ABSTRACT

Title of Dissertation: ESSAYS ON LINKAGES BETWEEN CAPITAL FLOWS, LEVERAGE, AND THE REAL ECONOMY

Jun Hee Kwak
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Dissertation Directed by: Professor Sebnem Kalemli-Ozcan
Department of Economics

Europe experienced a sovereign debt crisis starting in 2010, in which perceived default risk and interest rates on government bonds soared in many countries, leading to recessions. This episode was preceded by a steady rise in the ratio of corporate debt to GDP, suggesting that private sector leverage may be a contributing factor to rising sovereign risk.

In the main essay, I find that corporate debt causally affects sovereign default risk and show that this corporate-sovereign debt nexus is an important amplification mechanism driven by externalities that call for macroprudential policies. I run instrumental variable regressions to estimate a causal relationship running from aggregate corporate leverage to sovereign spreads. I use the weighted sum of idiosyncratic shocks to top 50 large firms in each Eurozone country as an instrument for aggregate corporate leverage to rule out potential reverse causality and omitted variable bias. The regressions suggest that rising corporate leverage causes sovereign spreads to rise, which confirms the existence of the corporate-sovereign nexus. To understand the mechanism, I build a model in which both firms and the government can default. When corporate debt increases, tax revenues are expected to

be lower, as firms stop paying taxes and dividends when they default, which raises sovereign default risk. This tax revenue channel is supported by empirical evidence. Country-level tax revenue regressions show that increases in corporate debt-to-GDP ratios reduce future tax revenue growth. Difference-in-difference regressions using firm-level data suggest that highly-leveraged firms reduce tax payments more compared to less-leveraged firms in response to the 2008 global financial crisis. Moreover, I analyze an externality that arises from firms' limited liability, which is distinct from the pecuniary and aggregate demand externalities. I find that there exist time-consistent optimal policies that correct the limited liability externality. A quantitative model calibrated to six Eurozone countries shows that such policies consists of a low constant debt tax rate together with transfers and investment credits to firms during the crisis. Implementing these policies alleviates the corporate-sovereign linkage, so that the number of defaulting firms decreases, and the government has enough fiscal space to provide transfers to households suffering from low consumption. Furthermore, practical policies such as either constant or cyclical debt tax schedules can correct overborrowing externalities. However, a countercyclical debt policy (which raises the debt tax rate during corporate credit booms) induces more firm defaults during crises, and thus it is less effective than constant and procyclical debt tax policies. This suggests that policymakers should be cautious about implementing countercyclical debt tax policies such as countercyclical capital buffers, and should even consider relaxing regulations when corporate default risk is high.

The second essay (co-authored) documents new facts on the relationship between sector-level capital flows and sectoral leverage.[1] We highlight the interconnections between

[1]This essay was published in Annual Review of Economomics (Vol.12:833-846, August 2020; https://doi.org/10.1146/annurev-economics-080218-025901) and reproduced here with permission.

different approaches and argue that harmonization of the macro and micro approaches can yield a more complete understanding of these effects of capital flows on country-, sector- and firm/bank-level leverage associated with credit booms and busts.

The third essay (co-authored) uses a historical quasi-experiment in the Ottoman Empire to estimate the causal effect of trade shocks on capital flows.[2] We argue that fluctuations in regional rainfall within the Ottoman Empire capture the exogenous variation in exports from the Empire to Germany, France, and the U.K., during 1859-1913. Our identification is based on the following historical facts: First, only surplus production was allowed to be exported in the Ottoman Empire (provisionistic policy). Second, different products grew in different regions that were subject to variation in rainfall. Third, Germany, France, and the U.K. imported these different products. When a given region of the Empire gets more rainfall than others, the resulting surplus production is exported to countries with higher ex-ante export shares for those products, and this leads to higher foreign investment by those countries in the Ottoman Empire. Our findings support theories predicting complementarity between trade and finance, where causality runs from trade to capital flows.

[2]This essay was published in Journal of Development Economoics (Vol.147, 102537, November 2020; https://doi.org/10.1016/j.jdeveco.2020.102537) and reproduced here with permission.

ESSAYS ON LINKAGES BETWEEN CAPITAL FLOWS, LEVERAGE, AND THE REAL ECONOMY

by

Jun Hee Kwak

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Advisory Committee:
Professor Sebnem Kalemli-Ozcan, Chair/Advisor
Professor Pierre De Leo
Professor Felipe Saffie
Professor John Shea
Professor Michael Faulkender

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Chapter 1: Corporate and Sovereign Debt: Linkages and Externalities

1.1 Overview

I show that corporate debt accumulation during booms can explain increases in sovereign risk during stress periods. Using idiosyncratic shocks to large firms as instruments for aggregate corporate leverage, I show that rising corporate leverage during the period 2002-2007 causally increases sovereign spreads in six Eurozone countries during the debt crisis period of 2008-2012. To explain these findings, I build a dynamic quantitative model in which both firms and the government can default. Rising corporate debt increases sovereign default risk, as tax revenues are expected to decrease. Externalities arise because it can be privately optimal but socially suboptimal for firms to default given their limited liability. The fact that firms do not take into account the effect of their debt accumulation on aggregate sovereign spreads is an important externality, rationalizing macroprudential interventions in corporate debt markets. I propose a set of such optimal debt policies that reduce the number of defaulting firms, increase fiscal space, and boost household consumption during financial crises. Both constant and cyclical debt tax schedules can correct overborrowing externalities. Contrary to conventional wisdom, it is optimal to cut a debt tax rate during credit booms, as raising the debt tax rate induces more firm defaults.

1.2 Introduction

Eurozone sovereign spreads surged during the European debt crisis of 2010 to 2012, reflecting sharp increases in the perceived probability of sovereign default. Previous research on sovereign default has identified high sovereign indebtedness as one of the precursors of sovereign debt crises. However, the average Eurozone government-debt-to-GDP ratio rose by only 19.7 percentage points from 2000 to 2011, while the non-financial corporate-debt-to-GDP ratio rose by 41.6 percentage points during the same period. Reinhart and Rogoff (2009a) show that corporate defaults have also been a predictor of government defaults or reschedulings in many episodes.[1] Consistent with their finding, Eurozone non-financial corporate interest rate spreads peaked before and during the sovereign debt crisis, as plotted in Figure 1.1.

The empirical literature on sovereign spreads faces the challenge of establishing causal mechanisms. Based on the long history of credit cycles across countries, the consensus view holds that credit booms lead to various forms of financial crises. However, this view arguably has not been properly supported by causal inference. One of the main empirical difficulties is that there is likely an omitted variable linking credit booms and financial crises. For instance, optimism among investors can generate a credit boom and a subsequent correction. In this case, the cause of the subsequent correction might be sudden changes in investors' sentiment, rather than the credit boom itself. A possible remedy to this endogeneity problem is to find instruments for credit that are unrelated to other macroeconomic shocks, but it is difficult to find (excludable) instruments for macroeconomic variables.

One of the main contributions of this paper is to establish a causal relationship running from corporate debt to sovereign default risk during the European debt crisis. I run instrumental variable (IV) regressions to show that a rising corporate debt-to-GDP ratio causally increases sovereign spreads during the pre-crisis period, using a weighted sum of idiosyncratic shocks to large firms as an instrument for aggregate corporate leverage. Gabaix and Koijen (2020) develop this type of general identification strategy for estimating aggregate relationships using idiosyncratic shocks as instruments for aggregate variables. An instru-

[1] Reinhart and Rogoff (2011) report that rapidly rising private indebtedness precedes banking crises, and that banking crises increase the likelihood of sovereign default, using a long-term historical database which dates back to the 1800s and covers 70 countries. See also Schularick and Taylor (2012), Drehmann and Juselius (2012), and many others.

mental variable regression suggests that a one standard deviation (23%p) increase in the corporate debt-to-GDP ratio causally increases sovereign spreads by 253 basis points, using a sample of six Eurozone countries during the period 2002-2012.[2] This regression controls for financial conditions in the banking sector together with country and time fixed effects. The core identification assumptions in my empirical strategy are that idiosyncratic shocks to large firms are correlated with aggregate corporate debt (relevance) and that these shocks affect sovereign spreads only through their impact on corporate debt, after controlling for country-specific GDP growth and time-varying factors common to all countries (exclusion). The exclusion condition states that the error term in the sovereign spread regression reflects systematic shocks to government solvency, which are not correlated with idiosyncratic firm-level shocks. Using idiosyncratic shocks to large firms as an instrument addresses potential reverse causality (e.g., government solvency shocks may spill over to corporate debt) and omitted variables bias (e.g., both corporate and government debt may be affected by liquidity shocks). To the best of my knowledge, my paper is the first to present evidence for a causal linkage between corporate debt and sovereign default risk, combining detailed firm-level balance sheet data with a new identification technique.[3] Also, local projections suggest that rising corporate leverage has persistent effects on perceived government solvency, increasing 3-year-ahead sovereign spreads.

Next, to explain the link between corporate debt and sovereign default risk, I build a model in which both firms and the government can default on debt, based on the models of Jermann and Quadrini (2012) and Arellano (2008). Rising corporate debt increases sovereign default risk, as government tax revenues are expected to decrease, given that firms

[2] The maximum increase from the start to the end of period among these countries' spreads is 883 basis points, and the average increase calculated in the same way is 320 basis points.

[3] Several papers estimate the causal link running from other variables (not corporate debt) to sovereign spreads. For example, Acharya et al. (2014) run regressions of daily European sovereign credit default swap (CDS) rates on bank CDS rates before, during, and after the governments' announcements on bank bailouts. Wang (2020) finds that surprise increases in corporate CDS rates lead to increases in sovereign CDS rates in emerging markets, using a high-frequency event-study analysis. Bernoth and Herwartz (2019) estimate a causal linkage between exchange rates and sovereign spreads in emerging market economies during 2004-2016, using structural vector autoregressive (SVAR) models.

pay fewer taxes when they default and given that rising firms' borrowing costs dampen economic activity and reduce overall tax revenues including household income taxes. When the government may not be able to raise enough taxes to finance public expenditure, it may choose to accumulate debt or repudiate debt to finance this expenditure. This means that the government has more incentive to default on its debt, and thus sovereign risk increases. Arellano et al. (2019) also build a model that connects firms and the government via the tax revenue channel. However, my model differs in that firms choose leverage endogenously and can default on debt, while firm leverage in their model is exogenously given by the working capital constraint. Endogenous firm leverage is a key ingredient in my model that enables assessment of overborrowing externalities, as described below.

To provide empirical evidence on the tax revenue channel, I run a country-level tax revenue regression, using the weighted sum of idiosyncratic shocks to large firms as an instrument for corporate leverage, and find that a one standard deviation increase in the ratio of corporate debt to GDP (23%p) leads on average to a 7.4%p decrease in one-year-ahead tax revenue growth. Moreover, a difference-in-difference regression using firm-level data suggests that highly-leveraged firms pay fewer taxes compared to less-leveraged firms during and after the 2008 global financial crisis, while controlling for interest payments.[4]

I use my model to perform a normative analysis in which firms do not internalize the effects of their borrowing on the welfare of households, and the government needs to intervene in corporate debt markets to correct this negative externality. When firms default, the economy bears the economic costs of bankruptcies. However, firms do not internalize these negative spillovers, since their liability is limited in the event of default. In this environment, firms tend to over-borrow and increase corporate default risk, which is likely to reduce household consumption and raise the risk of government default. Externalities arise because it is privately optimal but socially suboptimal for firms to default given their limited liability. Most papers on optimal macroprudential policies have been silent on externalities

[4]The ratio of tax payments to value added of highly-leveraged firms drops by around 0.28%p more than that of less-leveraged firms during this episode, while the average tax payment ratio of the sample is 4.15%.

due to limited liability. The limited liability externality that I introduce is qualitatively different from previously identified externalities such as pecuniary and aggregate demand externalities. The limited liability externality hinges on the corporate law, which is operative when a firm is a separate legal entity apart from its owners. This means that this type of externality can arise even if firms are not atomistic, in the sense that they internalize their effects on aggregate prices, unlike pecuniary and aggregate demand externalities.

I calibrate the model to six Eurozone countries during the period 2000-2012. This model reproduces the dynamics observed in the data during the period 2007-2017, successfully matching the duration and magnitude of both the corporate credit boom-bust cycle and fluctuations in sovereign spreads and output. Using the model, I uncover a set of time-consistent optimal policies (a constant debt tax rate and subsidies to firms during the crisis) that correct the limited liability externality. The welfare gain from these policies is substantial, equivalent to around a permanent 12.8% increase in consumption. The reason is that optimal policies mitigate corporate debt cycles and associated firm defaults, leading to more household consumption and tax revenue. As a result, government interest rates fall, and the government can finance more subsidies to firms, which again reduces firm defaults. This positive feedback loop of optimal policies gives rise to the large welfare gain by alleviating the causal linkage between corporate debt and government spreads. In reality, this type of state-contingent optimal policy might not be available to policymakers. Thus, I explore alternative simple debt policies. I find that both constant and cyclical debt tax schedules can increase welfare (2.1% and 3.8% increases in permanent consumption, respectively) by correcting overborrowing externalities. However, contrary to conventional wisdom, the model shows that it is optimal to cut the debt tax rate during credit booms. Intuitively, the government raises the debt tax rate during corporate credit booms after observing the current level of aggregate corporate debt, and this backward-looking stance of the simple countercyclical debt policy leads to more firm defaults during the crisis. Furthermore, in the presence of firm default risk, it is optimal for the government to cut the debt tax rate to reduce firm default risk when corporate leverage is high. This result is in sharp contrast to existing models based on borrowing constraints (Bianchi, 2011; Bianchi and Mendoza, 2018), as these models typically recommend raising the debt tax rate when the borrowing constraint is more likely to bind due to high leverage.

Related Literature

I contribute to three strands of research. First, I add to the empirical literature that has identified key covariates that are highly correlated with sovereign spreads (Longstaff et al., 2011; Aguiar et al., 2016; Hilscher and Nosbusch, 2010; Bevilaqua et al., 2020). This literature typically does not attempt to estimate a causal relationship between fundamentals and spreads. Also, such regressions usually do not include corporate debt as an explanatory variable, though corporate debt is known to predict financial crises well (e.g., Reinhart and Rogoff (2011)). An exception that considers corporate debt includes Du and Schreger (2017). They run spread regressions for emerging economies, using foreign currency corporate debt borrowed from foreign lenders as an explanatory variable. In contrast, I show that total corporate debt (denominated in all currencies and borrowed from all lenders) in advanced economies (the Eurozone) helps to explain increases in sovereign spreads after controlling for currency risk. Moreover, other variables typically included in existing research, such as GDP growth and government debt, fail to explain the bulk of variation in sovereign spreads empirically, as reported in Aguiar et al. (2016). Specifically, the growth rate of output and the government debt-to-GDP ratio together explain less than 20 percent of sovereign spread variation (within countries and across time) in emerging economies. In my IV spread regression for Eurozone countries, including country and year fixed effects, GDP growth and the government debt-to-GDP ratio together explain about 27 percent of sovereign spread variation, while the corporate debt-to-GDP ratio accounts for an additional 19 percent of this variation.

Second, I build a sovereign default model that sheds light on a new causal mechanism.

The canonical quantitative sovereign default models aim to explain sovereign default events as resulting from exogenous aggregate shocks to income flows and adjustments in external government debt (Arellano (2008), Aguiar and Gopinath (2006) and other papers that build on Eaton and Gersovitz (1981a)).[5] I contribute to this literature by building a model in which firms finance investment with internal funds, debt, or equity, and both firms and the government can default. In my model, endogenous variation in firm leverage generates time-varying firm default risk, which affects the expected path of dividends and taxes. This generates time-varying risk in government tax revenue, which is a new channel that helps to match the crisis dynamics of corporate leverage and sovereign spreads observed in the data. Wu (2020) builds a similar model in which exchange rate shocks and corresponding time-varying risk premia are key sources of variation in sovereign spreads, but his model abstracts from equity issuance and limited liability. Kaas et al. (2020) also build a model with sovereign and private default risk without modeling physical investment and limited liability. Their model explains business cycle regularities in emerging economies.

Third, I contribute to the literature on optimal macroprudential policies. The existing literature justifies the use of macroprudential policies as arising from deviations from the conditions assumed in the first welfare theorem (see Kehoe and Levine (1993) and Lorenzoni (2008)). The first welfare theorem states that a competitive equilibrium is Pareto-efficient under several conditions. One of these conditions is that there should be no externalities in the economy, in the sense that each person should be able to internalize their effects on other people via market prices. However, if people are atomistic and do not internalize their effects on market prices, the competitive equilibrium does not guarantee efficient allocations. In this environment, people can over-borrow compared to the socially optimal level of debt. The government can intervene in debt markets to correct externalities and increase social welfare. Bianchi (2011), Brunnermeier and Sannikov (2015), Benigno et al. (2016), Jeanne and Korinek (2020) and others identify this type of pecuniary externality in various settings

[5]See Mendoza and Yue (2012), Arellano et al. (2019), Bocola et al. (2019), Rojas (2020), and many others for recent sovereign default models.

and investigate optimal debt policies.[6] I introduce a new limited liability externality into a similar framework and analyze the resulting optimal policies. Wu (2020) also identifies a novel externality which emerges because firms do not internalize their effects on sovereign spreads, as sovereign spreads do not enter firms' budget constraint. His model assumes that owners do not walk away from their debts when firms go bankrupt. On the other hand, my model assumes that owners exit the business upon bankruptcy, which creates a fundamental externality arising from limited liability. Also, unlike Wu (2020), I analyze a set of optimal policies to correct externalities. Aguiar and Amador (2016) study optimal fiscal policy with implicit sovereign and private default risk in which the government minimizes tax distortions arising from financing exogenous public expenditure. I complement their work by introducing explicit corporate default decisions into the sovereign default model and analyzing optimal debt policy to address the limited liability externality.

