $t-1$.

associated with negative real returns on both indexes, we find that non-financial firms performed better than banks. Altogether, our findings suggest that the inflation redistributed from those that held debt of non-financial firms (such as banks) to equity holders, with equity investors in leveraged firms benefiting relatively more.

Book equity. We next examine the impact of inflation on book equity for firms with high and low leverage. As discussed in section 3, balance sheet outcomes during the hyperinflation (especially

Electronic copy available at: https://ssrn.com/abstract=4303537

1923) are subject to large and systematic measurement error. We therefore focus on the evolution of balance sheet outcomes at the start of the postwar inflation in 1919 to the aftermath of the inflation in 1924, when firms were required to construct new Goldmark balance sheets by estimating the market values of their assets and liabilities in Goldmarks. Table 5 presents estimates of the following long-difference firm-level regression for various balance sheet outcomes

$$\Delta_{19-24} Y_i = \alpha + \beta Leverage_{i,1919} + X_i \Gamma + \epsilon_i. \tag{5}$$

Table 5: *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)
Liabilities/Assets$_{i,1918-1919}$	0.58***	0.71***		
	(0.047)	(0.066)		
Debt/Assets$_{i,1918-1919}$			0.55***	0.65***
			(0.044)	(0.056)
Observations	656	656	656	656
R^2	0.252	0.308	0.234	0.282
Panel B: Dependent var.= $\Delta_{19-24}\ln(Equity)$				
	(1)	(2)	(3)	(4)
Liabilities/Assets$_{i,1918-1919}$	96.1***	162.3***		
	(27.5)	(37.7)		
Debt/Assets$_{i,1918-1919}$			78.7***	127.5***
			(28.4)	(35.4)
Observations	650	650	650	650
R^2	0.014	0.084	0.010	0.075
Industry FE		✓		✓
Firm Controls		✓		✓

Notes: Robust standard errors in parentheses. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Panel A documents that firms with higher leverage in 1919 saw 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 58 percentage points. Columns 2 and 4 show that the relation is robust to controlling for firm size, fixed assets to total assets,, and detailed

Electronic copy available at: https://ssrn.com/abstract=4303537

industry fixed effects for 30 industries. Panel B of Table 5 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 also suggest that the inflation led to redistribution from debt to equity holders of levered firms.

Interest, salary and material expenses. Next, we study the dynamics of interest expenses as well as material and salary expenses at the firm level. We test whether more levered firms pay less in interest and more for their wage bills and other working capital. Recall from Figure 6b that the average share of interest expenses in total expenses falls during the inflation. We now ask whether this fall is more pronounced for high leverage firms, thereby providing explicit evidence supporting the view that the debt-inflation channel can affect firm outcomes above and beyond the New Keynesian nominal rigidity channels.

Similar to our analysis of firm-level employment, we estimate equation (3) using either the share of interest expenses or the sum of salaries and material expenses as a share of total expenses as the dependent variable. Figure 11 shows the results. Firms with a relatively higher share of nominal liabilities relative to total assets at the onset of the inflation dedicate fewer resources to servicing their debt claims, and the effect was persistent throughout the hyperinflation. Note that a similar pattern arises when using the financial debt-to-assets ratio, see Figure A.3.19 in the Appendix. Relatively more levered firms were thus able to spend more of their revenue for other types of expenses.

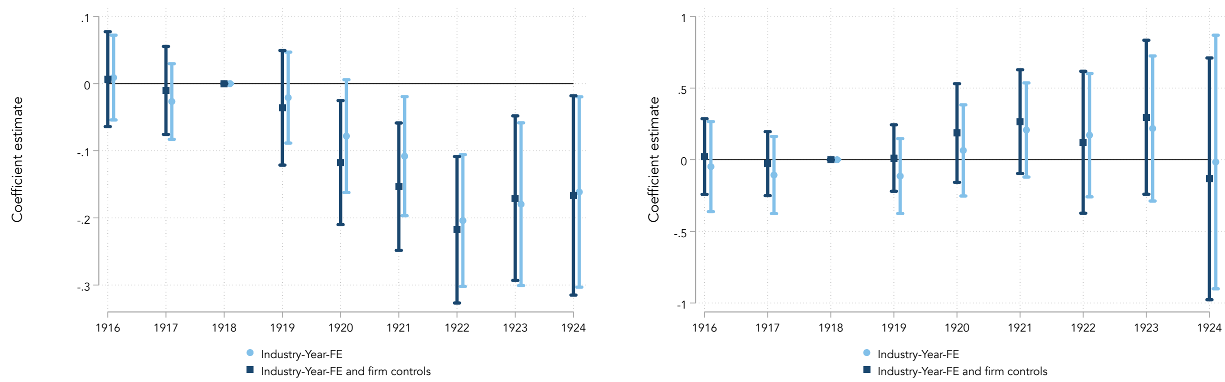
Indeed, we find that more highly levered firms start spending relatively more of their total expenses on materials and salaries, in line with higher economic activity at more levered firms during the inflation. This effects is somewhat less precisely estimated, which may be due to the fact that fewer firms break out material and salary expenses than interest expenses in their income statement.

We also estimate a model similar to equation (4) using interest expenses and salaries and material expenses as the outcome variable. Table 6 shows the results. Our findings confirm the patterns in Figure 11 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

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure 11: *Firm Leverage, Interest Expenses, and Material Expenses and Salaries.*

(a) *Interest Expenses.* **(b)** *Materials and Salaries.*



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

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

where y_{it} is either the ratio of interest expenses to total expenses (panel (a)) or the ratio of materials and salary expenses to total expenses (panel (b)). α_i is a set of firm fixed effects, γ_{st} a set of industry-year fixed effects, $Liabilities/Assets_{i,1918-1919}$ is firm i's liabilities-to-assets ratio averaged over 1918-1919 and X_i is our set of firm-level control variables. Error bars represent 95% confidence intervals.

higher initial debt-to-assets ratio is associated with 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 debt-to-assets ratio spends around 2 percentage points more of its total expenses on salaries and materials. Altogether, these findings are in line with highly levered firms benefiting relatively more from the inflation by decreasing the amount of resources that need to be spend on interest payments. Thus, inflation relaxes a firm's working capital constraint, allowing it to hire more employees and spend more funds on salaries and materials.

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. As a final exercise, we study whether, within firms that are more levered, firms with more long-term debt benefit relatively more.

Non-financial German firms relied extensively on fixed-rate long-term bond finance. We collect the loan terms on all bonds issued by firms in our sample as of 1918 and 1919, detailed in Table 7. Bonds were always fixed rate with rates being almost exclusively between 400 and 500 basis points. After origination, the loan terms typically specified an interest-only period during which

Electronic copy available at: https://ssrn.com/abstract=4303537

Table 6: *Firm Leverage, Interest Expenses, and Material Expenses and Salaries.*

Dependent Variable	Interest Expenses/Tot. Expenses				Salaries and Materials/Tot. Expenses			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liabilties/Assets$_{i,1918-1919}$ $\times \mathbf{1}_{t\geq 1920}$	-0.13***	-0.11**			0.21	0.22		
	(0.038)	(0.044)			(0.13)	(0.14)		
Debt/Assets$_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$			-0.17***	-0.14***			0.18	0.21
			(0.037)	(0.041)			(0.13)	(0.13)
Observations	3714	3714	3720	3720	1008	1008	1011	1011
Number of Firms	551	551	553	553	144	144	145	145
R^2	0.69	0.70	0.69	0.70	0.71	0.71	0.70	0.71
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓
Industry-Year-FE	✓	✓	✓	✓	✓	✓	✓	✓
Controls $\times$ $\mathbf{1}_{t\geq 1920}$		✓		✓		✓		✓

Notes: This table reports results from estimating:

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

where y_{it} is either firm i's share of interest expenses of total expenses, or the share of salaries and materials of total expenses. $Leverage_{i,1918-1919}$ is either ratio of firm i's ratio of financial debt or total liabilities to total assets averaged over 1918-1919, α_i is a set of firm fixed effects, δ_{st} is a set of industry-time fixed effects, and $\mathbf{1}_{t\geq 1920}$ is a indicator variable for observations from 1920 onward. Further, 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. The estimation period is from 1916 through 1923.

*,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

no amortization took place and which on average lasted around 5 years. 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 final maturity year was 1940. Figure A.3.20 in the Appendix also shows that most bonds were originated before WW1 and a final maturity date after 1950 was not uncommon.

To test whether the effects are 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 a triple-difference

Electronic copy available at: https://ssrn.com/abstract=4303537

Table 7: *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	4.25	4.5	4.5	5
Volume (in thousand RM)	4059	500	1000	2442	5500	11483
Panel B: Origination and maturity						
Origination year	1906	1894	1901	1906	1911	1919
Repayment start year	1911	1897	1906	1911	1917	1923.5
Repayment end year	1940	1924	1933	1940	1944.5	1955

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

specification of the following form

$$y_{it} = \alpha_i + \delta_{st} + \sum_{s \neq 1} \beta_{1,s} \mathbf{1}\left[LTD/Debt_{i,1918-1919} \in Q_s\right] \times Debt/Assets_{i,1918-1919} \times \mathbf{1}_{t \geq 1920}$$
$$+ \beta_2 \times Debt/Assets_{i,1918-1919} \times \mathbf{1}_{t \geq 1920} + \Gamma \times \left(X_i \times \mathbf{1}_{t \geq 1920}\right) + \epsilon_{it},$$

where $\mathbf{1}\left[LTD/Debt_{i,1918-1919} \in Q_s\right]$ is an indicator for each quartile s of the distribution of long-term debt to total debt.

The results are presented in Table 8. We find that indeed only those firms that have relatively a higher share of long-term debt in total debt experience a substantial reduction in the share of interest payments of total expenses. While the effect is close to zero for the lowest quartile of the long-term debt, we find that if the debt-to-assets ratio increases by 0.1, firms in the second and third quartile see a reduction of interest payments of around 2%, but a 3.5% reduction if a firm's long-term debt to debt ratio is in the fourth quartile.