1.3 Empirical Evidence: Corporate-Sovereign Linkage

1.3.1 Data Description

I estimate the impact of corporate leverage on sovereign spreads in the EU. Out of the 25 EU countries, only 20 have data on the ratio of corporate debt to GDP available from BIS. Out of these 20 countries, 11 have sovereign interest rate data for 10 year bonds denominated in euro available from Bloomberg during the period 1999q1–2012q4. I focus on this period to mitigate potential reverse causality running from sovereign risk to corporate debt during the post-2012 crisis. I drop Germany since the German rate is used as the reference rate in measuring the sovereign spread. I also focus on countries that adopted the euro in 1999 to eliminate currency risk as a source of yield differences relative to the German

[6] Also, Farhi and Werning (2016), Korinek and Simsek (2016), and Schmitt-Grohé and Uribe (2016) identify aggregate demand externalities in the presence of nominal rigidities that macroprudential policies can correct. Basu et al. (2020) consider both pecuniary and aggregate demand externalities. See Erten et al. (Forthcoming) for discussion of various types of externalities that can be corrected by macroprudential policies.

government bond. The resulting sample consists of country-quarter observations during the period 1999q1–2012q4 across nine Eurozone countries (Austria, Belgium, Finland, France, Ireland, Italy, Netherlands, Portugal, and Spain). Summary statistics are presented in Table 1.1 for this sample.

The sovereign spread is measured as the difference between a country's 10-year government bond rate and the 10-year German government bond rate. Both bond rates are denominated in euro. Quarterly GDP growth is the log difference of seasonally-and-calendar-adjusted real GDP (Eurostat). Debt-to-GDP ratios (based on core debt at market value) for government and non-financial corporates come from BIS total credit statistics.[7] These debt measures include credit from all sources in all currencies. VIX is the implied volatility of the S&P 500 (CBOE) based on option prices. The literature has identified GDP growth, the ratio of government debt to GDP, and a global common factor as being important to explaining sovereign spreads (see Longstaff et al. (2011), Aguiar et al. (2016), Bai et al. (2019) and others). I choose VIX as the global factor to capture changes in global investors' risk aversion. Additionally, I use the difference between US 3-month treasury rates and the 3-month LIBOR (TED spread) and the difference between US 10-year and 3-month treasury rates (term spread) as additional controls for global credit conditions. Both spreads and the VIX are available from FRED (Economic Data by the Federal Reserve Bank of St. Louis). I also control for country-level banking sector leverage, measured as the ratio of selected financial assets to total equity, available from OECD.[8] Banking sector leverage is only available at an annual frequency and thus is used only in annual regressions. Tax revenue is measured as total receipts from taxes and social contributions and comes from Eurostat. Real tax revenue is calculated as nominal revenue divided by the GDP deflator (obtained from Eurostat).

For IV regressions, I use the weighted sum of idiosyncratic productivity shocks to the top 50 largest firms in each country as an instrument for aggregate corporate debt. Thus,

[7] BIS (2019), Credit to the non-financial sector, https://www.bis.org/statistics/totcredit.htm.
[8] OECD (2020), Banking sector leverage (indicator). doi: 10.1787/027a0800-en.

I must restrict my IV regression sample to countries for which I can estimate total factor productivity in firm-level data (ORBIS-AMADEUS). Summary statistics for the IV regression sample are shown in Table 1.2. As I also use two years of lagged variables in the IV regressions, my final IV sample is limited to annual observations from six Eurozone countries (Italy, Spain, Portugal, Belgium, Finland, and France) during the period 2002-2012. The ORBIS-AMADEUS database is compiled by Bureau van Dijk Electronic Publishing (BvD), where AMADEUS is the European subset of ORBIS. This dataset has detailed annual firm-level information, including balance sheets, income statements, and profit and loss accounts. The main advantage of this data is that it contains both publicly and privately held companies, which distinguishes ORBIS from Compustat and Worldscope, which only contain large listed firms. I refer to Kalemli-Ozcan et al. (2019) for details on the construction of data.[9] Kalemli-Ozcan et al. (2019) show that the ORBIS-AMADEUS database is nationally representative, in the sense that aggregated firm-level data covers a considerable part of total gross output and employment (as compiled by official Bureaus of Statistics). Furthermore, I compare debt-to-GDP ratios from ORBIS-AMADEUS and BIS in Figure 1.2. I calculate debt-to-value-added ratios from ORBIS-AMADEUS as the sum of debt over the sum of value added (operating revenue net of material costs) across firms in a given country. I measure debt as the sum of loans and long-term debt, which represents financial debt excluding other accounts payable. I find that the time series of the debt-to-GDP ratio from ORBIS-AMADEUS and BIS track each other well for the six countries on average.

I use data from the ORBIS-AMADEUS database on non-financial sector firms only, because financial intermediaries such as banks and insurance companies likely have different decision rules regarding leverage from the non-financial sector. I also exclude the mining and oil-related sectors, since measurement of idiosyncratic shocks is problematic in these sectors, given that their revenues depend strongly on aggregate commodity price shocks. For firm-level regressions, I use a sample covering the period 2004-2012 in the six Eurozone countries

[9] See Data Appendix for data cleaning.

used for the aggregate IV regressions (Italy, Portugal, Spain, Belgium, Finland, and France). I exclude the recession period of 2000 to 2003. I include firms that have missing observations in some years to account for behavior of defaulting firms. The leverage measure is the ratio of financial debt to value added (b/y), where value added is operating revenue minus materials cost. Nominal variables are deflated by a 2-digit sector gross output deflator (EU KLEMS). To measure firm-level total factor productivity, I implement the Wooldridge (2009) extension of the Levinsohn and Petrin (2003) methodology.[10] I closely follow Gopinath et al. (2017a) for the TFP estimation. Capital is the book value of tangible fixed assets, and labor is measured as the wage bill, reflecting the quantity and quality of labor.[11] Capital is deflated by a 2-digit sector investment deflator, and labor and materials costs are deflated by the 2-digit sector gross output deflator (EU KLEMS). All firm-level regression variables measured with ratios are winsorized at the 3rd and 97th percentiles.

1.3.2 Sovereign Spread OLS Regression

To begin, I estimate the following OLS regression using quarterly observations on aggregate country-level data:

$$\begin{aligned}\text{Gov't Spread}_{c,t} &= \beta_y \text{GDP Growth}_{c,t-1} + \beta_{gov} Gov'tDebt/GDP_{c,t-1} \\ &\quad + \beta_{corp} CorpDebt/GDP_{c,t-1} + \delta_c + \gamma_t + \epsilon_{c,t} \qquad (1.1)\end{aligned}$$

where δ_c and γ_t are country and quarter fixed effects, respectively.

Table 1.3 presents OLS regression results using the sample of six Eurozone countries that will be used for IV regressions. In column (1), government spreads are negatively re-

[10]As I do not observe firm-level prices, this measure of TFP might capture both productivity and demand shocks. However, as long as these measured shocks are exogenous with respect to sovereign risk, I can use this measure to construct instruments for my identification strategy.

[11]Since I use year-on-year variation of productivity rather than its level, investment goods purchases are largely measured at current prices.

lated to GDP growth and positively related to government debt. These results suggest that the government is more likely to default in bad times when it has a large amount of debt. In column (2), corporate debt is positively related to spreads, suggesting that rising corporate leverage raises the perceived probability of sovereign default. The within-R^2 increases significantly (from 0.366 to 0.445) after including corporate debt, which suggests that corporate leverage is an important variable to explain within-country variation in sovereign spreads. In column (3), adding the log VIX does not change the other coefficients much, and VIX is not a significant predictor for sovereign spreads. Adding the TED spread or term spread does not affect the coefficients on corporate debt in columns (4) and (5). The insignificant coefficients on these variables suggest that global credit conditions as measured by these variables do not have significant impacts on these Eurozone countries. Adding quarter fixed effects in columns (6) and (7) yields similar coefficients for corporate leverage. These fixed effects generate a substantial increase in within-R^2. This is consistent with Longstaff et al. (2011), who find that global common factors explain a large amount of variation in sovereign spreads. In Table A.1, the same OLS regressions are presented using the larger sample of nine Eurozone countries during the period 1999q1–2012q4, and results are similar: the coefficients on corporate debt are positive and significant at the 1% level in all specifications. In Table A.2, I run similar regressions for individual Eurozone countries including a linear time trend, using all available observations for each country. Basic results do not change. Corporate debt is positively and significantly correlated with sovereign spreads in six of the nine sample countries (Spain, Portugal, Ireland, Belgium, Finland, and Austria).

In Figure 1.3, I plot regression coefficients estimated by Jordà (2005)-style local projections, as follows:

$$\begin{aligned}\text{Gov't Spread}_{c,t+h} &= \beta_{y,h}\text{GDP Growth}_{c,t} + \beta_{gov,h}Gov'tDebt/GDP_{c,t} \\ &+ \beta_{corp,h}CorpDebt/GDP_{c,t} + \delta_c + \gamma_t + \epsilon_{c,t+h}\end{aligned} \tag{1.2}$$

for each horizon $h = 0, 1, 2...$, where δ_c and γ_t are country and time fixed effects.

I find that a one standard deviation increase in the corporate debt-to-GDP ratio has persistent positive impacts on sovereign spreads (from 30 to 50 basis points) up to 12 quarters ahead. An increase in GDP growth reduces sovereign spreads up to 6 quarters ahead, while an increase in the ratio of sovereign debt to GDP raises spreads up to 6 quarters ahead.

1.3.3 Sovereign Spread IV Regression

OLS estimates of β_{corp} in equation (1.1) might be biased due to correlation between corporate debt and unobservables that lead to variation in sovereign risk. Consider the following OLS regression:

$$Y_t = \alpha + \beta X_{t-1} + \xi_t \tag{1.3}$$

where X is corporate debt, β is the true coefficient on X, and Y is the sovereign spread, where both X and Y are purged of their correlations with GDP growth, government debt, and common time-varying factors such as VIX.

Suppose market liquidity W is omitted from the regression. Thus, $\xi_t = \gamma W_{t-1} + \epsilon_t$ where ϵ_t is white noise.

Then, the OLS estimator is given by

$$\hat{\beta}^{OLS} = \frac{\sum_{t=1}^{T}(X_{t-1} - \bar{X})Y_t}{\sum_{t=1}^{T}(X_{t-1} - \bar{X})^2} = \beta + \gamma \frac{\sum_{t=1}^{T}(X_{t-1} - \bar{X})W_{t-1}}{\sum_{t=1}^{T}(X_{t-1} - \bar{X})^2} + \frac{\sum_{t=1}^{T}(X_{t-1} - \bar{X})\epsilon_t}{\sum_{t=1}^{T}(X_{t-1} - \bar{X})^2} \tag{1.4}$$

where $\bar{X} = 1/T \sum_{t=1}^{T} X_{t-1}$. Notice that $\sum_{t=1}^{T}(X_{t-1} - \bar{X})W_{t-1}$ might be positive, since tighter liquidity will reduce equilibrium corporate debt. The coefficient γ might be negative, as sovereign risk decreases with more liquidity. This implies that the OLS estimator might be biased downward, $\mathbb{E}[\hat{\beta}^{OLS}] < \beta$.

To estimate the causal relationship running from corporate debt to sovereign spreads, I use a weighted sum of idiosyncratic productivity shocks to each country's top 50 largest firms (sorted by sales in the previous year) as an instrument for that country's aggregate corporate leverage. The application of this type of identification strategy to the spread regressions is motivated by the fact that large firms drove the aggregate corporate leverage cycle during this period. Figure 1.4 shows that the top 50 largest non-financial firms in each Eurozone country on average increased their debt (both relative to value-added and in levels) prior to 2012, while small firms' debt remained relatively stable. To my knowledge, this finding is novel to the literature.[12] To construct idiosyncratic shocks, I estimate the following firm-level productivity growth ($g_{i,t}$) decomposition for each country in the spirit of Gabaix and Koijen (2020):

$$g_{i,t} = \beta_s \eta_t + u_{i,t} \tag{1.5}$$

where $g_{i,t} = (z_{i,t} - z_{i,t-1})/(0.5 \times (z_{i,t} + z_{i,t-1}))$, $z_{i,t}$ is firm-level productivity, η_t is an aggregate shock, and $u_{i,t}$ is an idiosyncratic shock to firm i at time t.

I assume that (i) the responsiveness (β_s) of firm-level productivity growth ($g_{i,t}$) with regard to an aggregate shock (η_t) is identical within a 4-digit sector s, and that (ii) aggregate and idiosyncratic shocks are separable in the growth decomposition. Under this assumption, regressing firm-level productivity growth on sector×year fixed effects gives residuals ($\hat{u}_{i,t}$) that are consistent estimators for idiosyncratic shocks ($u_{i,t}$).[13,14] I use total factor productivity (TFP) estimated by the Wooldridge (2009) method as a productivity measure. These

[12] Adrian and Shin (2010a) and Kalemli-Ozcan et al. (2012a) find that large banks drive the procyclicality of aggregate bank leverage. Alfaro et al. (2019) find that highly levered large firms in emerging markets are more vulnerable to exchange rate shocks compared to small firms.

[13] Yeh (2019) uses U.S. Census Bureau sources that include the universe of employer firms and trade transactions at the firm-destination-year level. He controls for differential responses of firms across destinations to estimate firm-level idiosyncratic shocks. Gabaix and Koijen (2020) suggest joint estimation of firm-specific responsiveness (β_i), which is a function of firm characteristics, and residuals. I find that this procedure is not feasible in my firm-level dataset, as it requires fully-balanced firm-year observations. This procedure would drop a considerable number of observations during the period 2000–2012, which would complicate the precise estimation of residuals. The assumption that aggregate and idiosyncratic shocks in growth are separable is consistent with a standard firm dynamics model in which aggregate and idiosyncratic shocks in levels are multiplicative in the production function.

[14] Regression (1.5) is estimated using a sample containing only the top 50 largest firms in each 4-digit sector for a given country. All residuals (growth rate) are winsorized at 20 and -20 percent following Gabaix (2011)'s calculations of "granular residuals".

productivity measures are obtained from the ORBIS-AMADEUS database for firms in the six sample Eurozone countries, following Gopinath et al. (2017a).

I construct the granular residual Γ_t as the weighted sum of idiosyncratic shocks to the top 50 firms for each country c, as follows:

$$\Gamma_{c,t} = \sum_{i=1}^{50} \frac{\text{Sales}_{i,c,t-1}}{\text{GDP}_{c,t-1}} \hat{u}_{i,c,t} \tag{1.6}$$

where $\text{Sales}_{i,c,t-1}$ is sales of firm i in country c at time $t-1$.[15]

The assumptions needed for identification are as follows: First, idiosyncratic firm-level productivity shocks are correlated with firm-level leverage. Second, large firms make up a substantial share of aggregate activity, so that the law of large numbers does not apply and $\Gamma_{c,t}$ will be relevant for aggregate leverage. Third, idiosyncratic shocks to large firms affect sovereign spreads only through their effect on corporate debt after controlling for alternative channels, and thus are uncorrelated with unobservable shocks affecting sovereign spreads. This will imply exogeneity of the instrument. I expect idiosyncratic firm-level productivity shocks to firms will be negatively correlated with their leverage following the previous finance literature (Rajan and Zingales (1995b), Harris and Raviv (1991), Titman and Wessels (1988) and others). This literature has established that profitability is negatively associated with leverage, since lower cash on hand implies more need to finance operating costs externally. As idiosyncratic productivity shocks are positively correlated with profitability, firms' optimal financing decisions in response to negative shocks imply a negative within-firm correlation between leverage and idiosyncratic productivity shocks. Regarding the exclusion restriction, it is difficult to see how idiosyncratic shocks to large firms would affect sovereign spreads directly without working through firm-level variables. These idiosyncratic shocks could potentially affect sovereign risk by reducing aggregate output growth as well as increasing aggregate corporate debt. As I control for aggregate output growth, while instrumenting for aggregate corporate debt, it is less likely that idiosyncratic shocks to large firms are cor-

[15] See the Data Appendix for discussion of alternative measures of idiosyncratic shocks.

related with other systematic unobservable shocks to government solvency. One concern is that negative shocks to firms could increase their probability of default on bank loans, and thus increase the probability of the government bailing out these banks. However, this does not necessarily mean that the instrument is invalid, as this banking channel works through rising corporate debt and associated corporate default risk, and the IV estimate can be interpreted as the impact of rising corporate debt on sovereign risk via this banking channel together with the tax revenue channel. Nevertheless, to tease out the tax revenue channel, I also control for aggregate bank leverage in some IV regressions.

In the IV regression, I use lagged granular residuals ($\Gamma_{c,t-1}$ and $\Gamma_{c,t-2}$) as excluded instruments for the lagged corporate debt to GDP ratio (Corp Debt/GDP$_{c,t-1}$). I use lagged values as instruments to better capture the relationship between firm-level productivity and firm borrowing, as lagged shocks are likely to be important determinants of firms' current borrowing decisions. I also include country fixed effects, year fixed effects, aggregate GDP growth, and government debt as controls in the regression. I run the following annual regression:

$$\begin{aligned}\text{Gov't Spread}_{c,t} = {} & \beta_y \text{GDP Growth}_{c,t-1} + \beta_{gov} \text{Govt Debt/GDP}_{c,t-1} \\ & + \beta_{corp} \text{Corp Debt/GDP}_{c,t-1} + \beta_{bank} \text{Bank Leverage}_{c,t-1} + \delta_c + \gamma_t + \epsilon_{c,t}\end{aligned} \tag{1.7}$$

where I instrument for corporate debt using the granular residuals $\Gamma_{c,t-1}$ and $\Gamma_{c,t-2}$. I add banking sector leverage as an additional control in some subsequent regressions.

Table 1.4 presents IV regression results. In column (1), I reproduce the OLS regression results from column (7) in Table 1.3 using annual data, in which corporate debt is positively correlated with sovereign spreads. In column (2), I present IV regression results, which establish that corporate leverage causally increases sovereign spreads. These effects are both statistically and economically significant. A one standard deviation increase in the corporate debt-to-GDP ratio (23%p) increases sovereign spreads by about 345 basis points, which is significantly different from zero at the 5% significance level. Notice that the IV estimate is larger than the OLS estimate, consistent with the idea that the IV regression identifies variation in corporate leverage that is orthogonal to unobservable shocks to sovereign spreads that bias OLS estimates of β_{corp} downward. In column (3), I add bank leverage to the OLS regression in column (1). The results show that bank leverage is positively correlated with sovereign spreads, which is consistent with existing findings that the need for government to bail out financially distressed banks increased government default risk during the Eurozone debt crisis (see Acharya et al. (2014), Farhi and Tirole (2017), and many others). Column (4) presents results instrumenting corporate debt, while controlling for bank leverage. The estimates imply that a one standard deviation increase in the corporate debt-to-GDP ratio (23%p) increases sovereign spreads by about 253 basis points, and this effect is significant at the 5% level. The magnitude of the coefficient on corporate debt decreases after controlling for bank leverage. This suggests that the IV estimate on corporate debt not controlling for bank leverage includes the impact of the corporate balance sheet channel working through bank balance sheets.

The first stage regression results reported in panel B of Table 1.4 suggest that the instruments are negatively correlated with corporate debt. Figure A.4 confirms that the instrument and corporate debt are negatively correlated, and that this correlation is not driven by outliers. The first-stage effective F statistic (calculated following Olea and Pflueger (2013)) reported in column (4) is 5.15. The rule-of-thumb threshold value is 10, above which instruments are considered as being highly correlated with the instrumented variables. While the coefficients on instruments are significant at the 5% level, the F statistic suggests that the instruments might be weak, and thus I conduct weak IV robust inference, as recommended by Andrews et al. (2019) in the presence of weak instruments. I find that the p-value associated with these author's proposed CLR statistic is 0.0628. This test rejects the null hypothesis that the coefficient on corporate debt is zero at the 10% significance level. The Hansen

(1982) test of overidentifying restrictions also does not reject the null that instruments are excludable.

There might be concerns that estimates of equation (1.5) do not identify true idiosyncratic shocks $u_{i,t}$ if firms' responsiveness (β_s) to aggregate shocks (η_t) is firm-specific. To address this concern, I relax one of the identification assumptions by allowing the response coefficient (β_s) in equation (1.5) to vary over firm size as well as sector. Specifically, I regress firm-level productivity growth on sector×size×year fixed effects, where size dummies represent each quintile (q) of firm size. A caveat is that these estimates of idiosyncratic shocks are more likely to be imprecise, as the number of observations used to estimate the coefficient $\beta_{s,q}$ for each sector and size group is smaller. Estimated residuals from this regression are used to construct alternative granular residuals. Another concern is that the weights for idiosyncratic shocks might be driving results, rather than idiosyncratic shocks themselves. Thus, I also construct an alternative granualr residual as a simple average of idiosyncratic shocks to top 50 firms in each country. I also construct granular residuals using idiosyncratic shocks to the top 100 firms in each country, to test the robustness of the instrument. Table A.3 presents IV regression results in which corporate debt is instrumented using the alternative measures. The results are robust to using these alternative instruments. In general, the coefficients on corporate debt are still positive and are mostly statistically and economically significant with or without bank leverage as a control. The instruments are generally significantly negatively correlated with corporate debt in the first-stage regressions. Figure A.3 plots estimated alternative residuals $\hat{u}_{i,t}$ (with sector×size×year fixed effects) for each top 50 firm i in each country in a given year t. There is no clustering of these residuals indicating a trend, which suggests that the residuals are independent of aggregate shocks, as implied by the estimation procedure itself. Table A.4 presents similar IV regression results replacing the ratio of corporate debt to GDP with the ratio of corporate debt to corporate value added. Results are robust to using this alternative measure of corporate leverage. The relationship between corporate debt and government spreads remains robust after including the ratio of household debt to GDP, as shown in Table A.5.

Next, I calculate the contributions of each explanatory variable to variation in sovereign spreads, using the IV regression results in column (4) of Table 1.4. First, I obtain predicted values of corporate debt-to-GDP ratios from the first-stage regression. Second, I purge sovereign spreads, GDP growth, predicted corporate debt-to-GDP ratios, sovereign debt-to-GDP ratios, and bank leverage of country- and year-fixed effects. To calculate the contribution of corporate debt, I multiply purged corporate debt by its coefficient $\hat{\beta}_{corp}$ and divide the variance of this multiplied term by the variance of purged sovereign spreads. I calculate the contributions of sovereign debt, growth, and bank leverage in the same fashion. Corporate debt accounts for about 19% of variation in sovereign spreads, while government debt, bank leverage, and GDP growth explain around 20%, 6%, and 7% of this variation, respectively.

1.3.4 Tax Revenue IV Regression

The model outlined in the next section proposes that corporate risk is linked to sovereign risk through total tax revenues. Rising corporate default risk implies higher borrowing costs and lower aggregate output. This reduces the general tax base, including not only corporate taxes but also labor income taxes. To test this mechanism directly, I run the following annual regression using the same sample of six Eurozone countries:

$$\begin{aligned}\text{Tax Revenue}_{c,t} &= \beta_y \text{GDP Growth}_{c,t-1} + \beta_{gov} \text{Govt Debt/GDP}_{c,t-1} \\ &\quad + \beta_{corp} \text{Corp Debt/GDP}_{c,t-1} + \beta_{bank} \text{Bank Leverage}_{c,t-1} + \delta_c + \gamma_t + \epsilon_{c,t}\end{aligned} \tag{1.8}$$

where the dependent variable is now real tax revenue growth in country c at time t. Table 1.5 presents both OLS and IV results. Column (1) presents OLS results and finds that corporate debt-to-GDP ratios are negatively correlated with one-year ahead tax revenue growth. These results suggest that expected government tax revenue becomes lower with rising corporate debt. My model below will provide a mechanism to explain this empirical finding, namely that rising corporate debt implies higher default rates on corporate taxes. In column (2), the dependent variable is one-year ahead tax revenue growth, and the corporate debt-to-GDP ratio is instrumented with the granular residuals as in Table 1.4. I find that a one standard deviation increase in corporate leverage (23%p) leads to a 7.4%p decrease in one-year ahead tax revenue growth, which is economically significant given that average tax revenue growth was only around 1% during the sample period. This effect is also statistically significant at the 1% level. The coefficients on the excluded instruments in the first-stage regressions are all significant, and the CLR statistics suggest that the IV results are robust to the presence of weak instruments. The Hansen (1982) test of overidentifying restrictions again does not reject the null that the granular residual instruments are excludable. In columns (3) (OLS) and (4) (IV), I additionally control for contemporaneous GDP growth to tease out the tax revenue channel via pure firm default risk by removing the negative effects of corporate debt overhang on output. I find that a one standard deviation increase in corporate leverage (23%p) causes tax revenue growth to decrease by around 6.7%p, and this coefficient is significant at the 5% level. This suggests that corporate default risk captures expectations about future developments beyond current fundmentals. Moreover, Table A.6 adds future tax revenue growth in years t and $t+1$ to the baseline sovereign spread regressions in Table 1.4. After including tax revenue growth, the impacts of corporate debt on sovereign spreads are muted, suggesting that future tax revenue is an important channel to explain the relationship between corporate debt and sovereign spreads.

1.3.5 Firm-level Tax Revenue Regression

I run the following difference-in-difference regressions using annual firm-level observations for the same countries as in the previous IV regression:

$$\text{Tax Payment}_{i,t} = \beta_1 \text{HighLev}_i \times \text{Crisis}_t + \beta_2 log(z_{i,t-1}) + \beta_3 log(k_{i,t-1}) \\ + \beta_4 log(1 + b_{it-1}) + \beta_5 \text{Interest Payment}_{i,t} + \delta_i + \gamma_{c,s,t} + \epsilon_{i,t} \quad (1.9)$$

where Tax Payment$_{i,t}$ is the ratio of firm i's tax payments to its value-added in year t. I include firm fixed effects δ_i and country×sector×year fixed effects $\gamma_{c,s,t}$. In different specifications, I replace country×sector×year fixed effects with country- and year-fixed effects or country×year fixed effects. I use the four-digit sector NACE code to construct sector dummies. I use a sample covering 2004-2012 to exclude the recession in the early 2000s, which is likely to include other large exogenous shocks to firms and complicate the quasi-experiment using the 2008 crisis shock. Figure 1.5 shows that there is a parallel trend in tax payment rates between high-leverage and low-leverage firms before 2008, which validates the use of difference-in-difference regressions. I control for key firm-level variables (productivity z, capital k, and debt b in log levels) that are state variables in typical firm dynamics models. The Crisis$_t$ dummy equals 1 in or after 2008 and 0 otherwise. The HighLev$_i$ dummy equals 1 if the firm's average leverage before 2008 is higher than the aggregate median before 2008, and 0 otherwise. Leverage is measured as the ratio of financial debt to value added. I include the firm's ratio of interest payments to value added to control for the effect of interest tax shields. See Table A.7 for firm summary statistics on this regression sample. I expect the coefficient on the interaction term HighLev$_i$ × Crisis$_t$ to be negative, meaning that highly-leveraged firms will decrease their tax payments more than less-leveraged firms in response to negative shocks from the 2008 global financial crisis. Columns (1)-(3) of Table 1.6 present results without controlling for interest payments, while columns (4)-(6) control for interest payments. I include country and year fixed effects in columns (1) and (4), country×year fixed effects in columns (2) and (5), and country×sector×year fixed effects in columns (3) and (6). In all specifications, the coefficients on $\text{HighLev}_i \times \text{Crisis}_t$ are negative and statistically significant at the 1 percent level. Following the 2008 crisis, highly-leveraged firms decrease tax payment rates by around 0.38%p more than less-leveraged firms in the specification reported in column (3), suggesting that part of the estimated impact in column (3) reflects the impact of leverage on interest tax shields. This response falls to 0.28%p when I control for interest payments. In both cases, the effect of the interaction term is economically significant, given that the average tax payment rate (relative to value-added) across firms was 4.15% in the regression sample during the period 2004-2012. Also, increases in the debt level are associated with lower tax payment rates, suggesting that future tax revenues are expected to be low even during non-crisis periods with higher corporate debt.

Table A.8 further controls for other state variables interacted with time dummies and shows that the results for leverage are robust.[16] Similarly, Kalemli-Ozcan et al. (2020) find that highly-leveraged firms tend to invest less in response to the 2008 global financial shocks, using ORBIS-AMADEUS data matched to banks' balance sheets (available from BANKSCOPE and ECB confidential data). Importantly, they show that corporate leverage is an important variable in accounting for sluggish post-crisis investment even after controlling for the bank lending channel using information on firm-bank relationships. This finding suggests that corporate indebtedness might also explain the behavior of firms' tax payments even after controlling for changes in banks' balance sheets.

[16] Using an alternative leverage measure such as a debt-to-tangible-fixed-assets ratio does not change the results.

1.4 Model, Mechanism, and Identifying Externalities

1.4.1 Competitive Equilibrium

1.4.1.1 Firms

A continuum of firms with unit measure operate with a production function $F(z_t, k_t^i) = z_t(k_t^i)^\alpha$, where z_t is aggregate productivity, and k_t^i and b_t^i are firm-specific capital and one-period non-state-contingent debt, respectively. i refers to firms, and t is time. For notational simplicity, I omit superscripts i for firm variables unless stated otherwise. As discussed below, it is not necessary to track firm-specific capital k^i and debt b^i to infer the dynamics of aggregate variables, because all firms will choose the same levels of capital and debt. A firm's budget constraint is given by

$$e_t + b_t + i_t \leq (1 - \tau_t^y)F(z_t, k_t) + q(z_t, k_{t+1}, b_{t+1})b_{t+1} \tag{1.10}$$

where e_t are dividend payments, and investment is $i_t = k_{t+1} - (1-\delta)k_t$ with a depreciation rate δ. $q(\cdot)$ is the schedule of the firm's debt price, which is determined by risk-neutral investors factoring in firm default risk. Firms take this schedule as given. τ_t^y is a corporate income tax rate, which firms also take as given.

Key aggregate state variables are productivity, capital, corporate and government debt, and share purchases. I collect these state variables as $X = (z, k, b, B, s)$, which are sufficient statistics to determine the evolution of all relevant variables in this model. I assume that the supply of shares s is fixed at 1 for simplicity, which firms and the government internalize. Pension funds purchase these shares on behalf of households. Let x' denote the one-period ahead realization of the variable x. Firms' objective is to maximize the discounted flow benefits resulting from dividend payments e, as shown in the following recursive form:

$$V^f(k,b;X) = \max_{e,k',b'} \quad \phi(e) + \mathbb{E}\big[m(X,X') \max_{d'_i} \langle V^f(k',b';X'), \nu_i^{d\prime} \rangle\big] \tag{1.11}$$

subject to

$$e \leq (1-\tau^y)F(z,k) + (1-\delta)k - k' - b + q(z,k',b')b' \tag{1.12}$$

$$\phi(e) = e - \kappa(e-\bar{e})^2 \tag{1.13}$$

$$X' = \Gamma(X) \tag{1.14}$$

Firms take the stochastic discount factor $m(\cdot)$ as given. $\nu_i^{d\prime}$ is an idiosyncratic firm default shock ($i.i.d.$ across time and firms) capturing the benefit from defaulting next period, generated from the cumulative distribution function, $\Omega(\nu_{i,t+1}^d)$. This default shock represents the limited liability of the owners of firms, where owners get the value of $\nu_i^{d\prime}$ when they decide to default on their firms' debt and stop paying dividends to households and taxes to the government. Equation (1.13) captures frictions in equity adjustment as in Jermann and Quadrini (2012), where $\bar{e}$ is a steady-state level of dividend payments. Aggregate productivity z_{t+1} is drawn from the conditional cumulative distribution function, $\Pi(z_{t+1}|z_t)$. Stochastic variables belong to compact sets such that $\nu_{i,t+1}^d \in [\nu_{min}^d, \nu_{max}^d]$ and $z_{t+1} \in [z_{min}, z_{max}]$. Firms and the government choose their actions simultaneously, based on the forecast rule for aggregate state variables given by equation (1.14). Firms choose next period capital k_{t+1} and debt b_{t+1}, taking into account their effects on the firm debt price $q(z_t, k_{t+1}, b_{t+1})$ and their default cutoff $\bar{\nu}^d(k_{t+1}, b_{t+1}; X_{t+1})$ for each state z_{t+1}. The cutoff with regard to the firm default decision at time t is determined by

$$\bar{\nu}^d(k_t, b_t; X_t) \in \{\nu_t^d | V^f(k_t, b_t; X_t) = \nu_t^d\} \tag{1.15}$$

and the corresponding firm default decision rule is given by

$$d(k_t, b_t, \nu_{i,t}^d; X_t) = \begin{cases} 1 \text{ (default)}, \text{ if } \nu_{i,t}^d \geq \bar{\nu}^d(k_t, b_t; X_t) \\ 0 \text{ (repay)}, \text{ otherwise} \end{cases} \tag{1.16}$$

When a firm defaults, creditors take over the firm as new owners and continue business as usual, issuing new debt and making investment. I assume that the internal funds that would have been used for dividend payments e_t, income taxes $\tau_t^y F(z_t, k_t)$, and debt repayment b_t had the firm not defaulted are used to pay bankruptcy costs, implying the following budget constraint for defaulting firms:

$$\underbrace{e_t + \tau_t^y F(z_t, k_t) + b_t}_{\text{bankruptcy costs}} + i_t \leq F(z_t, k_t) + q(z_t, k_{t+1}, b_{t+1}) b_{t+1} \tag{1.17}$$

This budget constraint can be rewritten to be identical to the budget constraint (1.10) of non-defaulting firms, implying that the new owners of defaulting firms choose the same b_{t+1} and k_{t+1} as non-defaulting firms.[17] For this reason, firm-specific capital k^i and debt b^i need not be tracked to infer the dynamics of aggregate variables, and I can omit superscript i. Bankruptcy costs capture not only direct administrative costs but also broadly defined macroeconomic costs entailed by bankruptcies.[18]

I assume that there is no pass-through of sovereign default risk into the corporate sector,

[17] Gomes et al. (2016) adopt a similar setting for computational tractability.

[18] See Hotchkiss et al. (2008) for the overview of corporate bankruptcy costs. Benmelech et al. (2018) and Bernstein et al. (2019) empirically show that there exist spillover costs of bankruptcies affecting local economies.

and thus firm values $V^f(k,b;X)$ are independent of government debt B. This assumption implies that firm default decisions and debt prices do not depend on government debt choices, such that $d_t = d(z_t, k_t, b_t, \nu^d_{i,t})$.