Finally, 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. These findings provide additional evidence that there is a direct link between the inflation reducing firms' financial constraints and thus allowing firms to expand their economic

Electronic copy available at: https://ssrn.com/abstract=4303537

Table 8: *Firm Leverage, Long-term Debt, Interest Expenses, and Employment.*

Dependent Variable	Int. Expenses/Tot. Expenses			ln(Employment)		
	(1)	(2)	(3)	(4)	(5)	(6)
Debt/Assets$_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$	0.019	0.019	0.012	16.0	16.0	11.4
	(0.049)	(0.049)	(0.055)	(26.4)	(26.4)	(30.6)
Q_2 × Debt/Assets$_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$	-0.096	-0.10	-0.084	21.3	19.9	12.2
	(0.079)	(0.078)	(0.078)	(51.4)	(51.8)	(50.0)
Q_3 × Debt/Assets$_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$	-0.19**	-0.19**	-0.13	25.5	25.5	26.1
	(0.083)	(0.083)	(0.083)	(32.8)	(32.8)	(35.3)
Q_4 × Debt/Assets$_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$	-0.32***	-0.33***	-0.31***	64.9*	64.9*	70.4*
	(0.090)	(0.088)	(0.089)	(33.9)	(33.9)	(40.6)
Observations	3482	3480	3482	1938	1937	1937
Number of Firms	547	547	547	360	360	360
R^2	0.67	0.67	0.72	0.97	0.97	0.97
Year FE	✓			✓		
Firm FE	✓	✓	✓	✓	✓	✓
Industry-Year-FE	✓	✓	✓	✓	✓	✓
Controls × $\mathbf{1}_{t\geq 1920}$			✓			✓

Notes: This table reports results from estimating:

$$y_{it} = \alpha_i + \delta_{st} + \sum_{s\neq 1} \beta_{1,s}\mathbf{1}\left[LTD/Debt_{i,1918-1919} \in Q_s\right] \times Debt/Assets_{i,1918-1919} \times \mathbf{1}_{t\geq 1920}$$
$$+ \beta_2 \times Debt/Assets_{i,1918-1919} \times \mathbf{1}_{t\geq 1920} + \Gamma \times (X_i \times \mathbf{1}_{t\geq 1920}) + \epsilon_{it},$$

where y_{it} is either firm i's share of interest expenses of total expenses, or a firm's numbers of employees. We interact the ratio of debt total debt with the ratio of long-term debt to total debt (using dummies indicating each quartile). Further, α_i is a set of firm fixed effects, and δ_{st} is a set of industry-time fixed effects. Further, 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. Data from 1916 through 1923.

*,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

activity and hire more employees.

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 striking 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 salary and material spending. These results are consistent

Electronic copy available at: https://ssrn.com/abstract=4303537

with the view that the inflation affected real activity through a debt-inflation channel. 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. Overall, our results suggest that the real economic effects of the inflation were more likely to operate through a financial channel than the traditional New Keynesian nominal rigidity channel.

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).[45] 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 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. Further, we focus on firm debt due to data availability, but the debt-inflation channel through household debt can also be quantitatively important (Doepke and Schneider, 2006). Finally, an important caveat is that we have not quantified 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.

[45]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 foreward 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."

Electronic copy available at: https://ssrn.com/abstract=4303537

References

Agarwal, I. and M. Baron (2022). Inflation and disintermediation. *Available at SSRN 3399553*.

Alvarez, F., M. Beraja, M. Gonzalez-Rozada, and P. A. Neumeyer (2018). From Hyperinflation to Stable Prices: Argentina's Evidence on Menu Cost Models*. *The Quarterly Journal of Economics 134*(1), 451–505.

Ball, L. and S. Mazumder (2019). A phillips curve with anchored expectations and short-term unemployment. *Journal of Money, Credit and Banking 51*(1), 111–137.

Barro, R. J. and J. F. Ursúa (2008). Macroeconomic crises since 1870. Technical report, National Bureau of Economic Research.

Braggion, F., F. von Meyerinck, and N. Schaub (2022). Inflation and individual investors' behavior: Evidence from the german hyperinflation. *University of St. Gallen, School of Finance Research Paper* (2021/07).

Bresciani-Turroni, C. (1937). *The Economics of Inflation: A Study of Currency Depreciation in Post-War Germany*. Northampton: Augustus M. Kelley.

Cagan, P. (1956). The monetary dynamics of hyperinflation. *Studies in the Quantity Theory if Money*.

Cagan, P. (1991). Expectations in the german hyperinflation reconsidered. *Journal of International Money and Finance 10*(4), 552–560.

Cordoba, J. C. and M. Ripoll (2004, 12). Collateral Constraints in a Monetary Economy. *Journal of the European Economic Association 2*(6), 1172–1205.

Correia, S. and S. Luck (2022). Digitizing historical balance sheet data: A practitioner's guide.

Doepke, M. and M. Schneider (2006). Inflation and the redistribution of nominal wealth. *Journal of Political Economy 114*(6), 1069–1097.

Doerr, S., S. Gissler, J. L. Peydró, and H.-J. Voth (2018). From Finance to Extremism: The Real Effects of Germany's 1931 Banking Crisis. Cepr discussion papers, C.E.P.R. Discussion Papers.

Dornbusch, R. (1985). Stopping hyperinflation: Lessons from the german inflation experience of the 1920s. Working Paper 1675, National Bureau of Economic Research.

Dornbusch, R. and S. Fischer (1986). Stopping hyperinflations past and present. Working Paper 1810, National Bureau of Economic Research.

Drechsler, I., A. Savov, and P. Schnabl (2022). Credit crunches and the great stagflation.

Einzig, P. (1937). Theory of forward exchange.

Feldman, G. D. (1993). *The Great Disorder: Politics, Economics, and Society in the German Inflation, 1914-1924*. Oxford University Press.

Ferguson, N. (1995). Keynes and the german inflation. *English Historical Review*, 368–391.

Fisher, I. (1933). The debt-deflation theory of great depressions. *Econometrica: Journal of the Econometric Society*, 337–357.

Electronic copy available at: https://ssrn.com/abstract=4303537

French, K. R., R. S. Ruback, and G. W. Schwert (1983). Effects of nominal contracting on stock returns. *Journal of Political Economy 91*(1), 70–96.

Frenkel, J. A. (1977). The forward exchange rate, expectations, and the demand for money: The german hyperinflation. *The American Economic Review 67*(4), 653–670.

Galí, J. (2015). *Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications*. Princeton University Press.

Garber, P. M. (1982). Transition from inflation to price stability. *Carnegie-Rochester Conference Series on Public Policy 16*(1), 11–42.

Gertler, M. and S. Gilchrist (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *The Quarterly Journal of Economics 109*(2), 309–340.

Golosov, M. and R. E. Lucas (2007). Menu costs and phillips curves. *Journal of Political Economy 115*(2), 171–199.

Gomes, J., U. Jermann, and L. Schmid (2016). Sticky leverage. *American Economic Review 106*(12), 3800–3828.

Graham, F. D. (1931). *Exchange, Prices and Production in Hyper-Inflation: Germany, 1920-23*. Princeton: University Press.

Hazell, J., J. Herreno, E. Nakamura, and J. Steinsson (2021). The slope of the phillips curve: Evidence from u.s. states. *working paper*.

Hoffmann, S. and S. P. Walker (2020). Adapting to crisis: Accounting information systems during the weimar hyperinflation. *Business History Review 94*(3), 593–625.

Holtfrerich, C.-L. (1986). *The german inflation 1914–1923*. Walter de Gruyter.

Jermann, U. and V. Quadrini (2012). Macroeconomic effects of financial shocks. *American Economic Review 102*(1), 238–71.

Jordà, Ò., M. Schularick, and A. M. Taylor (2017). Macrofinancial history and the new business cycle facts. *NBER macroeconomics annual 31*(1), 213–263.

Keynes, J. M. (1923). *A tract on monetary reform*. Cosimo Classics.

Kindleberger, C. P. (1985). *A financial history of Western Europe*. Routledge.

Kiyotaki, N. and J. Moore (1997). Credit cycles. *Journal of Political Economy 105*(2), 211–248.

Lian, C. and Y. Ma (2021). Anatomy of corporate borrowing constraints. *The Quarterly Journal of Economics 136*(1), 229–291.

McLeay, M. and S. Tenreyro (2020). Optimal inflation and the identification of the phillips curve. *NBER Macroeconomics Annual 34*(1), 199–255.

Modigliani, F. and R. A. Cohn (1979). Inflation, rational valuation and the market. *Financial Analysts Journal 35*(2), 24–44.

Nakamura, E., J. Steinsson, P. Sun, and D. Villar (2018). The elusive costs of inflation: Price dispersion during the us great inflation. *The Quarterly Journal of Economics 133*(4), 1933–1980.

Electronic copy available at: https://ssrn.com/abstract=4303537

Pazos, F. (1972). Chronic inflation in latin america.

Ritter, J. R. and R. S. Warr (2002). The decline of inflation and the bull market of 1982–1999. *Journal of financial and quantitative analysis 37*(1), 29–61.

Sargent, T. J. (1982). The Ends of Four Big Inflations. In *Inflation: Causes and Effects*, NBER Chapters, pp. 41–98. National Bureau of Economic Research, Inc.

Schacht, H. (1927). *Stabilization of the Mark*. George Allen and Unwin Limited, London.

Simonsen, M. H. (1983). Indexation: Current Theory and the Brazilian Experience. In *Inflation, Debt, and Indexation*. MIT Press.

Sommerfeld, H. (1924).

Summers, L. H. (1981). Inflation and the valuation of corporate equities. Technical report, National Bureau of Economic Research.

Sweeney, H. W. (1934). How inflation affects balance sheets. *Accounting Review*, 275–299.

Electronic copy available at: https://ssrn.com/abstract=4303537

APPENDIX [FOR ONLINE PUBLICATION ONLY]

- Appendix A.1: Historical Background
- Appendix A 2: Model of the Financial Channel of Inflation
- Appendix A.3: Supplementary Figures and Tables

Electronic copy available at: https://ssrn.com/abstract=4303537

A.1 Historical Background

In this section, we provide additional historical context for the German Hyperinflation.

A.1.1 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).

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 Treat 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. The signing of the Treat of Versailles also 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 Mathias Erzberger on August 26, 1921.

On April 16, 1922 Germany and the Soviet Union signed the Treaty of Rapallo, which opened diplomatic relations between the two countries and involved a mutual cancellation of financial claims. The Treaty violated the Treaty of Versailles.

Second phase of the inflation. The summer of 1922 was the turning point in the inflation when high inflation turned into hyperinflation. 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. Moreover, 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

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

Electronic copy available at: https://ssrn.com/abstract=4303537

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.

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.

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 1923, the Reichsbank also discounted commercial bills.

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. In July 1923, government employee wages became explicitly indexed to inflation.