I use λ_t to denote the Lagrange multiplier on the firm budget constraint (1.12), where it can be interpreted as the shadow value of marginal funds. Henceforth, I assume that first-order conditions are neccesary and sufficient and that all allocations are interior, implicitly imposing regularity assumptions such as concavity, monotonicity, and Inada conditions on $F(\cdot)$. Also, debt price functions are assumed to be differentiable. The optimality conditions for dividends, capital, and debt are as follows:

$$e_t \; :: \qquad \lambda_t = \phi_e(e_t) \tag{1.18}$$

$$k_{t+1} \; :: \qquad \Big[1 - \frac{\partial q(z_t, k_{t+1}, b_{t+1})}{\partial k_{t+1}} b_{t+1}\Big]\lambda_t = \int_{z_{min}}^{z_{max}} \int_{\nu^d_{min}}^{\bar{\nu}^d(X_{t+1})} \Big[m(X_t, X_{t+1})\big((1-\tau^y_{t+1})F_k(z_{t+1}, k_{t+1}) + 1 - \delta\big)\lambda_{t+1}\Big] d\Omega(\nu^d_{i,t+1}) d\Pi(z_{t+1}|z_t) \tag{1.19}$$

$$b_{t+1} \; :: \qquad \Big[\frac{\partial[q(z_t, k_{t+1}, b_{t+1})b_{t+1}]}{\partial b_{t+1}}\Big]\lambda_t = \int_{z_{min}}^{z_{max}} \int_{\nu^d_{min}}^{\bar{\nu}^d(X_{t+1})} \Big[m(X_t, X_{t+1})\lambda_{t+1}\Big] d\Omega(\nu^d_{i,t+1}) d\Pi(z_{t+1}|z_t) \tag{1.20}$$

Equation (1.18) shows that the shadow value of marginal funds must at an optimum equal the marginal equity adjustment cost, $\phi_e(e_t) = 1 - 2\kappa(e - \bar{e})$. The left-hand side of equation (1.19) represents the marginal cost of investment, incorporating the effect of additional capital on the firm debt price and the shadow value of current funds λ_t. The right-hand side of the same equation captures the expected discounted marginal product of capital conditional on no firm default, adjusting for the shadow value of future funds λ_{t+1}. Firms choose capital so that the marginal cost equals the marginal benefit. Equation (1.20) shows that firms choose debt so that the marginal benefit of the additional funds that they can raise today equals the marginal cost of expected discounted debt payments conditional on no firm default, adjusting for the shadow values of funds today and tomorrow.

Risk-neutral lenders' profit from making a loan to the firm is given by

$$\pi_t = -q(z_t, k_{t+1}, b_{t+1})b_{t+1} + \frac{1 - \int_{z_{min}}^{z_{max}} \mu(z_{t+1}, k_{t+1}, b_{t+1}) d\Pi(z_{t+1}|z_t)}{1+r} b_{t+1} \tag{1.21}$$

where $\mu(z_{t+1}, k_{t+1}, b_{t+1}) = \int_{\bar{\nu}^d(z_{t+1},k_{t+1},b_{t+1})}^{\nu^d_{max}} d\Omega(\nu^d_{i,t+1})$ is the default probability of the firm in the next period for each state z_{t+1}, and r is the risk-free rate. The zero-profit condition $\pi_t = 0$ pins down the firm debt price $q(\cdot)$.

1.4.1.2 The Government

The government's objective is to maximize households' utility taking into account the costs of government default. For simplicity, the corporate income tax rate τ^y is fixed exogenously and is not a choice variable of the government. The government chooses transfer payments G and government debt B' and chooses whether to default D' as follows:

$$V^g(B; X) = \max_{G,B'} \quad u(C) + \beta \mathbb{E} \max_{D'} \left\langle V^g(B'; X'), V^g(0; X') - \xi' \right\rangle \tag{1.22}$$

subject to the dividend equation (1.12) and

$$C = s\big([1 - \mu(z,k,b)]\phi(e) + p\big) - s'p + G \tag{1.23}$$

$$G + B \leq (1 - \mu(z,k,b))\tau^y F(z,k) + Q(z,k',b',B')B' \tag{1.24}$$

$$X' = \Gamma(X) \tag{1.25}$$

$$p = p(X, X') \tag{1.26}$$

where ξ is an *i.i.d.* government default cost shock, which is microfounded in standard sovereign default models as reputation costs or punishment by creditors. Households hold shares of firms s_t which pay dividends net of equity adjustment costs $\phi(e_t)$ and can be sold at a price p_t. Shares issued by defaulting firms pay zero dividends. G_t are lump-sum transfers (or taxes) to households from the government.[19] The fraction of defaulting firms $\mu(z,k,b)$ equals the firm default probability, determined by firms' optimality conditions, as the law of large numbers holds with a continuum of firms. In equation (1.24), the government collects taxes $(1-\mu(z,k,b))\tau^y F(z,k)$ from non-defaulting firms and issues one-period non-state-contingent debt B' at a price Q. The government forecasts aggregate state variables using equation (1.25). The share price equation (1.26) is determined by the pension funds' problem described later.

When the government defaults, its debt obligation becomes zero, $B'=0$, and the government continues with a value of $V^g(B'=0;X')$ but pays default costs ξ'. The threshold government default cost shock $\bar{\xi}$ with regard to government default D at time t is

$$\bar{\xi}(B_t;X_t) \in \left\{\xi_t | V^g(B_t;X_t) = V^g(0;X_t) - \xi_t\right\} \tag{1.27}$$

and the corresponding government default decision rule is given by

$$D(B_t,\xi_t;X_t) = \begin{cases} 1 \text{ (default)}, \text{ if } \xi_t \leq \bar{\xi}(B_t;X_t) \\ 0 \text{ (repay)}, \text{ otherwise} \end{cases} \tag{1.28}$$

[19] The government could finance a fixed path of final good spending instead of financing transfers. However, this assumption would generate distortions – due to changes in tax rates needed to finance the exogenous government expenditure – that the Ramsey planner would need to address. The objective of this paper is to study optimal policy to address externalities, rather than distortions that arise in a public finance problem without lump-sum taxes, and hence I abstract from this traditional public finance problem.

The government debt is priced by risk-neutral competitive lenders as below:

$$Q(z_t, k_{t+1}, b_{t+1}, B_{t+1}) = \frac{1 - \int_{z_{t+1}} \int_{\xi_{t+1}} D(B_{t+1}, \xi_{t+1}; X_{t+1}) d\Pi(z_{t+1}|z_t) d\Xi(\xi_{t+1})}{1+r} \tag{1.29}$$

where Π and Ξ are cumulative distributive functions for productivity and government default costs, respectively.

The associated government spread is

$$SPRD(z_t, k_{t+1}, b_{t+1}, B_{t+1}) = \frac{1}{Q(z_t, k_{t+1}, b_{t+1}, B_{t+1})} - (1+r) \tag{1.30}$$

The government takes into account its effects on the default cutoff $\bar{\xi}(B_t; X_t)$. The optimality condition for government debt B_{t+1} is given by

$$B_{t+1} :: \frac{\partial [Q(z_t, k_{t+1}, b_{t+1}, B_{t+1}) B_{t+1}]}{\partial B_{t+1}} u'(C_t) = \beta \Big[\int_{z_{min}}^{z_{max}} \int_{\bar{\xi}(X_{t+1})}^{\xi_{max}} u'(C_{t+1}) \Big] d\Pi(z_{t+1}|z_t) d\Xi(\xi_{t+1}) \tag{1.31}$$

The left-hand side of equation (1.31) shows the marginal benefit of financing additional household consumption with the marginal funds raised by government borrowing, accounting for the impact of government borrowing on its bond price. The right-hand side represents the expected discounted marginal cost of paying debt and the resulting decreases in households' future consumption, conditional on no government default. These benefits and costs are measured in terms of households' marginal utility $u'(C)$.

1.4.1.3 Pension Funds

Pension funds purchase shares s_{t+1} on behalf of households to maximize the households' utility, defined as in the government problem, after firms choose their capital k_{t+1} and debt b_{t+1}, and the government chooses its debt B_{t+1} and expenditure G_t. This pension fund problem is given by

$$V^g(B;X) = \max_{s'} \quad u(C) + \beta \mathbb{E} \max_{D'} \left\langle V^g(B';X'), V^g(0;X') - \xi \right\rangle \tag{1.32}$$

subject to the dividend equation (1.12), equity adjustment costs (1.13), and the household budget constraint (1.23), where k', b', B', G are taken as given by pension funds.[20]

The pension funds' first-order condition with regard to s' gives the following share price equation:

$$p(X,X') = \int_{z_{min}}^{z_{max}} \int_{\xi_{min}}^{\xi_{max}} m(X,X') \left[[1 - \mu(z',k',b')]\phi(e') + p(X',X'') \right] d\Pi(z'|z) d\Xi(\xi') \tag{1.33}$$

where $m(X,X') = \beta \frac{u'(C')}{u'(C)}$ is a stochastic discount factor. It can be shown that this stochastic discount factor is identical to the one found in the firm value function (1.11), in which firms maximize the shareholders' net present value of $\phi(e) + p(X,X')$.

1.4.1.4 Equilibrium

The equity market clears in equilibrium as follows:

$$s_t = 1 \tag{1.34}$$

where each firm issues one unit of shares to households for every period t, and in turn

[20] Households could instead purchase shares directly, and the main results would not change. The purpose of having pension funds is to show the case in which the first welfare theorem holds without firm and government default risk (and without tax distortions), when the social planner's objective is to maximize households' utility after adjusting for government default costs. Pension funds take into account government default costs on top of households' utility as the social planner does, which is the reason why pension funds are required to compare market allocations with social planner's allocations.

total share supply is 1 since there is a continuum of firms with unit measure. I define a recursive competitive equilibrium of the model as follows.

Definition 1. *A recursive competitive equilibrium consists of firms' equity value* $\{V^f(X)\}$ *and policies* $\{e(X), k'(X), b'(X), d'(X)\}$*, the government's value* $V^g(X)$ *and its policies* $\{B'(X), D'(X), G(X)\}$*, households' policy* $\{C(X)\}$*, the pension funds' policy* $\{s'(X)\}$ *and the associated share price equation* $\{p(X, X')\}$*, debt prices* $\{q(z, k', b'), Q(z, k', b', B')\}$ *and the fraction of defaulting firms* $\{\mu(X)\}$*, and a stochastic discount factor* $\{m(X, X')\}$*, given the corporate income tax rate* $\{\tau^y\}$ *and laws of motion for aggregate productivity* z*, firm default shocks* ν_i^d*, and the government default cost shocks* ξ*, such that (a) firms' policies and equity value solve (1.11); (b) the government solves (1.22); (c) pension funds solve (1.32); (d) the equity market clears,* $s(X) = 1$*; (e) the stochastic discount factor for firms is given by the households' marginal rate of substitution,* $m(X, X') = \beta \frac{u'(C')}{u'(C)}$*; (f) the law of large numbers holds,* $\mu(X) = \int_{\bar{\nu}^d(X)}^{\nu_{max}^d} d\Omega(\nu_i^d)$*; and (g) the actual law of motion for the aggregate variables* X *is consistent with the forecasting rule (1.14) and stochastic processes for* z*,* ν_i^d*, and* ξ*.*

1.4.2 Corporate-Sovereign Debt Nexus

Government tax revenue in the next period is given by

$$TR_{t+1} = [1 - \mu(z_{t+1}, k_{t+1}, b_{t+1})][\tau_{t+1}^y F(z_{t+1}, k_{t+1})] \tag{1.35}$$

Rising corporate debt implies higher firm default risk μ_{t+1} and lower expected tax revenues $\mathbb{E}_t[TR_{t+1}]$. The following proposition states that expected future tax revenue falls when corporate debt increases today.

Proposition 1. *The distribution of tax revenue* TR_{t+1} *in an economy with low firm debt* b_{t+1} *first-order stochastically dominates the one in an economy with high firm debt* b_{t+1}*. This implies that the realization of tax revenue* TR_{t+1} *with higher firm debt* b_{t+1} *is lower over the* *entire distribution of subsequent shocks to productivity z_{t+1}.*

Proof. See Appendix A □

When tax revenue decreases, the government might not be able to finance transfers that are essential to households. Transfers to households are essential, especially when the marginal utility of consumption for households is high in bad times. The government is thus more likely to prioritize transfers to households by defaulting on debt during bad times. Hence, government default serves as an insurance device to households. Moreover, households are more likely to have a high marginal utility of consumption when more firms default, since defaulting firms do not pay dividends and impose bankruptcy costs on the economy. The following proposition formalizes this risk spillover from the corporate sector to the government.

Proposition 2. *Suppose surviving firms pay non-negative net dividends $\phi(e_t) \geq 0$. If firm debt b_{t+1} increases, firm default risk $\mu(z_{t+1}, k_{t+1}, b_{t+1})$ (weakly) rises, and the government debt price $Q(z_t, k_{t+1}, b_{t+1}, B_{t+1})$ (weakly) decreases (the government spread increases).*

Proof. See Appendix B □

The causal linkage that rising corporate debt implies higher sovereign risk is reinforced by overborrowing externalities. I now identify externalities by comparing the market allocations of the competitive equilibrium with the constrained-efficient allocations.

1.4.3 Constrained Efficiency

1.4.3.1 Constrained Social Planner

I consider a constrained social planner who can choose $\{k_{t+1}, b_{t+1}, e_t, B_{t+1}, D_{t+1}\}$ directly, but who is constrained to allow firms to choose whether to default or not, and faces the equity adjustment cost (1.13) as well as risk-neutral debt price schedules. The social planner's problem is as follows:

$$V^g(k,b,B;z) = \max_{k',b',e,B'} \quad u(C) + \beta \mathbb{E} \max_{D'} \left\langle V^g(k',b',B';z'), V^g(k',b',0;z') - \xi' \right\rangle \tag{1.36}$$

subject to

$$\begin{aligned} C =& [1-\mu(z,k,b)]\big(F(z,k) + (1-\delta)k - k' - b + q(z,k',b')b' - \kappa(e-\bar{e})^2\big) \\ &+ Q(z,k',b',B')B' - B \end{aligned} \tag{1.37}$$

where the fraction of defaulting firms, $\mu(z,k,b) = \int_{\bar{\nu}^d(X_t)}^{\nu^d_{max}} d\Omega(\nu^d_{i,t})$, and the firm bond price, $q(z,k',b')$, are determined by (1.15), (1.16) and the associated pricing equation (1.21); the government bond price $Q(z,k',b',B')$ is determined by government default decisions according to equations (1.27) and (1.28), and the associated pricing equation (1.29); the resource constraint (1.37) combines budget constraints of firms (1.12), households (1.23), and the government (1.24); and the equity market clearing condition is given by $s = s' = 1$.

I focus on the allocations for key state variables $\{k_{t+1}, b_{t+1}, B_{t+1}\}$, which together with aggregate productivity z_{t+1} summarize all allocations in the recursive problem. For convenience, define firms' cash on hand before taxes as $e^{SP} = F(z,k) + (1-\delta)k - k' - b + q(z,k',b')b'$. The optimality conditions from the social planner's problem are as follows:

$$
k_{t+1} \;::\; \underbrace{\Big(1-\frac{\partial q(z_t,k_{t+1},b_{t+1})}{\partial k_{t+1}}b_{t+1}\Big)}_{\text{private marginal cost of capital}}\underbrace{\big(1-\mu(z_t,k_t,b_t)\big)}_{\text{externality}}-\underbrace{\frac{\partial Q(z_t,k_{t+1},b_{t+1},B_{t+1})}{\partial k_{t+1}}B_{t+1}}_{\text{externality}}
$$

$$
=\int_{z_{min}}^{z_{max}}\int_{\xi_{min}}^{\xi_{max}} m(X_t,X_{t+1})\Big[\underbrace{\big(1-\mu(z_{t+1},k_{t+1},b_{t+1})\big)\big(F_k(z_{t+1},k_{t+1})+1-\delta\big)}_{\text{private marginal product of capital without income taxes}}
$$

$$
-\underbrace{\frac{\partial \mu(z_{t+1},k_{t+1},b_{t+1})}{\partial k_{t+1}}e^{SP}_{t+1}}_{\text{externality}}\Big]d\Pi(z_{t+1}|z_t)d\Xi(\xi_{t+1}) \tag{1.38}
$$

$$
b_{t+1} \;::\; \underbrace{\frac{\partial[q(z_t,k_{t+1},b_{t+1})b_{t+1}]}{\partial b_{t+1}}}_{\text{private marginal benefit of borrowing}}\times\underbrace{\big(1-\mu(z_t,k_t,b_t)\big)}_{\text{externality}}+\underbrace{\frac{\partial Q(z_t,k_{t+1},b_{t+1},B_{t+1})}{\partial b_{t+1}}B_{t+1}}_{\text{externality}}= \tag{1.39}
$$

$$
\int_{z_{min}}^{z_{max}}\int_{\xi_{min}}^{\xi_{max}} m(X_t,X_{t+1})\Big[\underbrace{1-\mu(z_{t+1},k_{t+1},b_{t+1})}_{\text{private marginal cost of borrowing}}
$$

$$
+\underbrace{\frac{\partial \mu(z_{t+1},k_{t+1},b_{t+1})}{\partial b_{t+1}}e^{SP}_{t+1}}_{\text{externality}}\Big]d\Pi(z_{t+1}|z_t)d\Xi(\xi_{t+1})
$$

$$
B_{t+1} \;::\; \frac{\partial[Q(z_t,k_{t+1},b_{t+1},B_{t+1})B_{t+1}]}{\partial B_{t+1}}u'(C_t)=\beta\int_{z_{min}}^{z_{max}}\int_{\bar{\xi}(X_{t+1})}^{\xi_{max}}u'(C_{t+1})d\Pi(z_{t+1}|z_t)d\Xi(\xi_{t+1}) \tag{1.40}
$$

where the social planner optimally sets $e=\bar{e}$ to minimize equity adjustment costs. Comparing the social planner's optimality conditions (1.38) and (1.39) with their market counterparts (1.19) and (1.20), the externality terms in (1.38) and (1.39) show that firms do not internalize the effects of their capital and debt choices on the future equilibrium firm default rate μ_{t+1} and the associated total bankruptcy costs resulting from more firm defaults given their limited liability. Also, firms do not internalize their effects on bankruptcy costs of each firm given the current firm default rate μ_t. The limited liability externality is distinct from externalities identified in the previous literature on optimal macroprudential policy in the sense that the externality terms due to firm default risk do not disappear even when firms internalize their effects on the firm debt price. In this setting, firm default serves as a put option for firms, and in turn firms are likely to take more risk than is socially optimal. In contrast, the pecuniary externality in Bianchi (2011) and related literature exists because firms do not internalize their effects on asset prices that determine the tightness of their borrowing constraints. Also, in my model, firms do not internalize their effects on the government bond price Q, which appear as externality terms in conditions (1.38) and (1.39). In these terms, $\frac{\partial Q_{t+1}}{\partial k_{t+1}}$ and $\frac{\partial Q_{t+1}}{\partial b_{t+1}}$ are not zero. The reason is that Q does not enter the firms' budget constraint. Without limited liability, externality terms regarding firm default rates μ_t and μ_{t+1} would disappear. Without limited liability and government default risk, all externality terms would disappear. The government's optimality condition (1.40) is identical to condition (1.31) in the competitive equilibrium. The fraction of defaulting firms in the next period $1 - \mu_{t+1}$ is a part of the private marginal product of capital or marginal cost of borrowing, since firms take into account their default probabilities, which equal $1 - \mu_{t+1}$ due to the law of large numbers.