Stabilization. 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.[2] Sargent (1982) argues that fiscal stabilization in the form of both increased taxes and cuts in government spending

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

Electronic copy available at: https://ssrn.com/abstract=4303537

were crucial for success of stabilization. Spending was cut through personnel reduction of 25% over four months and retiring civil servants over age 65. Stresemann and Luther balanced the budget. In contrast, stabilization coincided with strong money growth. In additional to fiscal reform, Dornbusch (1985) emphasizes the importance of exchange rate stabilization, very high interest 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 final 330% devaluation between November 14 and 20, 1923. The success of the stabilization was highly uncertain in the first few months.[3]

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 much 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.1.2 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 1922, avoiding "Depression" of 1920-21 in the US, UK, and France (see Figure 4).[4] From final months of 1922, inflation associated with contraction, and 1923 saw a large decline in production. 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. Credit conditions became tight during the hyperinflation phase, when it became very difficult to obtain credit and external financing almost disappeared (Graham, 1931; Dornbusch and Fischer, 1986). For example, in July 1922, *The Economist* noted a shortage of credit amidst high credit demand.

The impact of the stabilization has 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.[5] Graham (1931) argues these redistributive effects were expansionary, but also notes that it caused over-investment and misallocation of resources to less productive 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).

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

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

[5] 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.

Electronic copy available at: https://ssrn.com/abstract=4303537

There were also distributional effects through wages and prices. Real wages declined, especially for the middle class and up through 1920 (see Figure A.3.12). 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). Some of the concerns built up during the inflation collapsed during the stabilization.

Electronic copy available at: https://ssrn.com/abstract=4303537

A.2 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.[6] Firms with negative value default. The cutoff value for Z^* for default is defined by:

$$Z^* = K_0 - \frac{D_0}{P} + V(Z^*). \tag{A.1}$$

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,

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

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.

[6] 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.

Electronic copy available at: https://ssrn.com/abstract=4303537

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

$$D_i - D_0 - Z_i = WL_i + P(K_i - K_0) \tag{A.2}$$

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:

$$D_i \leq \xi PAK_i^{\alpha} L_i^{1-\alpha}. \tag{A.3}$$

Combining (A.2) and (A.3) yields the following constraint:

$$D_0 + Z_i + WL_i + P(K_i - K_0) \leq \xi PAK_i^{\alpha} L_i^{1-\alpha} \tag{A.4}$$

The firm's problem is

$$P \cdot V = \max_{K_i, L_i} PAK_i^{\alpha} L_i^{1-\alpha} - WL_i - PK_i \quad \text{s.t. (A.4)}.$$

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 (A.4).

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

$$\frac{K_i}{L_i} = \frac{\alpha}{1-\alpha} \frac{W}{P}. \tag{A.5}$$

When the constraint binds, we can solve for firm i's labor demand by combining (A.4) and (A.5):

$$L_i^d = \frac{K_0 - \frac{D_0}{P} - Z_i}{\frac{1}{1-\alpha}\frac{W}{P} - \xi A \left(\frac{\alpha}{1-\alpha}\frac{W}{P}\right)^{\alpha}}. \tag{A.6}$$

Firm labor demand is an increasing function of its initial resources, $K_0 - \frac{D_0}{P} - Z_i$. Again assuming all firms are constrained, aggregate labor demand is given by

$$L^d = G(Z^*) \frac{K_0 - \frac{D_0}{P} - \frac{\int_{\underline{Z}}^{Z^*} Z dG(Z)}{G(Z^*)}}{\frac{1}{1-\alpha}\frac{W}{P} - \xi A \left(\frac{\alpha}{1-\alpha}\frac{W}{P}\right)^{\alpha}} \tag{A.7}$$

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

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

Electronic copy available at: https://ssrn.com/abstract=4303537

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 (A.6), 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

$$\frac{W}{P} = \frac{\frac{\epsilon}{\epsilon-1}\chi L^{\varphi}}{1-\frac{\epsilon}{\epsilon-1}\chi L^{1+\varphi}}\left(\frac{G(Z^*)D_0}{P}\right). \tag{A.8}$$

Electronic copy available at: https://ssrn.com/abstract=4303537

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.[7]

Flexible wage equilibrium. With flexible wages, the equilibrium in the labor market is given by the solution to (A.7) and (A.8). 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 A.1. 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 (A.7), 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.

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 $W = W_0$:

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

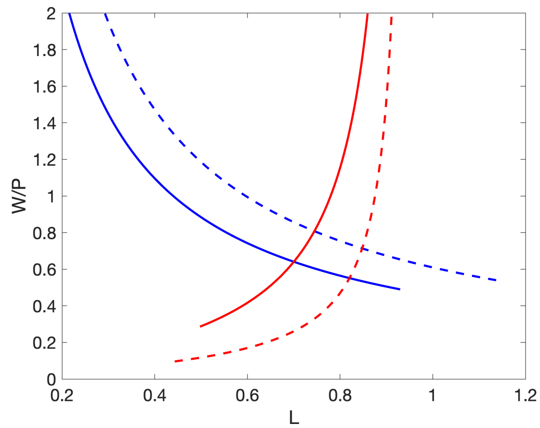
Result 3: Nominal Rigidity Channel of Inflation: Labor market equilibrium in response to shock to P depends on the size of the inflation shock. For a small inflation, the nominal wage is not updated, W/P falls, and employment increases significantly through both the nominal rigidity and debt-inflation 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 A.2 for various levels of the price level P.

[7] 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.

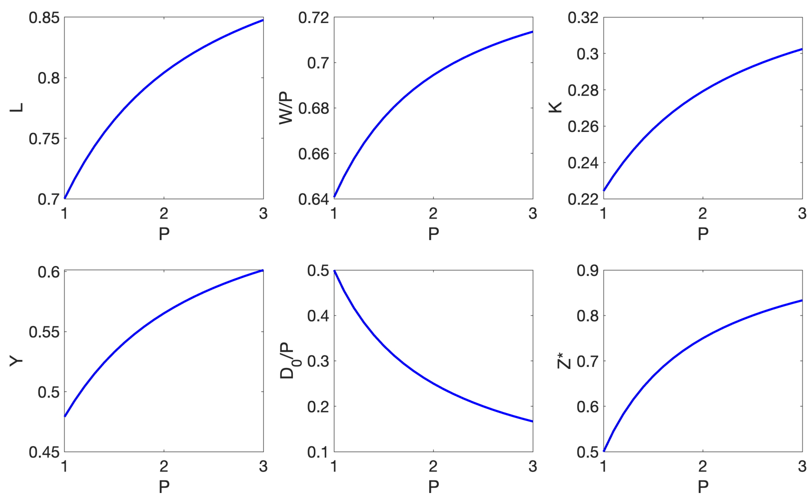
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.1: *Labor Market Equilibrium with Flexible Wages Following an Inflation Shock*

(a) *Labor market equilibrium*



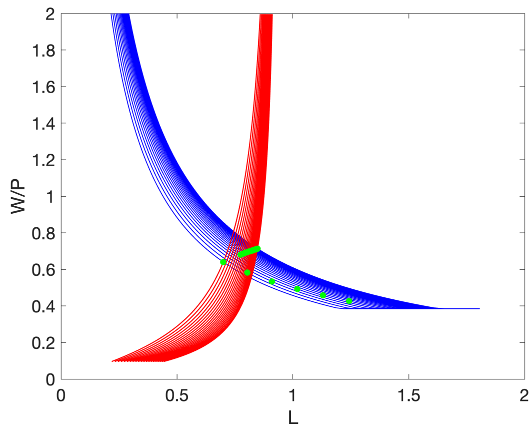
(b) *Outcomes as a function of inflation P*



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.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.2: *Labor Market Equilibria with Nominal Wage Rigidty for Different Levels of P*



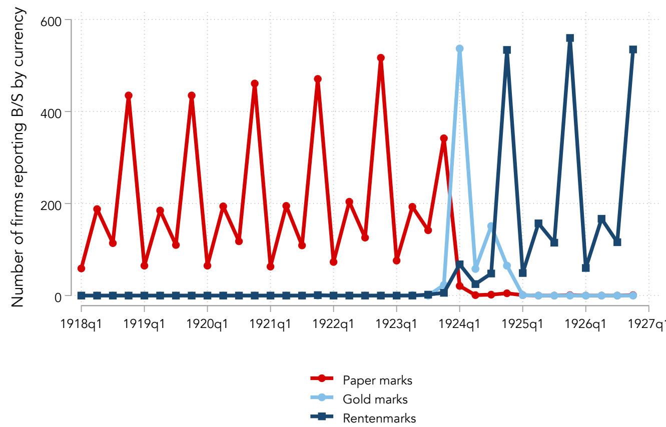
Notes: This figure illustrates labor market equilibrium for increasing values of P in the model with nominal wage rigidity. The downward sloping blue curves are labor demand curves for different levels of P, while the upward sloping red curves are labor supply curves. Green dots indicate the equilibrium,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

Electronic copy available at: https://ssrn.com/abstract=4303537

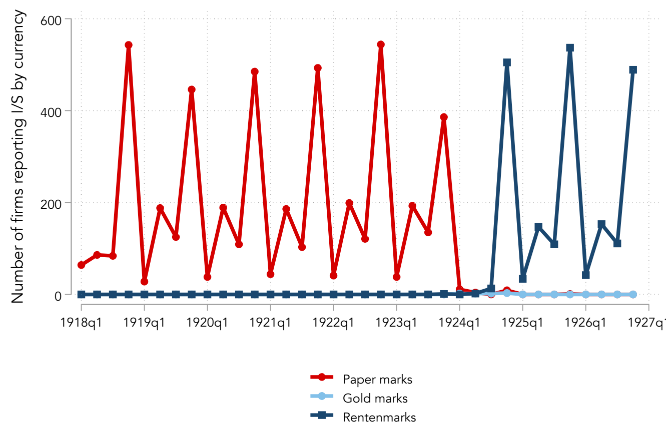
A.3 Supplementary Figures and Tables

Figure A.3.1: *Number of Firms in Reporting in Saling After Sample Restriction.*

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



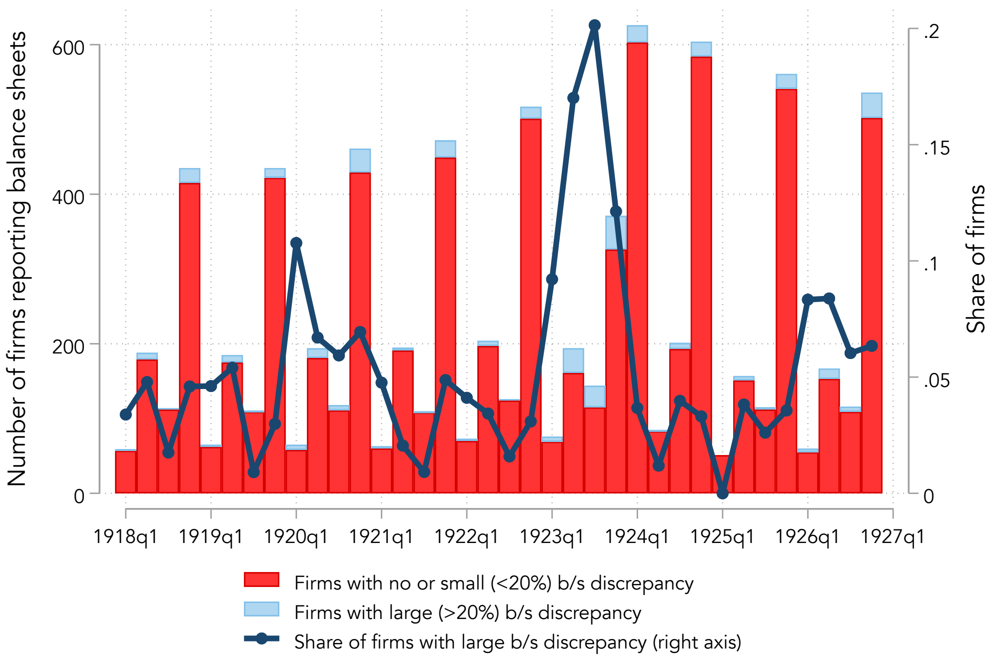
(b) *Number of firms reporting I/S by currency of reporting.*



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 majority of firms report balance sheets at the end of the year (fourth quarter). The spike in balance sheets in 1924Q1 is the new Goldmark balance sheets. Rentenmark balance sheets refers to Rentenmarks or Reichsmarks, which have the same value.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.2: *Saling Firm-Level Balance Sheet Data: Data Quality.*

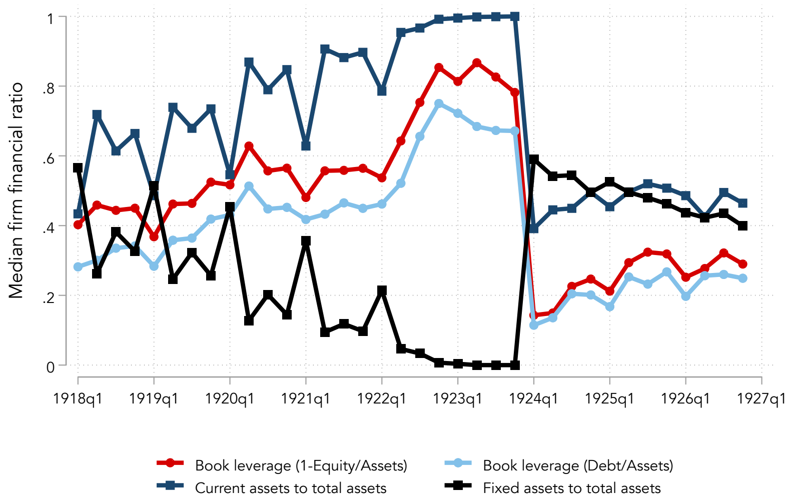


Notes: This figure plots the number and share of firms with no or small balance sheet discrepancies and large balance sheet discrepancies. Balance sheet discrepancies are defined as instances of a larger than 20% pairwise difference between either the sum of assets, the sum of liabilities and equity,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

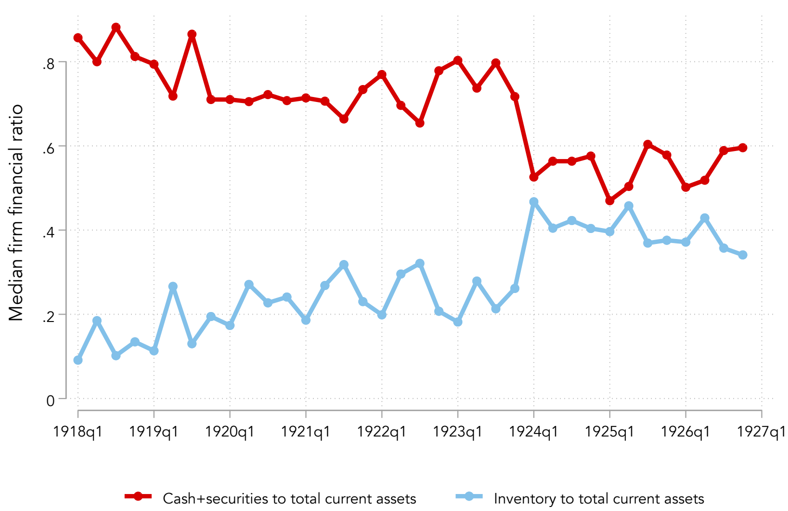
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.3: *Balance Sheet Dynamics in Saling: Ratios.*

(a) *Evolution of median financial ratios.*



(b) *Evolution of working capital ratios.*

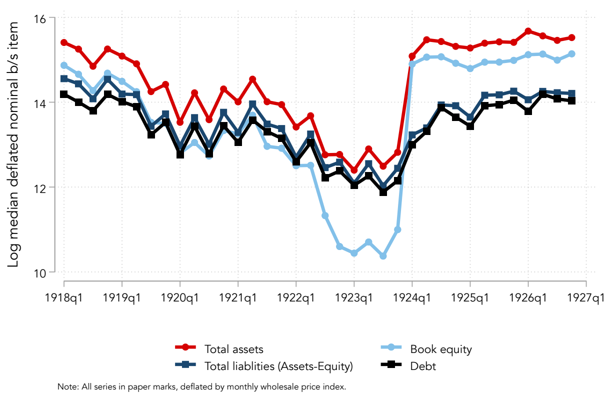


Notes: This figure plots the evolution of the median of key balance sheet ratios in the *Saling's* data over time. The large changes in 1924Q1 occur due to the introduction of revalued Goldmark balance sheets.

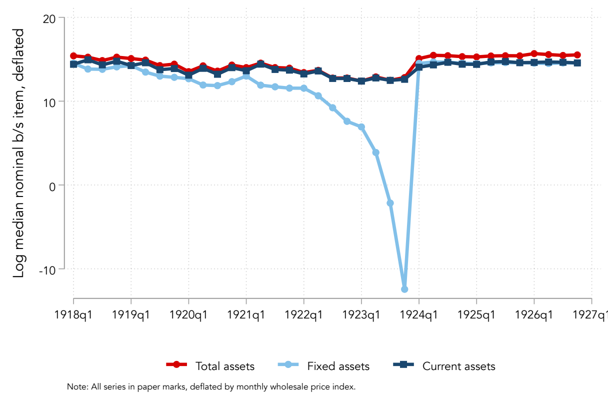
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.4: *Balance Sheet Dynamics in Saling: Deflated Levels.*

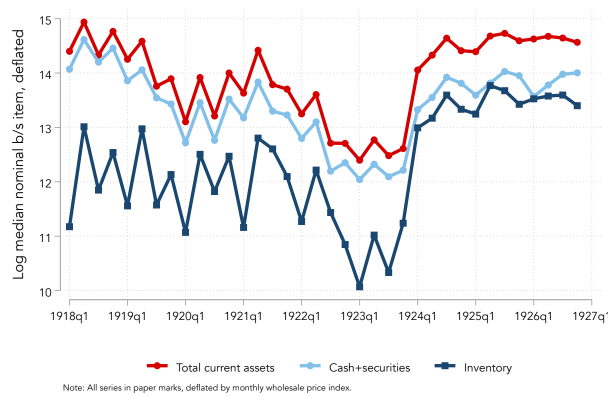
(a) *Evolution of median of liability components in paper marks, deflated.*



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



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

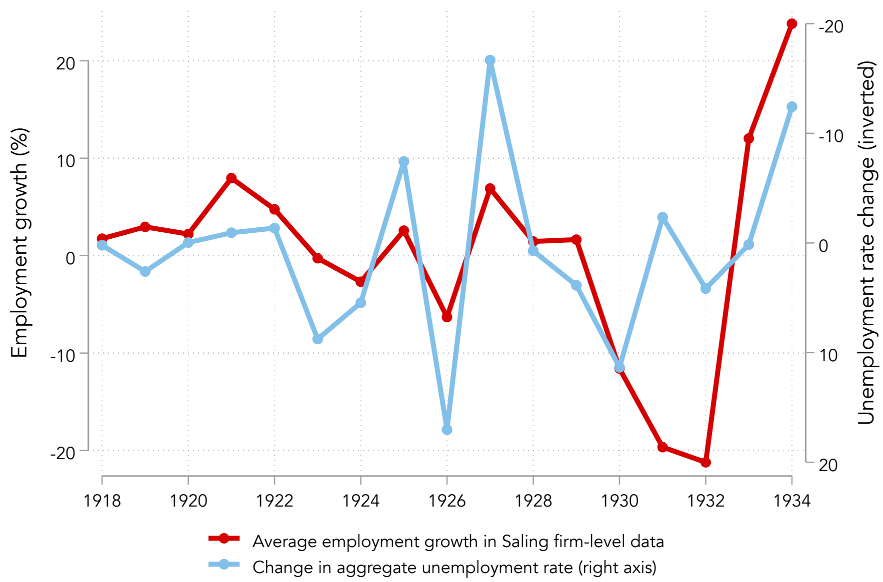


Notes: This figure plots the evolution of the medians of key balance sheet items in paper marks, deflated by the wholesale price index. The large changes in 1924Q1 occur due to the introduction of revalued Goldmark balance sheets.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.5: *Employment Growth in Saling's Compared with the Aggregate Unemployment Rate.*