1.4.4 Optimal Policy

1.4.4.1 Regulated Competitive Equilibrium

Next, I consider a decentralized economy in which debt taxes τ^b, transfers to firms T, and investment credits τ^k can be implemented. The Ramsey planner (or the government) chooses its policies $(\tau_t^b, T_t, \tau_t^k)$ first, and then firms choose their actions taking policies as given. The firms' budget constraint is given by

$$e_t = (1 - \tau_t^y)F(z_t, k_t) + (1 - \delta)k_t - (1 - \tau_t^k)k_{t+1} - b_t + (q(z_t, k_{t+1}, b_{t+1}) - \tau_t^b)b_{t+1} + T_t \tag{1.41}$$

where the path of the corporate income tax rate τ_t^y is exogenous and taken as given.[21]

Firms' optimality conditions for k_{t+1} and b_{t+1} are given by

$$k_{t+1} \;::\; [1-\tau_t^k - \frac{\partial q(z_t,k_{t+1},b_{t+1})}{\partial k_{t+1}} b_{t+1}]\lambda_t = \int_{z_{min}}^{z_{max}} \int_{\nu_{min}^d}^{\bar{\nu}^d(X_{t+1})} \Big[m(X_t,X_{t+1})\big((1-\tau_{t+1}^y)F_k(z_{t+1},k_{t+1}) + (1-\delta)\big)\lambda_{t+1}\Big] d\Omega(\nu_{i,t+1}^d) d\Pi(z_{t+1}|z_t) \quad (1.42)$$

$$b_{t+1} \;::\; \Big(\frac{\partial[q(z_t,k_{t+1},b_{t+1})b_{t+1}]}{\partial b_{t+1}} - \tau_t^b\Big)\lambda_t = \int_{z_{min}}^{z_{max}} \int_{\nu_{min}^d}^{\bar{\nu}^d(X_{t+1})} \Big[m(X_t,X_{t+1})\lambda_{t+1}\Big] d\Omega(\nu_{i,t+1}^d) d\Pi(z_{t+1}|z_t) \quad (1.43)$$

The government budget constraint is

$$B_t + G_t = \big(1-\mu(z_t,k_t,b_t)\big)[\tau_t^y F(z_t,k_t) - \tau_t^k k_{t+1} + \tau_t^b b_{t+1} - T_t] + Q(z_t,k_{t+1},b_{t+1},B_{t+1})B_{t+1} \quad (1.44)$$

where firms cannot receive investment credits $\tau_t^k k_{t+1}$ or transfers T_t if they default on income taxes $\tau_t^y F(z_t,k_t)$ and debt taxes $\tau_t^b b_{t+1}$.

By combining (1.41), (1.44), and the household budget constraint (1.23), I get the associated resource constraint as follows:

$$C_t = (1-\mu(z_t,k_t,b_t))\big[F(z_t,k_t) + (1-\delta)k_t - k_{t+1} - b_t + q(z_t,k_{t+1},b_{t+1})b_{t+1} - \kappa(e_t-\bar{e})^2\big] + Q(z_t,k_{t+1},b_{t+1},B_{t+1})B_{t+1} - B_t \quad (1.45)$$

[21] The corporate income tax rate τ_t^y could also be implemented optimally by a planner. Rather, I assume that τ_t^y follows a fixed path to consider the case when transfers T_t are flexibly adjusted by the planner, which belongs to a more realistic set of policies.

This equation is identical to the resource constraint that the social planner faces. The following definitions and proposition characterize the Ramsey planner's policy.

Definition 2. *A regulated competitive equilibrium is a sequence of prices* $\{q_t, Q_t, p_t\}$*, allocations* $\{e_t, k_{t+1}, b_{t+1}, d^i_{t+1}, C_t, s_{t+1}\}$*, and government policies* $\{\tau^y_t, T_t, \tau^k_t, \tau^b_t, B_{t+1}, D_{t+1}, G_t\}$ *such that (i) the modified firms' budget constraint* (1.41) *and firm optimality conditions* (1.42) *and* (1.43) *are satisfied; (ii) the modified government budget constraint* (1.44) *is satisfied; and (iii) all remaining conditions defined in the competitive equilibrium (Definition 1) are satisfied.*

Definition 3. *The Ramsey problem is to solve the problem* (1.22) *over the regulated competitive equilibrium by setting optimal paths for policy instruments* $\{T_t, \tau^k_t, \tau^b_t, B_{t+1}, D_{t+1}, G_t\}$ *given the path of the corporate income tax rate* $\{\tau^y_t\}$*.*

Proposition 3. *The Ramsey planner implements policies* $\{T_t, \tau^k_t, \tau^b_t, B_{t+1}, D_{t+1}, G_t\}$ *such that the outcome of the Ramsey problem solves the problem of the constrained social planner* (1.36)*. The implemented set of policies is time-consistent.*

Proof. See Appendix C □

Notice that the Ramsey planner and the social planner face common constraints, including the firm and government debt pricing equations and equity adjustment costs. The only difference is that the social planner can directly allocate firm capital $\{k_t\}$, debt $\{b_t\}$, and dividends $\{e_t\}$, while the Ramsey planner indirectly chooses the path of these three variables mainly by adjusting three policy instruments $\{\tau^k_t, \tau^b_t, T_t\}$. Thus, it can be shown that the Ramsey planner solves the social planner's problem, which leads to Pareto-optimal allocations under the common constraints. Optimal policies $\{\tau^k_t, \tau^b_t, T_t\}$ are obtained by plugging the social planner's allocations into the optimality conditions ((1.42) and (1.43)) and the firms' budget constraint (1.41). These are time-consistent policies because the policy functions are solutions to the recursive equilibrium, which implies that optimal paths for policies are invariant in every period. These policies are also called Markov stationary policies, as the planner does not have the incentive to deviate from policy rules determined by a Markov perfect equilibrium.[22]

1.4.5 Discussion of Assumptions

1. I have assumed that there is no pass through of the sovereign debt price $Q(\cdot)$ into the private capital market, to highlight the key mechanism causally linking corporate debt to sovereign spreads. This assumption is also consistent with my empirical analysis, in which I exclude post-crisis observations and use instrumental variables to overcome reverse causality running from sovereign spreads to corporate debt. This assumption can be relaxed by allowing firms to lose access to financial markets when the government defaults, as in Mendoza and Yue (2012). This setting will generate an endogenous firm debt price that decreases in government debt, generating endogenous costs of government default. These endogenous government default costs will be another externality that firms do not internalize.

2. I have assumed that $\nu_i^{d\prime}$ is an *i.i.d.* firm default shock for computational tractability. As in D'Erasmo and Boedo (2012), this assumption can be relaxed so that firms compare the continuation value of repayment against the value of liquidating capital and defaulting. However, relaxing this assumption is not likely to change the results, as liquidation also serves as a put option for firms and encourages overborrowing.

3. I have assumed that ξ represents the costs of repudiating government debt. While costs of default can be microfounded, exogenous default costs are commonly used in the literature to represent default costs associated with reputation, roll-over risk, and other factors in a reduced-form way (see, for example, Arellano et al. (2020)).

4. I have abstracted from labor income taxes and capital adjustment costs. In the next

[22] See Bianchi and Mendoza (2018) for more discussions about the properties of both time-consistent macroprudential policies and time-inconsistent policies under commitment.

section, I add labor income tax revenues and firms' capital adjustment costs to the quantitative model in a simple way.

1.5 Quantitative Model and Policy Analysis

1.5.1 Additional Ingredients

To better explain the data, I add additional ingredients to the model including capital adjustment costs, labor income, and debt recovery rates. Capital adjustment costs paid by firms are given by

$$\Psi(k_t, k_{t+1}) = \psi k_t \Big(\frac{k_{t+1} - (1-\delta)k_t}{k_t}\Big)^2 \tag{1.46}$$

Firms pay the fraction θ of output $F(z,k)$ to households as wages, which are not defaultable. The government receives labor income taxes $\tau^l \theta F(z,k)$ from households. Investors get fractions R^f and R^g of defaulted debt from firms and the government, respectively. Also, for computational tractability, I assume that the firms' stochastic discount factor is given by $m(X, X') = \beta$. This type of assumption on stochastic discount factors is common in the small open economy literature in that the discount factor is not fully determined by domestic factors. The productivity process is as follows:

$$log(z_{t+1}) = \mu_z + \rho_z log(z_t) + \sigma_z u_{t+1} \tag{1.47}$$

where u_{t+1} follows a standard normal distribution, and $\mu_z = \frac{-\sigma_z^2}{2(1+\rho_z)}$ so that the level of z equals one on average.

In a similar fashion to Arellano (2008), I assume that investors price government debt as follows:

$$Q(z_t, k_{t+1}, b_{t+1}, B_{t+1}) =$$
$$\int_{z_{t+1}} \int_{\xi_{t+1}} M(z_{t+1}, z_t)[1 - (1 - R^g)D(B_{t+1}, \xi_{t+1}; X_{t+1})] d\Pi(z_{t+1}|z_t) d\Xi(\xi_{t+1}) \tag{1.48}$$

where $M(z_{t+1}, z_t) = \frac{1}{1+r} - \gamma v_{t+1}$ is a stochastic discount factor, and v_{t+1} is productivity growth, $log(z_{t+1}) - log(z_t)$. γ is non-negative and represents the sensitivity of the investors' sentiment to productivity shocks. This assumption implies that debt repayments in relatively bad states are more valuable to investors than those in good states.

1.5.2 Numerical Solution

I solve the model using value function iteration. Key state variables $X = (z, k, b, B)$ are discretized so that firms and the government choose their actions out of a finite set of options. The potential challenge facing this solution method is that the existence of equilibrium is not guaranteed when two types of players move simultaneously and can only use pure strategies. To overcome this problem and improve the convergence of the algorithm, I adopt a discrete choice model with taste shocks such that firms and the government can assign probabilities to their actions. To be specific, I add taste shocks ϵ' associated with the choice of capital k', firm debt b', and firm default d' to firms' value functions, and taste shocks ϵ' associated with the choice of government debt B' to the government's value function. Firms and the government choose the probability of taking certain actions out of their choice set before taste shocks are realized. Realized taste shocks determine the actual actions of firms and the government. This type of algorithm has recently been formalized by Dvorkin et al. (forthcoming). See Appendix D for more details.

1.5.3 Calibration

The model is solved for the competitive equilibrium and calibrated to six European countries during the period 2000-2012. The six countries are those included in the main IV spread regression. Table 1.7 presents the parameter values assigned for the quantitative model. First, I set four structural parameters following the standard literature. The capital income share α and labor income share θ are set to 0.35 and 0.5, respectively. Households' preferences are given by the following CRRA utility function:

$$u(C_t) = \frac{C_t^{1-\nu}}{1-\nu} \tag{1.49}$$

where I assume a risk aversion parameter ν of 2. The capital depreciation rate δ is set to 0.06 at an annual frequency. Following Arellano et al. (2019), corporate and government discount factors β and β_g are set to 0.98 and 0.90, respectively, as governments are usually considered less patient than the private sector.[23] As firms are more patient than the government, the overborrowing problem for firms is less severe, and thus welfare gains from correcting overborrowing externalities are lower with this parameterization. The annual risk-free rate is set to 1.9 percent, which is the average German nominal interest rate minus the average inflation rate of the six sample countries during 2000-2012. The corporate income tax rate is set to 32.7 percent, using the average combined income tax rates of the six sample countries during 2000-2012 (OECD corporate tax statistics database).[24] The government debt recovery rate R^g is set to 63 percent, based on the average global government debt haircut ratio (Cruces and Trebesch, 2013), and the corporate debt recovery rate R^f is set to 70 percent, based on the average debt recovery rate for the six sample countries (World Bank Doing Business database).[25] I set the equity issuance cost parameter κ to 0.426 following

[23] In Panel A of Table 1.10, I redo main exercises using identicial discount factors ($\beta = \beta_g = 0.98$). Later, I explain that main results (including welfare implications of policies) do not change with this alternative parameterization.

[24] OECD (2020), Corporate Tax Statistics Database, https://www.oecd.org/tax/beps/corporate-tax-statistics-database.htm

[25] World Bank (2020), Doing Business 2020, https://www.doingbusiness.org/

Jermann and Quadrini (2012). The volatility of taste shocks is set to 0.001, a sufficiently small number such that solutions to the model with taste shocks are close to those without taste shocks. This parameter value is commonly used in the literature (see Dvorkin et al. (forthcoming)).

As shown in Panel B of Table 1.7, I set the remaining parameters by matching moments observed in data to those obtained in the model simulation. I set the persistence of the productivity process ρ_z by targeting the autocorrelation of log GDP, where the autocorrelation is obtained by regressing log real GDP on its own lag (after pooling country-year observations of the sample six countries and controlling for country fixed effects). Productivity volatility σ_z is set to match the standard deviation of the same data on log GDP. I set the capital adjustment cost parameter ϕ by targeting the standard deviation of log gross fixed assets (divided by the GDP deflator) of the six sample countries (after pooling country-year observations and controlling for country fixed effects). The log GDP series and log gross fixed assets are initially detrended using the Hamilton (2018) filter. The mean parameter of the corporate default shock ν^d is set to target the average corporate spread of Euro area non-financial corporate bonds during the period 2000-2012, using spread data (Euro area Bund NFC) obtained from Gilchrist and Mojon (2017). Similarly, the mean and standard deviation of the government default cost ξ are set by targeting the mean and standard deviation of government spreads for the six sample countries during the period 2000-2012. To better match the standard deviation of government spreads, I adjust the sensitivity of investors' sentiment γ.[26]

Table 1.8 presents moments calculated from model simulations and data. To obtain model moments, I simulate the model economy for 10,000 periods and take averages of moments from 1,000 simulations after dropping the first 500 periods and excluding periods

[26] Aguiar et al. (2016) find that increases in the standard deviation of government spreads are associated with increases in the average government spread in standard sovereign default models, and it is difficult to match both the mean and standard deviation without modeling a time-varying risk premium. As shown by Chatterjee and Eyigungor (2012), adding long-duration bonds and asymmetric output costs caused by government default can solve this puzzle in an endowment economy.

of government default for each simulation. All targeted moments from the model and data are close to each other. The table also shows non-targeted moments from the simulations and data, which are reasonably close to each other. For example, the annual corporate default rate is 4.4% in the model and 4.1% in the data.[27] Also, the government default rate is 1.9% in the model and 1.5% in data.[28] I reproduce the government spread regression using simulated data, treating variables in the same way as in the actual data. I report the 5th and 95th percentiles of the model-simulated estimates out of 1,000 simulations in brackets, together with their median reported above the brackets. The model-implied regression coefficients qualitatively match the main regression coefficients from column 1 of Table 1.4, confirming that this model is a good representation of the data generating process.

I quantify the magnitude of overborrowing externalities using the optimality condition for firm borrowing b' presented in equation (1.39). I calculate each term in equation (1.50) (shown below), using the model simulations in the competitive equilibrium as before, and I obtain the values for each term as the average across simulations. I normalize these values so that the private marginal benefit and cost of borrowing are 100, respectively. The social marginal benefit of borrowing is the sum of (i) the private marginal benefit, (ii) the externality associated with increasing the bankruptcy costs regarding debt issuance of each firm given the current firm default rate μ_t (externality A), and (iii) the externality associated with the falling government debt price (externality B). I find that the social marginal benefit of borrowing is about 5.1% lower than the private marginal benefit, and that externality A accounts for about 84% of this difference (=4.3/5.1), while externality B only explains 16%. At the same time, the social marginal cost of borrowing is 2.8% higher than the private marginal cost, where this difference is due soley to the externality term associated with the rising future firm default rate μ_{t+1} and the resulting increase in bankruptcy costs (externality C). These results show that externality terms (A and C) associated with firm

[27] The annual corporate default rate in the data is measured as the historical global corporate default rate (speculative-grade) obtained from Moody's (2020).