(a) *Time series comparison.*

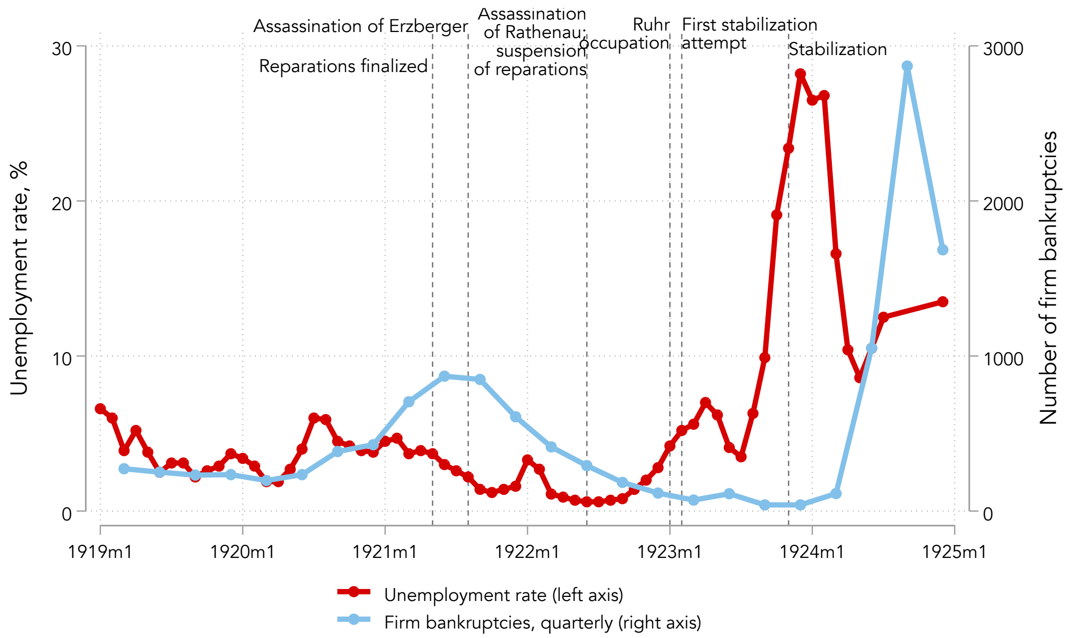


(b) *Scatterplot.*

Notes: This figure validates self-reporting 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 unweighted 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*.

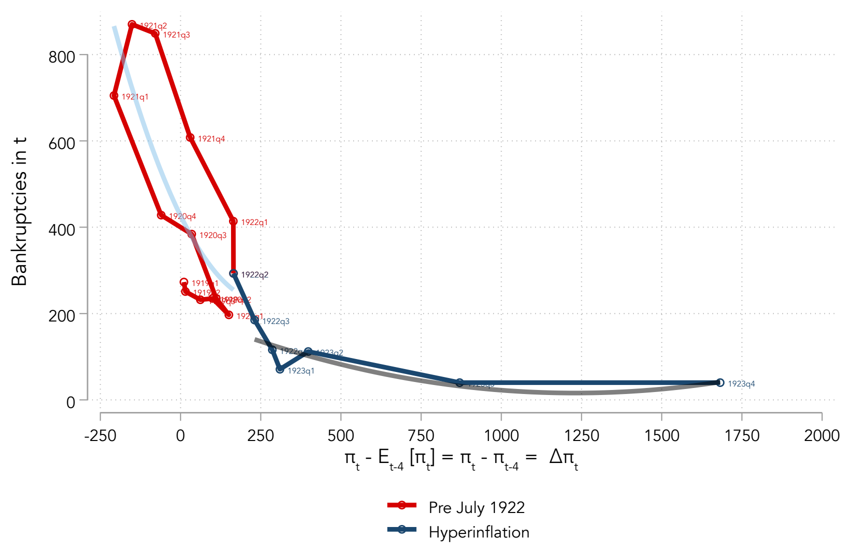
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.6: *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 A.3.7: *Inflation and Firm Bankruptcies: Robustness using the Acceleration in Inflation.*

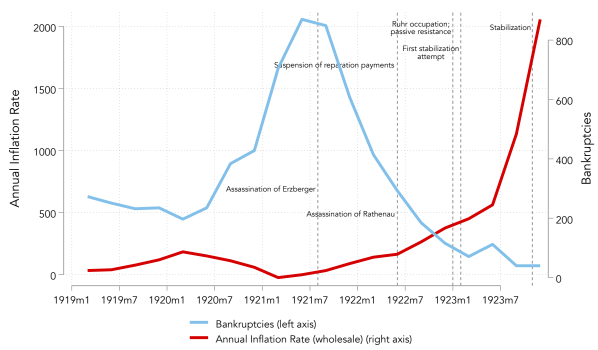


Notes: This figure plots the number of firm bankruptcies in quarter t against inflation over the past four quarters net of expected inflation over the same period. Expected inflation is assumed to be inflation over the past year from quarter $t-8$ to $t-4$. Inflation is calculated as the log change (times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

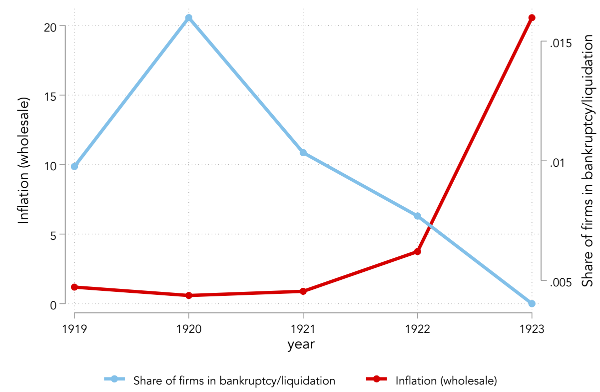
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.8: *Inflation and Firm Bankruptcies.*

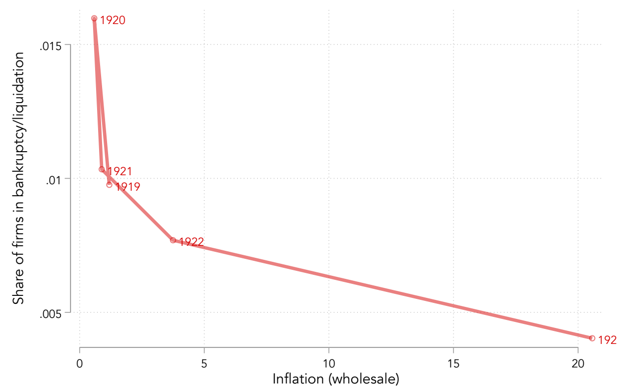
(a) *Inflation and no. of bankruptcies and liquidation by quarter.*



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



(c) *Inflation and rate of bankruptcies and liquidations by year.*

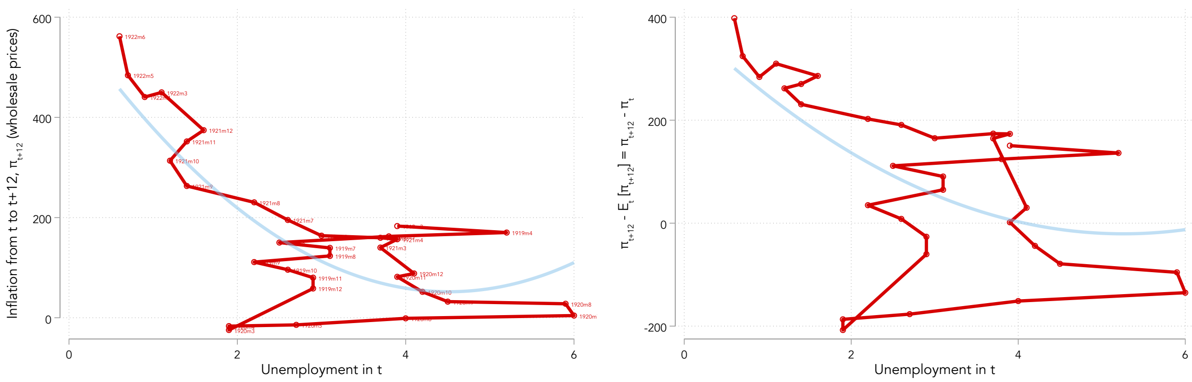


Notes: Quarterly counts of firm bankruptcies are obtained from the *Vierteljahrshefte zur Statistik des Deutschen Reichs Herausgegeben vom Statistischen Reichsamt*. Inflation of wholesale prices as reported in *Zahlen zur Geldentwertung*.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.9: *The "Classic" Phillips Curve: Subsample from 1919:1 to 1922:6.*

(a) *Level-level Phillips Curve, 1919:1-1922:6.* **(b)** *Accelerationist Phillips Curve, 1919:1-1922:6.*



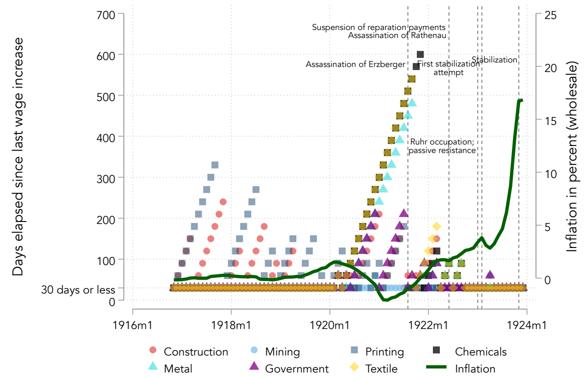
Notes: This figure presents level-level and accelerationist Phillips curves using data from 1919:1 to 1922:6, the first phase of the post-war inflation, before the hyperinflation phase. Inflation of wholesale prices as reported in *Zahlen zur Geldentwertung*. Monthly unemployment in the German industries as reported in the *Reichsarbeitsblatt*.

Electronic copy available at: https://ssrn.com/abstract=4303537

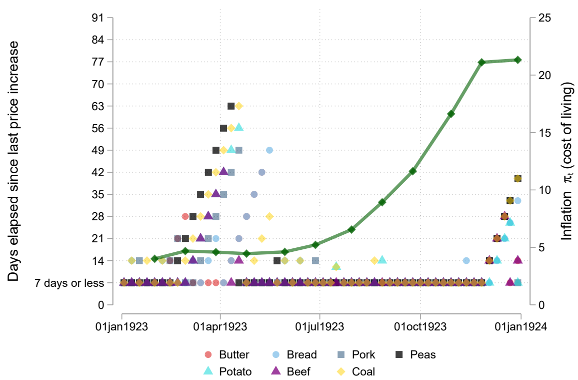
Figure A.3.10: *Interval between Price Adjustment Falls during the Inflation: Evidence from Wages and Cost-of-Living Index Prices.*

(a) *Wage adjustments.*

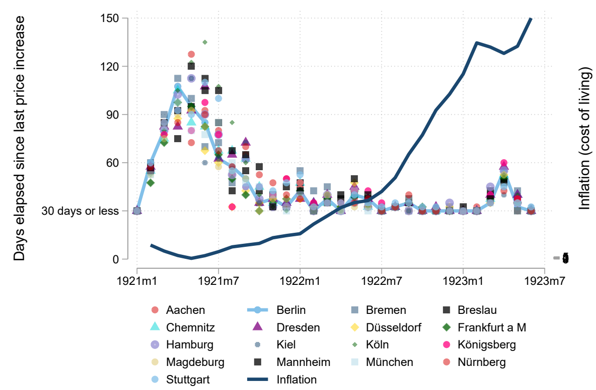
(b) *Wage adjustments, by industry.*



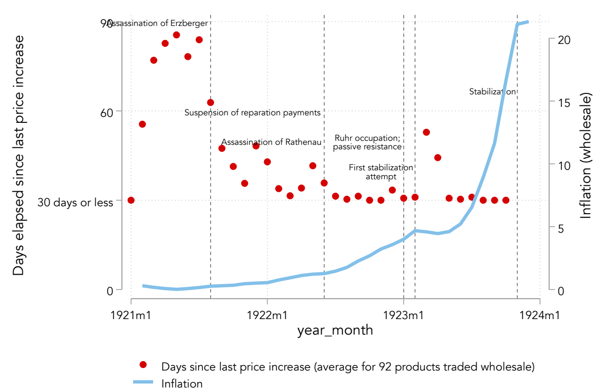
(c) *Weekly price adjustment by product for Berlin during 1923.*



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



(e) *Price adjustments for 95 product traded wholesale.*

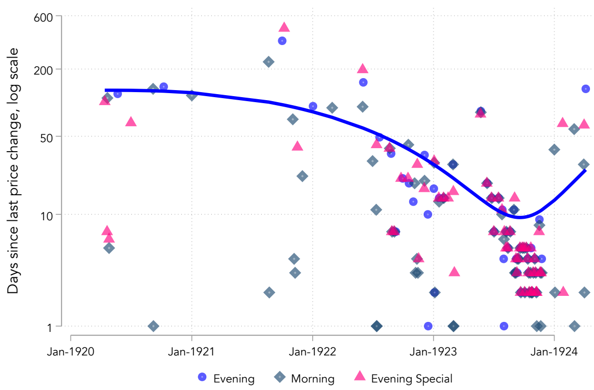


Notes: This figure plots the duration of unchanged wages and prices products underlying the cost-of-living index over time.

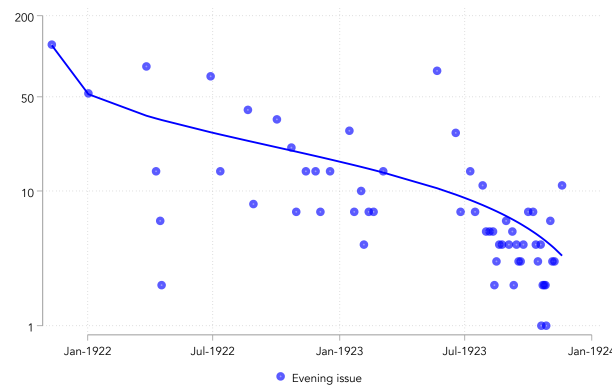
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.11: *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.*

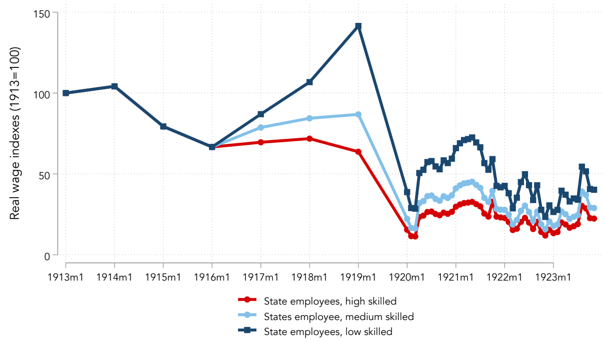


Notes: This figure plots the duration of unchanged prices for various issues of two German newspapers, the *Berliner Börzen Zeitung* and the *Berliner Tageblatt und Handels-Zeitung*. Daily newspaper prices are hand-collected from scans of the newspapers.

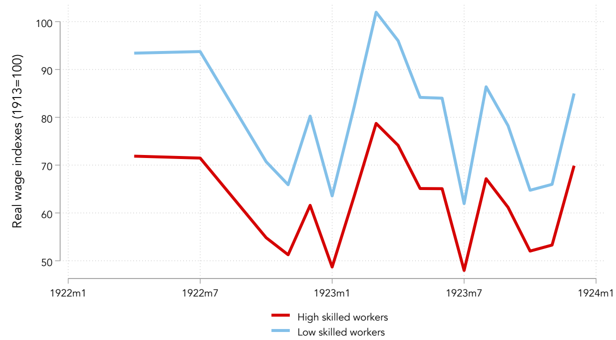
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.12: *Real Wages Declined Relative 1913 during Germany's Inflation, Especially for High Skilled Workers.*

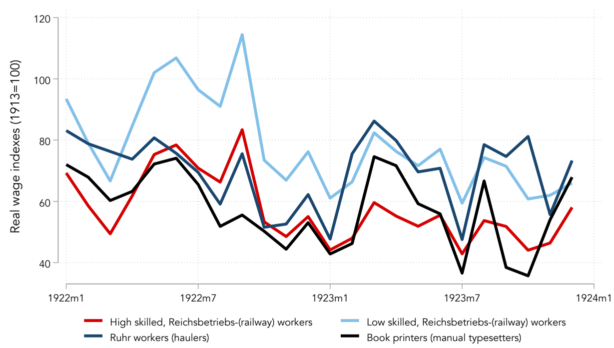
(a) *Real wages for state employees*



(b) *Real wages for high and low skilled workers, average across six industries*



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



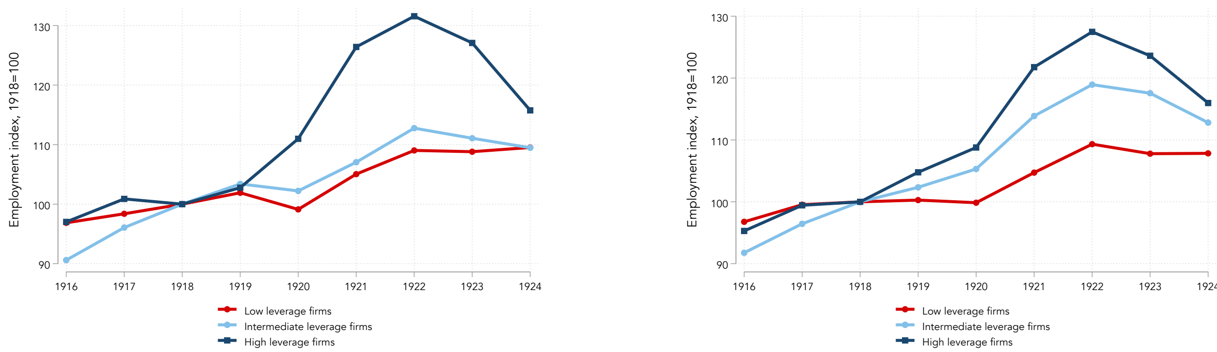
Notes: This figure plots the evolution of real wages for various groups of workers and industries. Real wage data are from *Wirtschaft und Statistik*. Real wages are deflated by wholesale prices.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.13: *Employment Dynamics across Low and High Leverage Firms: Alternative Measures of Leverage.*

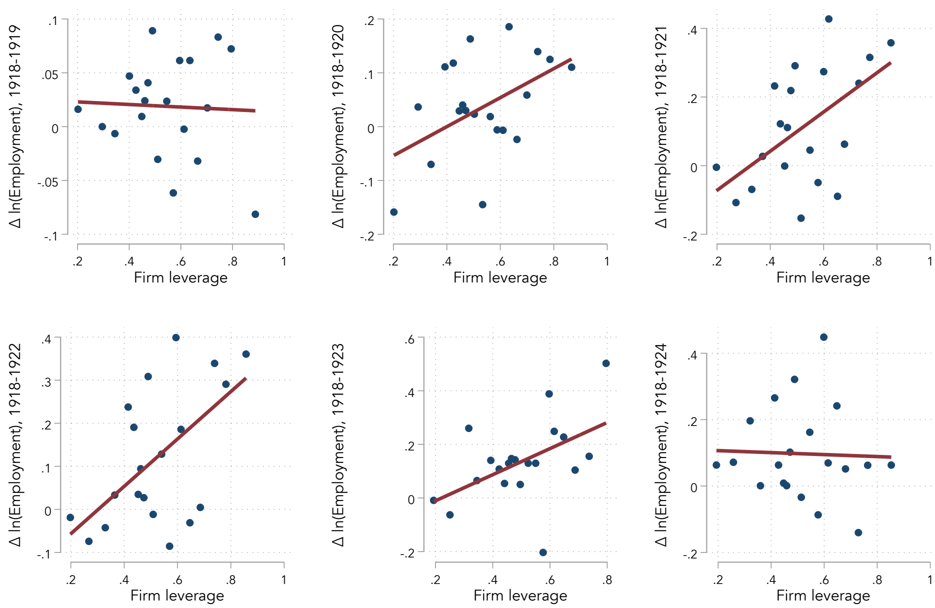
(a) *Sorting firms by average liabilities to assets over 1917-1919*

(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 A.3.14: *Firm Leverage and Firm Employment Growth During the Inflation.*

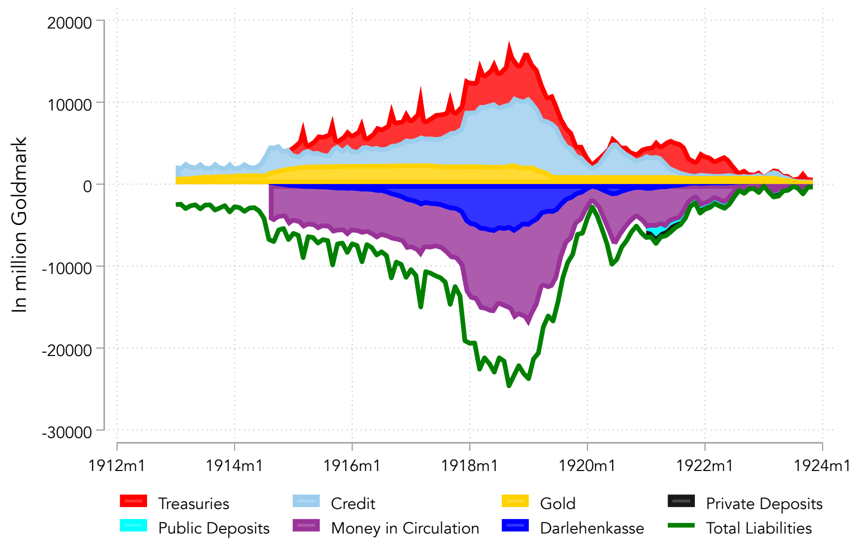


Notes: This figure plots binned bivariate means of firm-level employment growth (defined as the change in log employment, multiplied by 100) in each year from 1919 to 1924, relative to 1918. Firm leverage is defined as $\frac{Liabilities}{Assets}$, averaged over 1918 and 1919.