[28] The government default rate in the data is the average default rate of the six sample Eurozone countries during 1900–2014, calculated using Table 6.4 of Reinhart and Rogoff (2009a).

default drive most of the overborrowing externalities quantitatively, while externality B – directly associated with the government bond price – does not play a large role. Without the limited liability associated with the firm default shock ν_i^d, the externality terms A and C would disappear. Wu (2020) focuses on externality B without allowing for limited liability of firms.

$$\overbrace{\underbrace{\frac{\partial[q(z_t,k_{t+1},b_{t+1})b_{t+1}]}{\partial b_{t+1}}}_{\text{private marginal benefit = 100}} \underbrace{-\mu(z_t,k_t,b_t)\frac{\partial[q(z_t,k_{t+1},b_{t+1})b_{t+1}]}{\partial b_{t+1}}}_{\text{externality A = -4.3}} + \underbrace{\frac{\partial Q(z_t,k_{t+1},b_{t+1},B_{t+1})}{\partial b_{t+1}}B_{t+1}}_{\text{externality B = -0.8}}}^{\text{social marginal benefit of borrowing = 94.9}}$$

$$= \mathbb{E}\Big\langle \overbrace{\Big[\underbrace{\beta\big(1-\mu(z_{t+1},k_{t+1},b_{t+1})\big)}_{\text{private marginal cost = 100}} + \underbrace{\beta\frac{\partial\mu(z_{t+1},k_{t+1},b_{t+1})}{\partial b_{t+1}}e_{t+1}^{SP}}_{\text{externality C = 2.8}}\Big]}^{\text{social marginal cost of borrowing = 102.8}}\Big\rangle \tag{1.50}$$

1.5.4 Decision Rules and Government Spread Functions

Figure 1.6 shows the equilibrium decision rules plotted against corporate debt. Firms choose a higher level of debt b_{t+1} when they have higher initial debt b_t, as firms need to borrow money to pay off existing debt. Firms choose to reduce the stock of capital k_{t+1} as they accumulate more debt, because the corporate debt price decreases due to rising default risk. Firms choose to pay constant dividends net of equity adjustment costs $\phi(e_t)$ regardless of their debt level, which reflects firms' dividend-smoothing motive. Firms' debt price q_t decreases with rising new debt issuance b_{t+1} due to the increase in firm default risk, as the probability of default $\mu(z_t,k_t,b_t)$ increases with debt b_t. The government chooses to issue more debt B_{t+1} when aggregate corporate debt b_t increases. The reason is that tax revenues decrease as more firms default, and the government is induced to finance transfers to households externally to smooth households' consumption.

Figure 1.7 presents government default probabilities and the associated government spread function as a function of the levels of next-period corporate and government debt.

Panel A shows that the government is more likely to default when next-period government or corporate debt is higher. The mechanism is as follows: With higher government debt, the government's value of defaulting increases, as it can finance a larger amount of transfers to households to increase households' consumption by repudiating its debt. Higher corporate debt increases the fraction of defaulting firms, which in turn reduces government tax revenue, while households receive fewer dividends from firms. This leads to lower consumption and gives the government more incentive to repudiate its debt to increase transfers to households. A higher government default probability is associated with higher government spreads, as investors need to be compensated for higher government default risk. Thus, as shown in Panel B, government spreads increase in both government and corporate debt. Interestingly, the government spread increases at a faster rate in government debt when corporate debt is higher. This is because households' consumption is lower when a larger fraction of firms stop paying taxes and dividends, so that the marginal gain from repudiating debt is higher for the government. At the same time, the government is willing to pay high interest rates to finance transfers to households when households are suffering from low consumption, and the government tends to increase its debt. These forces make the government spread more sensitive to rising government debt when the corporate debt level is higher.

1.5.5 Optimal Policy, Simple Debt Policies, and Welfare Gains

To explore model dynamics during a sovereign debt crisis, I perform an event study using the model. Using the solution to the competitive equilibrium, I simulate the economy for a million periods and drop the first 500 periods. I identify a period t as a sovereign debt crisis if government spreads at time t increase by more than three standard deviations of government spreads across all periods. Next, I obtain the paths of variables within each event window ranging from $t-5$ to $t+5$ and calculate the deviation of each variable from its average within each event window. I plot the average of the demeaned variables across event windows.

Figure 1.8 presents simulation results in the absence of macroprudential policy, alongside their data counterparts. I mark time t with the shaded area, which corresponds to the year 2012, when the average sovereign spread in the six sample countries peaked. In the model without macroprudential policy (blue dashed lines), output decreases by about 3% during the crisis, which matches the magnitude of the recession in the data.[29] In the model, investment and consumption drop by around 12% and 8%, respectively. The corporate debt-to-output ratio increases before the crisis. As a result, corporate spreads increase by more than 50 basis points, and the fraction of defaulting firms rises by more than 2%p. As more firms default, bankruptcy costs increase, and firms deleverage sharply, reducing consumption drastically. Furthermore, corporate income tax revenue decreases, and government spreads increase by around 150 basis points. At the same time, the government issues more debt to finance transfers to households (government expenditure), but the amount of transfers decreases in equilibrium due to higher government interest rates. This adds to the reduction in household consumption during the crisis. The sovereign debt crisis is associated with negative shocks to productivity. These model-simulated time series qualitatively match their data counterparts, although there are some differences in terms of the timing of shocks and the magnitude of responses. In the data, consumption does not decrease as much as implied by the model, possibly because of intervention by the European governments and the European Central Bank, as evidenced by rising government debt and sustained government expenditure during and after the crisis. The firm default rate peaks during the 2008-2009 global financial crisis in the data, in response to a large negative shock to total factor productivity during the same period. In contrast, the model implies that the negative productivity shock and the corresponding increase in the firm default rate occur in 2012.

Figure 1.9 plots these simulation results for economies with various policies in which

[29] Output is measured net of bankruptcy and equity adjustment costs, $F(z_t, k_t) - DW_t - \kappa(e_t - \bar{e})^2$. The resource constraint can be written as follows: $C_t + I_t + DW_t + \kappa(e_t - \bar{e})^2 = F(z_t, k_t) - (1 - \mu_t)b_t - \mu_t R^f b_t + q_t b_{t+1} - B_t + Q_t B_{t+1}$, where $I_t = k_{t+1} - (1 - \delta)k_t + \Psi(k, k')$ is gross investment, $DW_t = \mu_t(\phi(e_t) + \tau^y(1 - \theta)F(z_t, k_t) + (1 - R^f)b_t)$ is deadweight costs due to corporate defaults, and $\kappa(e_t - \bar{e})^2$ is the equity adjustment cost.

the path of productivity and the timing of the crises are identical to the previous economy without policy. To study optimal policy in the presence of corporate-sovereign linkages, I solve for a set of time-consistent optimal policies as described in section 1.4.4, using the same parameters of the quantitative model used for the competitive equilibrium. The bottom panels of Figure 1.9 present the set of implemented optimal policies as red solid lines. It is optimal for the government to impose a low constant tax rate on debt, which is around 0.13% of new firm debt issuance. The government subsidizes firms during the crisis by reducing their lump-sum taxes relative to output by about 0.3%p. The government also subsidizes firm investment during the crisis. Intuitively, the government uses the constant debt tax rate to incentivize firms to reduce debt, correcting the over-borrowing externalities due to the limited liability of firms. At the same time, it implements lump-sum taxes and investment credits to reduce firm default risk in bad times and to increase tax revenue buffers in good times, in preparation for future negative shocks. With this set of optimal policies, output decreases only about 2% during the crisis, compared to a 3% decrease in the economy without policy. Moreover, investment and consumption do not collapse as much as in the economy without policy. The reason is that, as the government subsidizes firms by reducing lump-sum taxes and increasing investment credits, firms' financing needs decrease, and firm default risk decreases. This translates into smoothed paths of corporate debt and income tax revenue. As the government has enough tax revenue to finance transfers to households, it has less incentive to default. Hence, government spreads do not respond much during the crisis, and the government has more than enough room to provide transfers to households and implement its set of optimal policies. Again, these policies reduce firm defaults. This positive feedback loop reinforces the effectiveness of optimal policy in smoothing out the path of consumption and increasing welfare.

I calculate welfare gains from implementing this set of optimal policies. To be specific, I compute the permanent increase in consumption ω_0 that households would require as compensation when they move to the economy without policy from the one with optimal policy, using the following equation:

$$\sum_{t=1}^{100} \beta_g^{t-1} u\big(C_t^{NP}(1+\omega_0)\big) = \sum_{t=1}^{100} \beta_g^{t-1} u(C_t^{OP}) \tag{1.51}$$

where household consumption is C^{NP} and C^{OP} in the economy without and with optimal policy, respectively. I simulate the economy 100,000 times for 200 periods, dropping the first 100 periods. I compute the average welfare gain ω_0 from these simulations. Table 1.9 presents the welfare gain from this optimal policy and associated business cycle statistics. I find that the average welfare gain from implementing optimal policy is substantial (a 12.8% increase in permanent consumption), because optimal policy alleviates the risk spillover from corporate debt to government spreads with a positive feedback loop as described above. We can see that the mean of consumption with optimal policy is higher than its counterpart without optimal policy, while the standard deviation of consumption falls substantially after implementing this optimal policy. Importantly, these results are not driven by direct bankruptcy costs, which are only about 2.2% of output on average in the simulations, but rather are driven by corporate credit cycles and the amplification mechanism through the corporate-sovereign linkage.[30]

Although optimal policy improves welfare dramatically, this type of policy is arguably not realistic, in the sense that the government may not be able to assess the economic conditions so precisely as to be able to implement state-contingent optimal policies, or such policies may not be politically viable. For this reason, I consider two types of simple debt policies: (i) a constant debt tax and (ii) a cyclical debt tax rate. When imposing a constant debt tax rate $\bar{\tau}^b$, the government does not change the debt tax rate over the credit cycle.

[30] The ratio of total direct bankruptcy costs to output are calculated as the average of $\mu_t(\phi(e_t) + \tau^y(1-\theta)F(z_t,k_t) + (1-R^f)b_t)/F(z_t,k_t)$ across simulations. Average bankruptcy costs associated with the tax revenue channel, $\tau^y(1-\theta)F(z_t,k_t)/F(z_t,k_t)$, are about 0.7%, while average bankruptcy costs for dividend cuts ($\phi(e_t)/F(z_t,k_t)$) and direct debt repudiation ($(1-R^f)b_t)/F(z_t,k_t)$) are about 0.3% and 1.2%, respectively. In Panel B of Table 1.10, I assume that only half of the corporate income tax revenue is defaultable so that direct bankruptcy costs are lower than the baseline parameterization. In this case, the welfare gain from optimal policy does not fall much relative to the baseline (from 12.8% to 12.2%), suggesting that direct bankruptcy costs are not the first-order part of this large welfare gain.

In contrast, with the cyclical debt tax, the government adjusts the debt tax rate τ_t^b when the current corporate debt-to-output ratio b_t/Y_t deviates from a target leverage ratio $\bar{b}/\bar{Y}$, as shown in equation (1.52) below:

$$\tau_t^b = max[\bar{\tau}^b + \beta_\tau(b_t/Y_t - \bar{b}/\bar{Y}), 0] \tag{1.52}$$

where the debt tax rate τ_t^b is always non-negative. I assume that the government cannot collect debt taxes from defaulting firms.[31]

Panel A of Figure 1.10 plots average welfare gains from imposing different constant debt tax rates $\bar{\tau}^b$ ranging from 0% to 20%, setting the slope β_τ to zero. These welfare gains are obtained in the same way as when considering optimal policy, and each average welfare gain is calculated by repeating simulation exercises across different debt tax rates. Panel A shows that, as the constant debt tax rate increases, the welfare gain increases and reaches a maximum of 2.1% with a debt tax rate of 6%. After reaching the peak, the welfare gain decreases monotonically in the debt tax rate and eventually becomes negative. Intuitively, raising the debt tax rate corrects overborrowing externalities, but at the same time increases firm default risk. Given that a constant debt tax rate $\bar{\tau}^b$ of roughly 6% gives the maximum welfare gain, I calculate welfare gains for different debt tax rule slopes β_τ ranging from -1.5 to 1.5, while I set $\bar{\tau}^b = 6\%$. I set the target leverage $\bar{b}/\bar{Y}$ to 0.91, which is the average corporate leverage ratio across simulations in the regulated equilibrium with a constant debt tax rate of 6%. The best debt tax slope β_τ is roughly -1.0, which gives the maximum welfare gain of 3.8%. This suggests that the optimal debt tax rate should fall during corporate credit booms to reduce firm default risk. Surprisingly, welfare decreases when the slope of debt tax rule is positive. As the government implements a more countercyclical debt tax rate, the welfare gain decreases. The reason is that firms face higher default risk, as they have to pay higher debt taxes and run out of cash during credit booms, while the government

[31] The government could regulate the individual firms' planned corporate debt issuance b_{t+1} using microprudential measures, but in practice the government can regulate firms based only on current aggregate debt b_t when it comes to macroprudential policies.

collects more debt tax revenue than is optimal. At a deeper level, the problem is that (i) the countercyclical debt tax raises the debt tax rate based on the current corporate debt b_t, which is out-of-date information compared to planned debt issuance b_{t+1},[32] and (ii) this type of policy is not sophisticated enough to replicate the state contingency of optimal policies, under which the government subsidizes firms during the crisis.

Table 1.9 again shows welfare gains from the best constant debt tax rate and the best cyclical debt tax rate along with associated business cycle statistics. We can see that both debt policies reduce volatilities of consumption compared to the case without macroprudential policy. The ratios of corporate debt to output are higher with debt policies, as firm default rates are higher, and output is lower due to debt tax burdens. However, by collecting debt taxes, the government can reduce its spread and default frequency. This allows the government to better finance transfers to households, which contributes to reductions in volatilites of consumption. Notice that the best cyclical debt tax rule can achieve higher tax revenue despite a slightly higher firm default rate compared to the best constant debt tax. The reason is that lowering debt tax rate during credit booms effectively subsidizes firms and smooths out the variation in firm default rates. Figure 1.9 again presents dynamics during the crisis implied by simple debt policies. The evolutions of variables in the economy with the best cyclical debt tax rule ($\bar{\tau}^b = 6\%, \beta_\tau = -1$) are presented as black solid lines with yellow circles, while its counterparts with the best constant debt tax rule ($\bar{\tau}^b = 6\%, \beta_\tau = 0$) are shown as green dashed lines. Compared to the constant debt tax, the cyclical debt tax induces fewer increases in defaulting firms, resulting in a larger welfare gain of 3.8%. To sum up, the welfare gain from the optimal policy is the largest (12.8%), which is followed by the cyclical debt tax (3.8%) and the constant debt tax (2.1%).

Table 1.10 shows that the welfare rank between optimal policy, the constant debt

[32] I find that raising a debt tax rate based on the planned firm debt issuance b_{t+1} gives larger welfare gains than raising a debt tax rate based on the current firm debt b_t, but smaller welfare gains than imposing a constant debt tax rate. Levying debt taxes based on b_{t+1} is close to microprudential policy in the sense that planned debt choice b_{t+1} can be regulated immediately and that regulated firms internalize the effect of their individual debt choice on a debt tax rate.

tax, and the cyclical debt tax is robust to alternative parameterizations. In Panel A, I assume that corporate and government discount factors are identical ($\beta = \beta_g = 0.98$) and calculate the welfare gain and business cycle statistics in the economy with optimal policy. The welfare gain becomes larger compared to the baseline case, since inefficiency arisng from heterogeneous discount factors disappears with identical discount factors. Compared to the parameterization with heterogeneous discount factors (baseline), the government is more patient in borrowing with the assumption of identical discount factors. This leads to a subtantially low ratio of corporate debt to output (57%) with optimal policy, compared to its counterpart (86%) with no macroprudential policy.[33] This result confirms that optimal policy addresses firms' overborrowing externalities. On the other hand, welfare implications of different policies do not change: optimal policy gives the maximum welfare gain, followed by the cyclical and constant debt tax. This result applies to alternative parameterizations in Panels B and C, in which I assume that firms cannot default on the half of their income and that investors are risk neutral, respectively.

To better understand the nature of the cyclical debt tax rule, consider the following version of equation (1.43) when lump-sum taxes and investment credits are not available.

$$\tau_t^b = \underbrace{\frac{\partial [q(\cdot) b_{t+1}]}{\partial b_{t+1}}}_{\text{marginal funds that can be borrowed}} - \beta \underbrace{\int_{z_{min}}^{z_{max}} \int_{\nu_{min}^d}^{\bar{\nu}^d(X_{t+1})} \frac{\lambda_{t+1}}{\lambda_t} d\Omega(\nu_{i,t+1}^d) d\Pi(z_{t+1}|z_t)}_{\text{expected appreciation of marginal funds}} \qquad (1.53)$$

When corporate leverage and corporate default risk increases, the marginal funds that can be borrowed decrease, and the value of marginal funds is likely to increase, implying that the planner should cut the debt tax rate to reduce firm default risk. Notice that the debt tax rate still should be positive to correct the overborrowing externality under reasonable parameterizations. Confirming this intuition, Panel B of Figure 1.10 shows that the welfare

[33] In the baseline simulation of Table 1.9, the ratio of corporate debt to output is higher for optimal policy relative to no policy, since the government is less patient than firms.

gain increases as the planner cuts the debt tax rate more aggressively during corporate credit booms. In contrast, models with a borrowing constraint (based on a pecuniary externality) typically show that the planner should raise the debt tax rate when corporate leverage increases, and the borrowing constraint is more likely to bind. The reason is that these models abstract from firm defaults and associated bankruptcy costs, and the planner therefore faces smaller costs when raising the debt tax rate, compared to my model with firm bankruptcy costs.

1.6 Conclusion

In this paper, I find that corporate debt causally affects sovereign default risk and show that this corporate-sovereign debt nexus is an important amplification mechanism, driven by externalities that call for macroprudential policies. I run instrumental variable regressions to estimate a causal relationship running from aggregate corporate leverage to sovereign spreads. I use the weighted sum of idiosyncratic shocks to the top 50 largest firms in each Eurozone country as an instrument for aggregate corporate leverage to rule out potential reverse causality and omitted variable bias. The regressions suggest that rising corporate leverage causes sovereign spreads to rise, which confirms the existence of the corporate-sovereign nexus. To understand the mechanism, I build a model in which both firms and the government can default. When corporate debt increases, tax revenues are expected to be lower, as firms stop paying taxes and dividends when they default, and this raises sovereign default risk. This tax revenue channel is supported by empirical evidence. Country-level tax revenue regressions show that increases in corporate debt-to-GDP ratios reduce future tax revenue growth. Difference-in-difference regressions using firm-level data suggest that highly-leveraged firms reduce tax payments more compared to less-leveraged firms in response to the 2008 global financial crisis. Moreover, I analyze externalities that arise from firms' limited liability, which are distinct from the pecuniary and aggregate demand externalities analyzed by previous literature. I find that there exist time-consistent optimal policies that correct the limited liability externality. A quantitative model calibrated to six Eurozone countries shows that such policies consist of a low constant debt tax rate together with transfers and investment credits to firms during crises. Implementing these policies alleviates the corporate-sovereign linkage, so that the number of defaulting firms decreases, and the government has enough fiscal space to provide transfers to households suffering from low consumption. Furthermore, practical policies such as either constant or cyclical debt tax schedules can correct overborrowing externalities. However, a countercyclical debt policy (which raises the debt tax rate during corporate credit booms) induces more firm defaults during crises, and thus it is less effective than constant and procyclical debt tax policies. This suggests that policymakers should be cautious about implementing countercyclical debt tax policies such as countercyclical capital buffers, and should even consider relaxing regulations when corporate default risk is high.