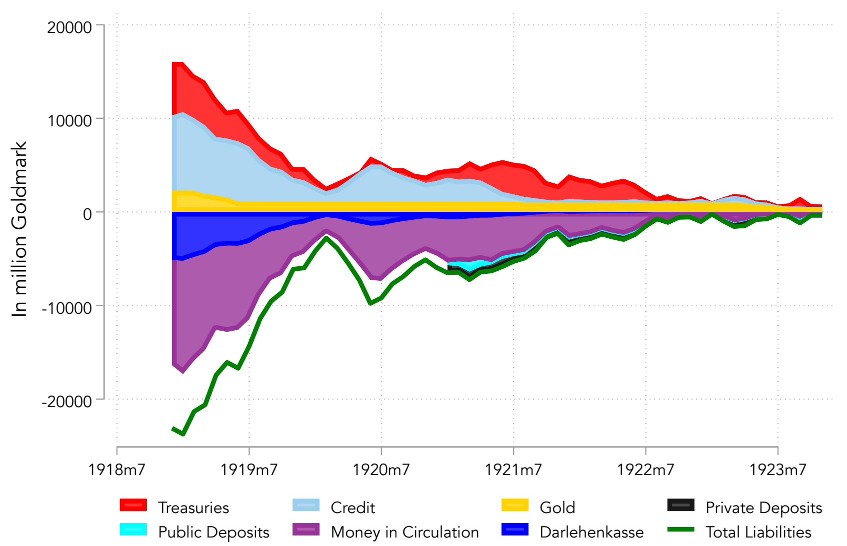
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.15: *Reichsbank Balance Sheet in Goldmarks.*

(a) *1914-1923*



(b) *1919-1923*

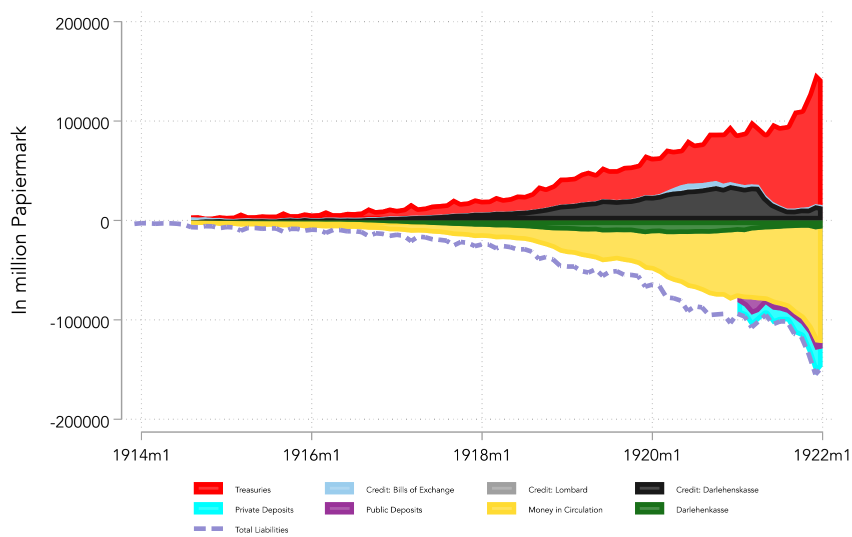


Notes: Data according to *Zahlen zur Geldentwertung*.

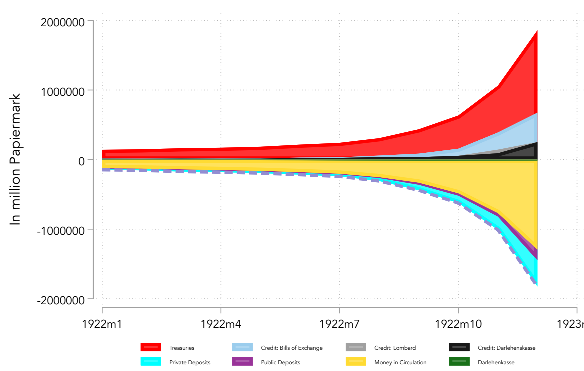
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.16: *Reichsbank Balance Sheet in Papiermark.*

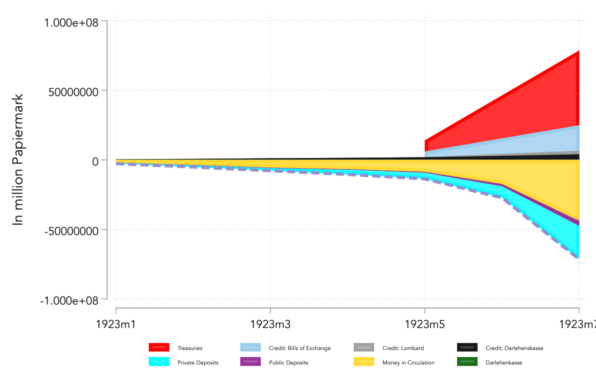
(a) *1914-1921*



(b) *1922*



(c) *1923*

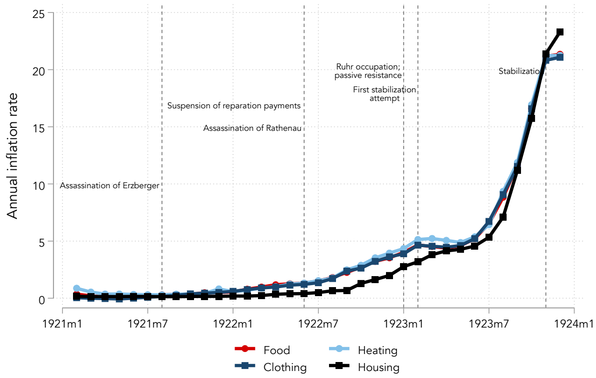


Notes: Source: Data are as reported in *Zahlen zur Geldentwertung*.

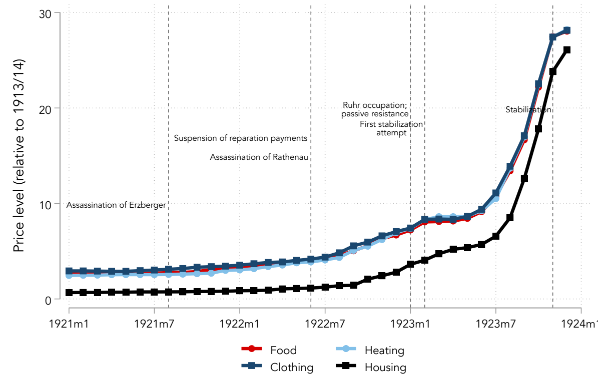
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.17: *Cost of Living and Wholesale Prices by Type.*

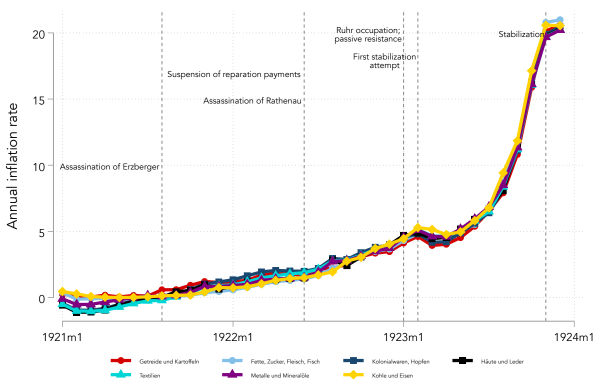
(a) *Cost of living inflation.*



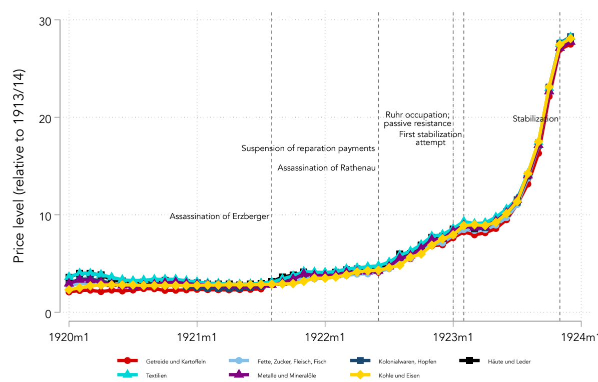
(b) *Cost of living price level.*



(c) *Wholesale goods inflation.*



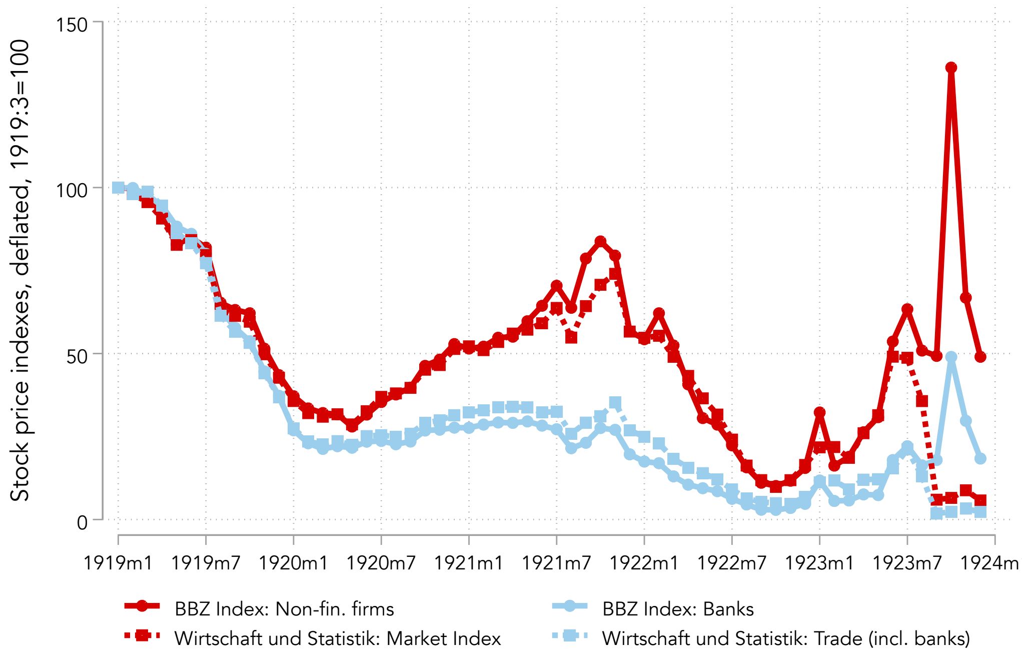
(d) *Wholesale goods price level.*



Notes: Data according to *Zahlen zur Geldentwertung*.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.18: *Nonfinancial Equity and Bank Equity Returns Based on Indexes from Berliner Börsen Zeitung and Wirtschaft und Statistik.*

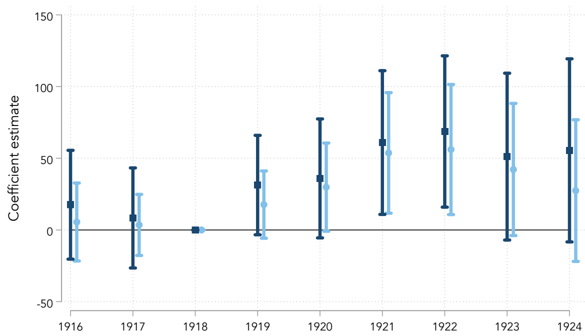


Notes: This figure plots equity indexes for nonfinancial firms and banks. We use two sources. The first is an equal-weighted from our hand-collected stock price data from *Berliner Börsen Zeitung* (BBZ). The second is published stock price indexes from *Wirtschaft und Statistik*. *Wirtschaft und Statistik*'s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

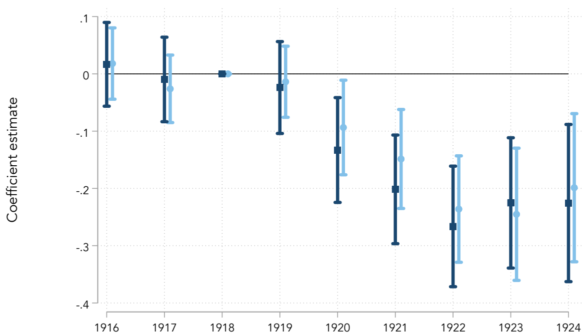
Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.19: *Firm Leverage, Interest Expenses, and Material Expenses and Salaries.*

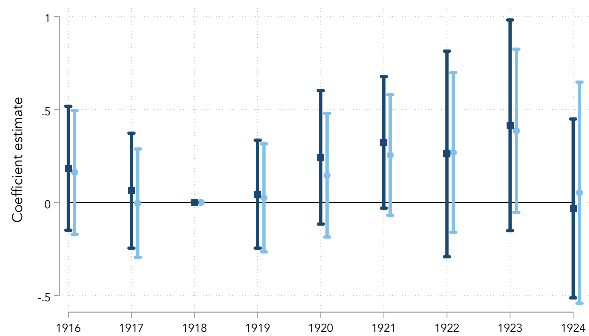
(a) *Employment.*



(b) *Interest Expenses.*



(c) *Materials and Salaries.*



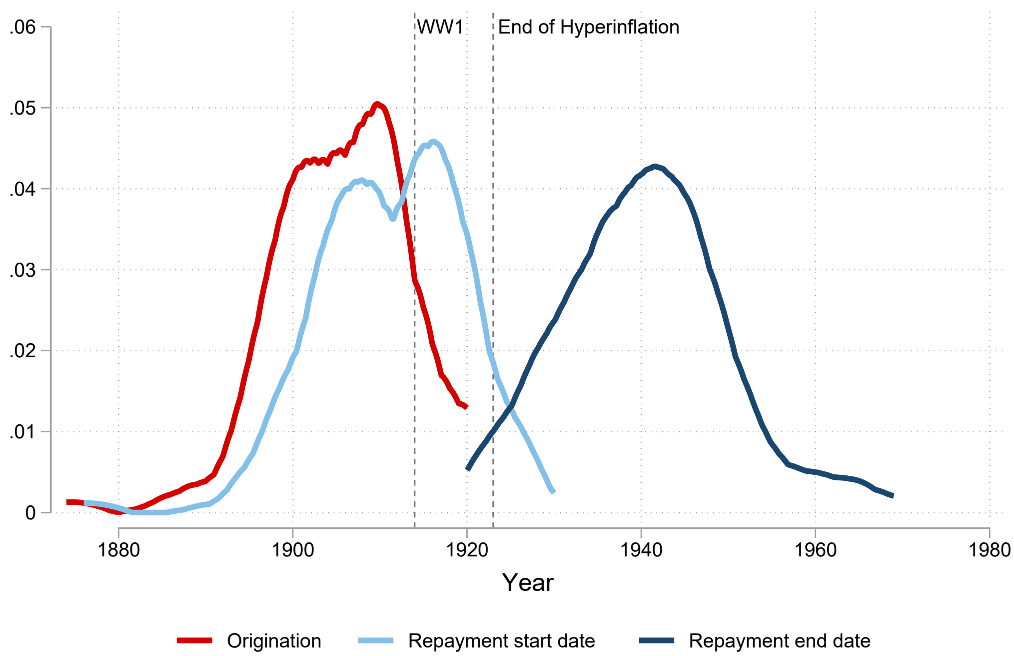
Notes: The figure plots the sequence of estimates $\{\beta_k\}$ from estimating the following model:

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

where y_{it} is either the ratio of interest expenses to total expenses (panel (a)) or the ratio of materials and salary expenses to total expenses (panel (b)). 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. 95% confidence bands applied.

Electronic copy available at: https://ssrn.com/abstract=4303537

Figure A.3.20: *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 non-financial 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.

Electronic copy available at: https://ssrn.com/abstract=4303537

Table A.3.1: *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 A.3.2: *Time Series Estimates of the "Classic" Phillips Curve.*

	(1)	(2)	(3)	(4)	(5)	(6)
Unemployment	-8.16	75.4	-74.0***	-238.5***	-51.4***	89.0
	(17.8)	(63.6)	(14.1)	(46.5)	(16.6)	(57.2)
Unemployment^2		-3.27		26.4***		-5.30**
		(2.39)		(7.21)		(2.09)
Observations	50	50	34	34	17	17
R^2	0.0044	0.042	0.46	0.62	0.39	0.58
Sample	1919-1923	1919-1923	1919-July 1922	1919-July 1922	July 1922-1923	July 1922-1923
Frequency	Monthly	Monthly	Monthly	Monthly	Monthly	Monthly

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

$$\pi_{t+12} = \alpha + \beta \times \text{Unemployment}_t + \epsilon + t,$$

were t is monthly, and π_{t+12} is the inflation in wholesale prices from t to $t+12$. Inflation of wholesale prices as reported in *Zahlen zur Geldentwertung*. Monthly unemployment rate in the German industries as reported in the *Reichsarbeitsblatt*. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Electronic copy available at: https://ssrn.com/abstract=4303537

Table A.3.3: *Correlates of Firm Leverage.*

	$\text{Leverage}_{i,1918-1919}$				
	(1)	(2)	(3)	(4)	(5)
$\ln(\text{Total Assets})_{i,1918-1919}$	0.059***				0.056***
	(0.0050)				(0.0050)
$\text{Fixed Assets/Total Assets}_{i,1918-1919}$		-0.14***			-0.16***
		(0.031)			(0.032)
$\text{EBIT margin}_{i,1918-1919}$			0.078**		-0.028
			(0.031)		(0.031)
$\text{ROA}_{i,1918-1919}$				-0.10	-0.071
				(0.12)	(0.12)
Observations	798	798	758	743	728
R^2	0.17	0.036	0.0096	0.0011	0.22

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

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

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

Electronic copy available at: https://ssrn.com/abstract=4303537

Table A.3.4: *Firm Leverage and Employment—Robustness to Different Measures of Leverage.*

Dependent Variable	ln(Employment)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liabilties/Assets$_{i,1918}$ $\times \mathbf{1}_{t \geq 1920}$	36.8**	24.9*						
	(14.3)	(15.1)						
Debt/Assets$_{i,1918} \times \mathbf{1}_{t \geq 1920}$			35.2**	29.5*				
			(15.7)	(16.4)				
Liabilties/Assets$_{i,1919}$ $\times \mathbf{1}_{t \geq 1920}$					41.8***	37.4**		
					(14.8)	(15.2)		
Debt/Assets$_{i,1919} \times \mathbf{1}_{t \geq 1920}$							42.9***	41.6***
							(14.7)	(14.8)
Observations	1785	1742	1785	1742	1865	1817	1865	1817
Number of Firms	331	326	331	326	345	339	345	339
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.

Electronic copy available at: https://ssrn.com/abstract=4303537

Table A.3.5: *Firm Leverage and Employment—Robustness to Credit Supply Controls.*

Dependent Variable	ln(Employment)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liabilties/Assets$_{i,1918-1919}$ $\times \mathbf{1}_{t\geq 1920}$	44.8***	51.3**	40.2**	46.6**				
	(15.8)	(20.7)	(20.2)	(19.8)				
Debt/Assets$_{i,1918-1919}$$\times \mathbf{1}_{t\geq 1920}$					42.5***	47.1**	35.7*	42.2**
					(16.2)	(20.8)	(19.9)	(19.5)
Distance to Berlin $\times \mathbf{1}_{t\geq 1920}$			-0.0057				-0.0057	
			(0.013)				(0.013)	
Observations	1920	1734	1719	1719	1920	1734	1719	1719
Number of Firms	358	323	321	321	358	323	321	321
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		✓	✓	✓		✓	✓	✓
Baseline Controls $\times$ $\mathbf{1}_{t\geq 1920}$		✓	✓	✓		✓	✓	✓
Large Banks-Time FE		✓				✓		
Quintiles of Dist. to Berlin-Time FE				✓				✓

Notes: This table is similar to Table 2 but adds additional controls for proxies of credit supply. Columns 1 and 5 correspond to columns 1 and 4 in Table 2. Columns 2 and 6 adds separate 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), as well as a dummy for firms without a connection to one of the major banks (eight bank-time FE in total). Columns 3 and 7 control for the distance to Berlin (in kilometers). Columns 4 and 8 control for five dummy variables for quintiles of distance to Berlin. The baseline controls are firm size (log of assets), the share of fixed assets in total assets, return on assets, and profit margin. All controls are interacted with the post-1920 fixed effect. *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Electronic copy available at: https://ssrn.com/abstract=4303537