Taxes on total corporate debt have not been given much attention by policymakers or researchers, as previous research on macroprudential policy typically discusses currency and maturity mismatch in debt (in either the corporate or banking sector) and associated bank regulations. My results suggest that it is important to regulate total corporate leverage when firms' liability is limited. Moreover, it would be useful to study the consequences of limited liability and the implied optimal mix of macroprudential policies and capital controls in future research.

Chapter 2: Capital Flows and Leverage

2.1 Overview

This chapter surveys the literature on capital flows and leverage. We summarize results from existing papers and document new facts. The empirical literature takes both a macro and a micro approach. The macro approach focuses on aggregate data both over time and in the cross-section of countries and documents a positive correlation between total capital flows, build-ups in terms of the external and domestic debt-to-GDP ratios, and financial crises. The micro approach uses granular data and focuses on leverage at the firm- and bank-level and associates this leverage with country-level capital flows and related exchange rate movements. We document new facts from a hybrid approach that focuses on the relationship between sector-level capital flows and sectoral leverage. We highlight the interconnections between different approaches and argue that harmonization of the macro and micro approaches can yield a more complete understanding of the effect of capital flows on country-level, sector-level and firm/bank-level leverage associated with credit booms and busts.

2.2 Introduction

International capital flows have nontrivial consequences for macro and micro economic outcomes. There is a large empirical literature that studies both the determinants and effects of capital flows. This literature utilizes cross-country and time-series panel data, making use of both "between" country and "within" country variation. The former source of variation compares countries to each other, averaging the data over decades and focusing on the long-run causes and effects of capital flows, while the latter source of variation keeps average differences across countries fixed using country-fixed effects, and uses yearly or even quarterly changes in variables for identification.

In general, this literature recognizes that the most important determinant of capital flows is the institutional quality of countries in the long run. When yearly or quarterly variation is used, macroeconomic policies turn out to be more important than institutional quality, as the latter changes slowly over time. The consensus view is that countries with higher levels of institutional quality have lower risk of expropriation, are more productive, and have more stable macroeconomic policies. Hence, foreign investors can get a higher return from investing in these countries, which have lower probabilities of default. This literature also finds that strong fundamentals in terms of GDP growth attract capital flows. External factors, such as US interest rates, oil prices, and global financial conditions, are also important determinants of capital flows, especially in the short run. Connecting the effects of fundamentals and external factors, Kalemli-Özcan (2019) shows that capital flows in and out of countries with higher levels of default risk are more sensitive to changes in US interest rates.[1] On the effects of capital flows, the literature tends to find a strong association between capital flows, GDP volatility and financial crises. In terms of growth benefits, only certain forms of capital flows, such as foreign direct investment (FDI), seems to bring growth to host countries.

This literature mostly focuses on net capital flows, that is the current account. Recently, Forbes and Warnock (2012) and Fratzscher (2012) studied total gross flows and show the importance of global risk factors for gross capital flows for the period after 1995. Obstfeld and Taylor (2005) argue that gross flows provide risk sharing and should not be considered from the perspective of efficient allocations of capital that is associated with current account

[1]See, among others, Alfaro et al. (2008), Gourinchas and Jeanne (2006), Reinhart and Rogoff (2009b), Aguiar and Amador (2011), Alfaro et al. (2014), Gourinchas and Jeanne (2013), Calvo et al. (1996), Calvo (1998), Gourinchas and Obstfeld (2012).

deficits and surpluses. In general, current account deficits are associated with large gross inflows, especially for emerging markets. Several papers argue that credit booms and capital inflows go hand in hand, leading to debt build-ups and high leverage in the receiving economies. This process often ends with a financial crisis and a long de-leveraging process. Even without capital flows, credit growth is important to understanding financial crises, as shown by Jordà et al. (2013).

For open economies, a credit boom can be financed by capital flows that can manifest as higher leverage in the banking sector or in the corporate and government sectors. Gourinchas and Obstfeld (2012), using data from advanced and emerging markets during 1973–2010, show that the most important predictors of financial crises are an increase in leverage, credit growth and a sharp appreciation of the currency. Similarly, Borio and Disyatat (2011) study the relationship between leverage in the banking sector, cross border capital flows and the exchange rate. The recent work by Bruno and Shin (2015a,b) provides a model and supporting evidence that can connect these findings. Their work links global banks' leverage to global push factors that are related to capital flows. Their argument is that when global financial conditions are easy (due to expansionary monetary policy in the US, for example), global banks' leverage goes up due to a relaxation in their value-at-risk constraint, and this process is associated with an increase in cross-border banking flows. An alternative model by Gabaix and Maggiori (2015) focuses on the risk-bearing capacity of global financial intermediaries.

In order to understand the relationship between capital flows and leverage, we have to understand the effects of global push factors on capital flows. As shown by Rey (2013), a global financial cycle (GFC), which involves synchronized surges and retrenchments in gross capital flows, as well as booms and busts in risky asset prices and leverage is an important phenomenon to understand in terms of its effects on domestic credit creation and leverage. The GFC has a strong common component across countries that comoves with the VIX.[2]

[2]This VIX is a forward-looking volatility index of the Chicago Board Options Exchange. It measures the market's expectation of 30-day volatility and is constructed using the volatilities implied by a wide range of

The VIX is related to monetary policy in the US and global changes in risk aversion and uncertainty (Bekaert et al. (2013); Miranda-Agrippino and Rey (2019); and Bruno and Shin (2015b)). In association with these findings, many researchers show that the VIX has an important role in pushing capital flows, especially into emerging markets (See Forbes and Warnock (2012), Cerutti et al. (2019b), Fratzscher et al. (2016), Miranda-Agrippino and Rey (2019), Cerutti et al. (2019a), and Giovanni et al. (2017)). However, this literature also underlines the cyclicality in the relationship between VIX and capital flows (See Avdjiev et al. (2018), Avdjiev et al. (2020), and Giovanni et al. (2017)). Kalemli-Özcan (2019) shows that changes in US monetary policy affect capital flows in and out of emerging markets more than for advanced economies, since capital flows of emerging markets are more risk-sensitive, and US policy affects the risk sentiments of global investors.

The theoretical work by Bruno and Shin (2015a) argues that global banks' US dollar lending increases during the boom phase of the GFC due to abundant liquidity in US dollar funding markets. An appreciating domestic exchange rate as a result of capital inflows then allows domestic banks and firms with currency mismatch on their balance sheet to take on more leverage and to increase the share of foreign currency debt (e.g., Bruno and Shin, 2015b). The model by Coimbra and Rey (2017) points to the importance of bank heterogeneity in leverage in such a mechanism, whereas the models by Bruno and Shin (2015a,b) consider the aggregate leverage of the banking sector. Kalemli-Özcan et al. (2018b) show that domestic firms increase their leverage during exchange rate appreciations and decrease it during depreciations. As shown by Kalemli-Özcan (2019), this relationship is stronger in countries with higher foreign currency debt, while this relationship disappears in countries with a lower level of foreign currency debt. Fluctuations in VIX affect firm leverage in all countries, regardless of the extent of foreign currency debt.

The model of Coimbra and Rey (2017) shows that financial cycles are due to heterogeneous intermediaries whose credit growth is driven in part by lower funding costs, especially

S&P 500 index options.

for the more leveraged intermediaries. Coimbra and Rey (2015) test the implications of their model using bank-level data from several countries and show that the negative relationship between funding costs and credit growth is stronger when the banking system is skewed, in the sense that larger banks have high leverage. Avdjiev et al. (2020), using confidential bank-level data from several countries, show that heterogeneity in cross-border liabilities of domestic banks is the key to understanding the transmission of global financial conditions. Giovanni et al. (2017), using detailed bank-firm-loan-level data from Turkey, show that lower funding costs for banks pass through as lower borrowing costs for firms, leading to a credit boom. This process is mainly driven by large banks with access to international funding markets.

In the next section, we summarize findings from the literatures that use macro and micro data in detail. Section 2.4 documents new facts from a hybrid approach that focuses on sector-level capital inflows and leverage. Section 2.5 states the conclusions of the survey.

2.3 Literature

2.3.1 Macro Approach: Countries

Figure 2.1 shows the importance of the VIX as a global push factor in determining total capital inflows both into advanced and emerging market economies. This figure is reproduced from Avdjiev et al. (2018) and uses a sample of 25 advanced and 35 emerging market economies. Given our focus on leverage, we examine debt inflows. The VIX is plotted on an inverted scale.

It is clear that the VIX and capital (debt) flows move together. Notice the importance of private debt inflows in driving the dynamics of the relationship between total debt inflows and the VIX. The decline in total debt inflows is smaller than the decline in private debt inflows when the VIX rises. This means that public debt inflows move in the opposite direction of private inflows and help to smooth out the decline in total inflows, especially in emerging markets.

This figure is informative, since it indicates that the leverage of different sectors might change differentially over time as a response to global and country shocks, and that it may not be straightforward to detect the relationship between leverage and total capital flows in the aggregate data.

The global factor VIX is clearly important, but we should consider the role of external factors together with countries' own fundamentals. Avdjiev et al. (2018) construct a new data set for gross capital flows during 1996–2014 for a large set of countries at a quarterly frequency, decomposing debt inflows and outflows by borrower and lender type: banks, corporates, and sovereigns. They run regressions of both total capital inflows and capital inflows by sector on the VIX and countries' own GDP growth. These regressions show that banking flows are important for the comovement of capital inflows and outflows. These regressions also show that capital inflows move procyclically with domestic GDP growth, and that this procyclicality is driven by both banking inflows and corporate inflows. This means that, when countries grow fast, their banking sectors and corporate sectors borrow more externally, while foreign investors leave these sectors during recessions. These results hold for both advanced countries and emerging markets.

2.3.2 Micro Approach: Firms and Banks

Several papers in the literature focus on bank- and firm-level data and try to connect leverage at this granular level to capital flows. It is important to have an understanding of the stylized facts on bank and firm leverage that can be generalized to more than one country before establishing the connection of leverage to capital flows.

Kalemli-Özcan et al. (2012b) show that leverage is heterogeneous across banks and varies a great deal over time. For nonfinancial firms, leverage at the firm level, although heterogeneous in the cross-section of firms, does not move as much over time as bank-level leverage. These authors show that there was an increase in leverage for "investment banks" prior to the 2008–2009 crisis not only in the US but also in other countries. They also show a procyclical leverage ratio for "investment banks" in other countries, as shown by Adrian and Shin (2008) for US investment banks. In addition, Kalemli-Özcan et al. (2012b) show that leverage is also procyclical for large commercial banks in many countries. Although there have been theoretical papers that aim at understanding the endogenous leverage process (Farhi and Tirole (2012); Fostel and Geanakoplos (2008); Brunnermeier and Pedersen (2008)), the literature until recently lacked evidence on the behavior of leverage of banks and non-financial firms based on internationally comparable data. The exception is the seminal work of Rajan and Zingales (1995a), who focus on the comparison of firm-level leverage across G7 countries using data on listed firms.

Kalemli-Özcan et al. (2012b) utilize the most comprehensive and comparable world-wide dataset covering banks and non-financial firms, namely, ORBIS from Bureau van Dijk Electronic Publishing (BvD). They use data from 2000–2010, which covers listed, private, large, and small non-financial firms, financial firms, and banks. In studying leverage and capital flows, it is important to use micro data because aggregate country-level data may mask micro-level patterns. Adrian and Shin (2008, 2009, 2010b) and He et al. (2010) investigate US commercial banks and investment banks mainly using aggregate sectoral Flow of Funds data from the Federal Reserve. Such sectoral data may be driven by the largest banks, and it is also important to know how typical investment and commercial banks behave. In fact, the key finding that large banks are more leveraged from Kalemli-Özcan et al. (2012b) supports models such as Coimbra and Rey (2017), as mentioned in the introduction.

2.3.2.1 Funding Cost Channel

What about the relationship between leverage of large banks and capital flows? There are papers that have emphasized the role of financial intermediaries in channeling capital flows into leverage in both the financial and non-financial private sectors. Cetorelli and Goldberg (2012) use bank-level data to study the role of global banks in transmitting shocks to capital flows related to changes in liquidity conditions across borders. Using Mexican loan-level data, Morais et al. (2019) find that, under easy global liquidity conditions, the supply of credit of foreign banks to Mexican firms increases. Such transactions would register in the balance of payments as a capital flow from a foreign country to the Mexican banking sector. Bräuning and Ivashina (2020) show that cross-border syndicated bank loans increase when monetary conditions in the US are related.

Using confidential loan-level data on the universe of loans combined with firm- and bank-level data from Turkey, Giovanni et al. (2017) and Baskaya et al. (2017) show a direct link between banking inflows, bank leverage, corporate leverage, and credit booms. They show that increased capital inflows into Turkey lead to rising leverage in the corporate sector and a credit boom via bank intermediation of these capital inflows. However, this credit boom is created by a subset of banks that have a high level of non-core liabilities. A high level of a bank's non-core liability ratio means that this bank has more access to international funding, since most non-core liabilities are non-domestic-deposits that are externally funded. Baskaya et al. (2017) show that banks' non-core liabilities move in tandem with banking sector inflows.

The key intuition behind these patterns is the pass-through of variation in the cost of funds. Large banks that fund themselves cheaply in international markets pass through this low cost of funding as a lower cost of borrowing to corporates. **Figure 2.2** below, reproduced from Giovanni et al. (2017), shows the relationship between Turkish firms' borrowing costs and the VIX. This relationship gets stronger during low VIX periods associated with Quantitative Easing (QE) policies of the US Federal Reserve. The figure plots the "time effects" on loan rates (nominal and real) in the sense that the authors plot the average interest rate on the average loan at each date, after purging each loan's interest rate of the effects of determinants such as loan amount, maturity, risk, currency and so forth. The aim is to solely focus on the time pattern of borrowing costs at a very granular level and to see if this time pattern is associated with the global push factor, VIX. They find that this is the case.

Some papers link firm-level leverage to capital flows and other aggregate outcomes.

Gopinath et al. (2017b) links corporate leverage and credit growth to capital flows and to misallocation of capital that leads to a decline in aggregate productivity. They show that countries in Southern Europe experienced low productivity growth alongside declining real interest rates during 1999–2008 due to capital inflows from Northern Europe. They argue that capital inflows from North to South Europe led to the misallocation of this capital across firms, which gave rise to lower aggregate productivity. They show that firms with higher net worth got more capital, regardless of whether they were more productive. They develop a model with size-dependent financial frictions that is consistent with firm leverage being a function of firm size in the data. They provide evidence consistent with their model from six European countries.

Kalemli-Özcan et al. (2018a) also focus on firm-level leverage, but they link it to declining aggregate investment in Europe in the aftermath of the 2008–2009 crisis. They show that declining firm-level and aggregate investment can be explained by higher firm-level leverage, increased debt service associated with this leverage, and firm relationships with weak banks that led to a decrease in credit supply. Banks were important to the transmission of capital flows, since Northern European banks expanded their credit supply to Southern European banks, which in turn were exposed to Southern European governments' debt. This deadly embrace created a doom loop between firms, banks, and sovereigns across Europe linked by capital flows.

2.3.2.2 Balance Sheet Channel

One dimension of bank- and firm-level leverage is borrowing/lending in local versus foreign currency. As argued in the introduction, the model of Bruno and Shin (2015a) explicitly predicts higher leverage for banks and firms when there is currency mismatch on their balance sheets as a result of the movements in the exchange rate that are linked to capital flows.

Kalemli-Özcan et al. (2018b) directly test the Bruno and Shin (2015a) model using firm-level data. Using firm-level data from private and public firms in ten Asian emerging markets during 2002–2015, these authors show that firms with higher foreign currency debt, prior to exchange rate appreciation, increased their relative leverage after appreciations. Kalemli-Özcan et al. (2016) show that these balance sheet currency mismatch effects can be detrimental on the downside, when the credit boom turns into a bust with associated liquidity shortages. Using firm-level data from six Latin American countries, they show that if currency crises are accompanied by banking crises, domestic exporters holding unhedged foreign currency debt decrease investment, while foreign exporters with better access to credit increase investment despite their unhedged foreign currency debt. There is no such effect if the crisis is a pure currency crisis.

2.4 New Facts From a Hybrid Approach: Sectors

In this section, we undertake an exercise that is a hybrid between micro and macro approaches. This approach establishes a direct link between capital inflows into the banking sector and rising leverage in the corporate sector. We use data from Avdjiev et al. (2018). Note that the previous literature could not undertake such an exercise for a large set of countries over a long period since capital flows data by sector are very limited at the quarterly frequency. Avdjiev et al. (2018) build a new sector-level capital flow dataset that expands the existing data frontier significantly in terms of country and time coverage. See Avdjiev et al. (2018) for details.

Domestic banks play an important role in channeling funds from foreign lenders into domestic non-bank firms. **Figure 2.3** presents an example of how domestic banks intermediate funds and how the balance sheets of the domestic bank and its counterparties are adjusted. If foreign lenders increase loans to a domestic bank, the domestic bank's external liabilities increase. If the domestic bank's external assets do not change, its external leverage (defined as the ratio of external liabilities to external assets) increases, and this implies that its domestic assets should increase to restore the balance sheet identity. The increase in the bank's domestic assets means that the domestic bank increases loans to the domestic non-banking sector (non-financial firms and households), and in turn, the domestic non-banking sector's debt increases.

First, we show empirical evidence that domestic banks' external leverage has increased since 2000 in emerging market economies (EMEs). **Figure 2.4** panel (b) shows that bank debt inflows are positively correlated with bank external leverage (the ratio of external liabilities to assets) in EMEs. This finding indicates that domestic banks' external assets do not change much following bank debt inflows, and hence their domestic assets should increase.[3] As a result, the banking sector in EMEs mainly uses inflows of funds from abroad to make loans to the domestic sector instead of acquiring assets held by the external sector. Panel (a) of the same figure shows that this is not the case in advanced economies (AEs).

Second, domestic banks in EMEs grant more loans to the domestic non-banking sector following inflows of external funds from abroad, as shown in panel (b) of **Figure 2.5**. As before, this is not the case for AEs, as shown in panel (a). This is a new and important finding which points towards a hidden financial stability risk: for emerging markets, capital flows into the banking sector can substantially increase domestic vulnerabilities. However, as shown in **Figure 2.9** in the appendix, capital flows into the corporate sector do not increase the corporate sector's external leverage, suggesting that corporates that can borrow directly in international markets (mostly large multinationals) increase their external assets at the same time. These sector-level results are also consistent with the firm-bank-level results in Giovanni et al. (2017).

Next, to further support our results, we show firm-level evidence on the effects of bank inflows on firm leverage. In **Table 2.1**, we regress firm-level leverage on sectoral inflows using the ORBIS database that covers 43 countries. We run regressions for different country groups as follows:

[3] **Figure 2.8** in the appendix illustrates that rising external leverage in EMEs is driven by increasing external liabilities.

$$Leverage_{i,c,t} = \beta_1 BankInflows_{c,t} + \beta_2 CorporateInflows_{c,t} + \beta_3 PublicInflows_{c,t} + \gamma_i + \delta_c + \epsilon_{i,c,t}$$

Leverage is measured as the ratio of financial debt (loans and debt instruments) to total assets for each firm i in country c and year t; γ_i and δ_c are firm and country fixed effects, respectively. Note that the ratio of financial debt to assets is usually considered to be a better measure of firm vulnerability than other leverage measures.[4]

We find that the ratio of financial debt to assets is positively correlated with bank inflows in (i) EMEs, (ii) countries with a high foreign currency (FX) debt share, and (iii) countries with managed floats. These results suggest that domestic banks channel funds obtained abroad into domestic firms in these country groups and that these firms are more vulnerable to subsequent sudden stops in capital inflows, as they build up leverage significantly during the credit boom via the domestic bank lending channel. The table shows that there is no significant positive effect of direct capital flows into the corporate sector and the government sector on firm leverage. If anything, higher direct capital flows into the corporate sector decrease firm leverage in countries with free floats.

Finally, we investigate the currency composition of domestic banks' liabilities and assets to assess the vulnerability of these banks' balance sheets to exchange rate shocks. Given that domestic banks play a pivotal role in channeling funds from foreign lenders to the domestic non-banking sector, currency mismatch in these domestic intermediary balance sheets poses a great risk to the financial system of a country. In **Figure 2.6**, we calculate the share of foreign currency liabilities as the sum of the liabilities in foreign currency across countries divided by total liabilities. We also calculate the share of foreign currency assets in the same fashion. Foreign currency shares in both liabilities and assets have gradually declined

[4]For example, BIS includes debt securities and loans in its main credit indicator (core debt in total credit statistics) but excludes other liabilities such as pension, trade credit, or other accounts receivable/payable.

over time, but they look fairly stable. In fact, from these figures, it does not seem that there is a currency mismatch issue for banks' balance sheets in AEs and EMEs. If anything, the mismatch would go in the opposite direction, in that assets in foreign currency exceed liabilities in foreign currency.

Figure 2.7 panel (b) shows that a 1%p increase in the domestic currency appreciation rate is associated with a 0.84%p increase in bank external leverage (and similarly a depreciation will be associated with de-leveraging) across emerging market economies during the pre-crisis period 2000–2007. This cross-country correlation is significant, with a t-statistic of -3.48. However, notice that causality can go the other way around, in that more borrowing by domestic banks from overseas can lead to an appreciation of the domestic currency. We do not find the same pattern during the post-crisis period 2009–2014. Also, we do not find this pattern in advanced economies during pre- and post-crisis periods.

2.5 Conclusion

This paper surveys the literature on capital flows and leverage. We summarize results from existing papers and document some new facts. The literature takes both a macro and a micro approach. The macro approach focuses on aggregate country-level data over time and in the cross-section and documents a positive correlation between total capital inflows, build-ups of external and domestic debt, and financial crises associated with de-leveraging. The micro approach uses granular data, focuses on leverage at the firm- and bank-level and associates this leverage with aggregate country-level capital inflows.

The key messages from these approaches are as follows. At the macro level, boom periods for countries that are associated with domestic credit growth, and hence leverage, are also associated with increased capital inflows, especially for emerging markets. These episodes often end with financial crises. At the micro level, non-financial firm leverage is not as cyclical as bank leverage, where bank-level leverage moves in tandem with global push factors, most notably the VIX index, which is a measure of global uncertainty and risk aversion. The connection between bank-level leverage and the cyclicality of this leverage as a function of the VIX can be explained by the association between the VIX and capital inflows. When the VIX is low, capital flows from advanced economies into the banking sectors of many emerging countries, and bank-level leverage increases. There is important heterogeneity in the behavior of bank-level leverage, however, in that not all banks increase their leverage when global liquidity conditions are easy (low VIX). Only large banks and banks that fund themselves in the international markets end up with higher leverage during such periods. Firm-level leverage is connected to bank-level leverage and capital inflows via increases in bank credit supply to non-financial firms.

We document some new facts from a hybrid approach that focuses on the relationship between sector-level capital inflows and sectoral leverage. We show that capital flows into the domestic banking sector of a given country are associated with increased leverage in the same country's corporate sector. This result is strong for emerging markets but weaker for advanced countries.

The bottom line of this survey is that countries' own domestic banks are central to the relationship between capital inflows and leverage. This is not to say global banks are not important. They are, because in open economies that are financially integrated with the rest of the world, domestic banks fund themselves mostly through global banks using the interbank market. However, understanding the importance of the domestic banking sector in the transmission of capital flows has an important policy implication. Macro-prudential authorities in open economies that aim at financial stability should start with their own domestic banking sector.

Chapter 3: Does Trade Cause Capital to Flow? Evidence from Historical Rainfall

3.1 Overview

We use a historical quasi-experiment to estimate the causal effect of trade on capital flows. We argue that fluctuations in regional rainfall within the Ottoman Empire capture the exogenous variation in exports from the Empire to Germany, France, and the U.K., during the period of 1859–1913. The identification is based on the following historical facts: First, only surplus production was allowed to be exported from the Empire (provisionistic policy). Second, different products grown in different regions were subject to variation in regional rainfall. Third, different bundles of products were exported to Germany, France, and the U.K. by the Empire. Using the export-bundle-weighted regional rainfall as an instrument for Ottoman exports to each country, our instrumental variable regression suggests the following: When a given region of the Empire received more rainfall than others, the resulting surplus production was exported more to countries that historically imported more of those products, and this leads to higher foreign investment by those countries in the Empire. Our findings support theories predicting complementarity between trade and finance, in which causality runs from trade to capital flows.

3.2 Introduction

Theory predicts an ambiguous relationship between trade and financial flows. Mundell (1957) shows that trade and capital flows are substitutes as an increase in trade integration reduces the incentive for capital to flow. Formalized by the Heckscher-Ohlin-Mundell paradigm, in a two-goods, two-factors framework, free trade leads to factor price equalization, and so there is no need for international capital mobility. Other papers modify this framework by adding technological differences (Kemp, 1966; Jones, 1967) and/or production uncertainty (Helpman and Razin, 1978), and these papers show that trade and factor flows can be complements with causality running from international capital to trade flows.

The recent theoretical models incorporating financial frictions advocate another view. It is not only that there is the complementarity between trade and capital flows but also the causality runs from trade to capital flows (Antràs and Caballero, 2009). In this paper, a historical quasi-experimental setting was used to identify the causal effect of trade on capital flows in a dynamic framework. It is argued that fluctuations in regional rainfall within the Ottoman Empire capture the exogenous variation in exports from the Empire to Germany, France, and the U.K., during the period of 1859–1913. The identification is based on the following historical facts: First, only surplus production was allowed to be exported from the Empire (provisionistic policy). Second, different products grown in different regions were subject to variation in regional rainfall. Third, different bundles of products were exported to Germany, France, and the U.K. by the Empire. Using the export-bundle-weighted regional rainfall as an instrument for Ottoman exports to each country, our instrumental variable regression suggests the following: When a given region of the Empire received more rainfall than others, the resulting surplus production was exported more to countries with higher ex-ante export shares of those products, and this leads to higher foreign investment by those countries in the Empire. The empirical results show that higher trade integration leads to higher capital inflows to the capital-scarce country.

We illustrate a plausible mechanism for this cause-effect relationship based on the theoretical model of Antràs and Caballero (2009) in the historical context of the Ottoman Empire during the late 18th and early 19th centuries. The Empire was a financially-underdeveloped country exporting agricultural goods, while Germany, France and the U.K. were financially-developed countries exporting manufactured goods. This trade pattern was consistent with the fact that the manufacturing sector was more capital-intensive than the agricultural sector, and Germany, France and the U.K. were financially-developed enough to finance investment in capital. The Empire was less financially-developed than Germany, France and the U.K., and the Empire allocated their resources mainly in the agricultural sector, which contributed to an increase in output and a decrease in prices of agricultural goods. With trade integration, the Empire could take advantage of the low prices of its agricultural goods (comparative advantage) and increase export revenues. As a result, the return to capital in the Ottoman agricultural sector increased, and Germany, France and the U.K. had more incentive to invest in industries that were complementary to the agricultural sector of the Empire. In fact, railroads constituted 33 percent of the foreign direct investment from Europe in the Empire as of 1888, and the construction of railroads reduced transportation costs of crops. Thus, the trade integration attracted capital flows from Germany, France and the U.K. into the Empire, as the return to capital in the Ottoman agricultural sector rose due to increases in export revenues in this sector.

During the late 18th and early 19th centuries, similar to other countries in that era, the Ottoman economy was closely determined by the political and administrative environment. The leading concern of the Ottoman policy was the adequate provisioning of food for the army, palace, and urban areas. This emphasis on "provisioning" created an important distinction between imports and exports. Imports were encouraged since they added to the available goods in the urban markets. Exports, on the other hand, were permitted *only* once the requirements of the domestic economy were met (See Genc (1994) and Inalcik (1994)).[1] During 1880-1913, 90% of the labor force was employed in the agricultural sector, while industrial production constituted only 10% of Ottoman GDP (Altug et al., 2008). As a result, during our sample period, the Empire was an importer of manufactured goods

[1] Pamuk and Williamson (2011) argue that these provisionistic views paved the way for the Ottoman de-industrialization process that had been completed around 1880. They also argue that the Ottoman Empire specialized in agriculture and became a net importer of manufactured goods. This is what is predicted by the model of Antràs and Caballero (2009).

and exporter of *surplus* agricultural goods. Given the dependency on widely-used furrow irrigation systems, weather—rainfall variation—was an exogenous factor that determined exports since surplus production varied with the regional variation in rainfall in the Ottoman Empire.[2]

Our identification methodology can be summarized as follows. The Ottoman Empire only exported agricultural goods, namely cotton, wheat, grapes, corn, barley, olives, raisins, nuts, and figs. These goods grow in different regions of the Empire, and hence, depending on regional variation in the rainfall, there is surplus production in a given region and thus in a given group of goods. We will group goods as grains and orchards. We use this broad category rather than the narrow one since we know that the specialization of regions in crops by this broad category stays more or less the same in the last 200 years, based on the maps provided by the State Institute of Statistics (SIS) historical and contemporaneous yearbooks. We know the regions where these goods were grown, and we combine this information with historical rainfall data that vary by region and by time to obtain good groups specific surplus production. Different regions of the Empire specialize in different types of good groups. While some consist of cultivated land and grow various grains, others consist of non-cultivated orchard land and grow primarily fruits and vegetables. Hence, within the Empire, differences in rainfall ensure that Ottoman grain and orchard products were affected differently in different years. Ottoman trading partners were historically purchasing very different export bundles from the Empire: while some were mainly buying grains, others were interested in olives and grapes. Therefore, if we interact the time-varying grain and orchard production shocks, caused by the time variation in rainfall, with the country-specific export bundles, we obtain rainfall-based time-varying country-specific instruments for Ottoman exports into France, Germany, and the U.K.

We obtain unique yearly panel data for the period 1859–1913 that covers trade and private financial flows between France, Germany, the U.K., and the Ottoman Empire. As

[2]The development of irrigation systems occurred in Turkey only at the end of the 20th century (Food and Agriculture Organization of the United Nations, 2009).

a measure of private capital inflows, we use foreign direct investment (FDI) of these three source countries into the Empire. For trade flows, we use exports from the Empire into France, Germany, and the U.K. Hence, trade flows are outflows from the Empire, and financial flows are inflows to the Empire. The predominantly uni-directional capital flows were typical for the first wave of globalization when the industrialized North was investing in the agricultural South. It is important to notice that our data set covers all major Ottoman Empire investors – as of 1914, FDI from France, Germany, and the U.K. constituted 96% of total foreign direct investment into the Empire (Geyikdagi, 2011). A simple OLS regression of FDI in the Empire on exports from the Empire to France, Germany, and the U.K., using country fixed effects for the investor countries, dummies for important events like default, and time fixed effects on the medium-term cycle, produces a positive coefficient. This result is the panel version of the cross-sectional findings in the literature. The advantage of the panel data is that we can use country fixed effects and hence control for the unobserved investor country heterogeneity in foreign investment. Nevertheless, these OLS estimates suffer from reverse causality, therefore we run a 2SLS regression instrumenting bilateral trade with our instrument described above and verifying that our results are causal; that is, trade flows causally determine foreign investment. Our first stage predicts that a deviation of 10 percent in rainfall from the mean (which approximately corresponds to one standard deviation in rainfall from the mean) resulted in a 5 percent increase in Ottoman exports.[3] Our second stage regressions deliver an effect of a 3 percent increase in FDI as a result of a 5 percent increase in exports.

Our instrument is similar to the instrument developed by Nunn and Qian (2014) who identify the causal effects of US food aid on the conflict in recipient countries. They instrument US food aid with the interaction of US wheat production and cross-sectional variation in a country's tendency to receive any US food aid. Our instrument is year-on-year regional rainfall variation weighted by the country-specific export bundles, which allows our instru-

[3]See also Dell et al. (2009, 2012) who focus on the effect of weather changes (temperature and precipitation) on GDP and exports and find large estimates in the case of exports.

ment to vary across years and countries. This type of identification strategy follows the logic of the difference-in-differences estimator. Conceptually, our reduced-form estimates measure the difference in a change in foreign investment from a country importing grain and a change in foreign investment from a country importing orchard in years following an increase in rainfall for grain-growing regions.

There is an extensive literature that uses weather shocks as an instrument for growth in GDP in agricultural economies without well-developed irrigation systems that rely on rain.[4] Our identification strategy is based on temporary fluctuations in agricultural production caused by year-to-year changes in *regional* rainfall around the "permanent" component of rainfall which might affect long-run production and trade patterns.[5] This strategy is relevant for our case since we want rainfall to affect capital flows *only* through exports in the short run. For this strategy to be valid, there should not be any significant autocorrelation in precipitations, which is indeed the case as shown in Figure 3.9. Short-run fluctuations in rainfall create temporary variation in the size of surplus production, which in turn creates variation in exports. Our strategy of using short-run fluctuations allows us to avoid the effects of permanent rainfall differences on permanent incomes, which might also affect capital flows.[6] The length of our time series allows us not only to exploit time-series variation and control for unobserved heterogeneity using country fixed effects but also makes it possible to include country-specific trends that will account for any increasing/trending investment by Northern countries into the Ottoman Empire due to certain trade/war treaties.

We measure historical rainfall based on the "tree-ring" methodology. This methodology recovers the level of rainfall during a growing season based on the width of the tree rings in

[4]This literature goes back to Paxson (1992), who used weather variability to measure the response of savings to temporary income fluctuations. See Schlenker and Roberts (2006), and Deschênes and Greenstone (2007) who focus on U.S. agricultural production. See Donaldson (2018) estimates for the India.

[5]Miguel et al. (2004) use yearly changes in rainfall to identify the effect of temporary growth on the likelihood of civil conflict in Africa.

[6]Temporary fluctuations in income will affect savings only, resulting in net capital outflows, according to the standard models. During the course of the 19th century, capital flows were one way from the center to the periphery countries, as argued by Obstfeld and Taylor (2005), and hence capital outflows were essentially zero. The authors argue that this is either because periphery countries were full colonies or they were not integrated fully into the world markets to invest their savings.

a given year. During droughts, rings are narrower, while extensive moisture results in wider rings. To check the validity of the tree-ring methodology, we compared our rainfall data constructed from tree-rings to real-time historical rain data. The real-time historical data comes from the Ottoman Archives but only for a few regions. The correlation between the real-time data and our data is 0.495 for the overlapping regions and significant at 5%. We use data that we obtain using the tree-ring methodology for our analysis since this data is available for all the regions of the Empire during the entire period we are interested in.

A valid threat to the identification is the possibility of a third variable driving both Ottoman exports to North and North's investment in the Empire. Our instrumental variable strategy will be able to deal with this issue as long as the omitted variable is not correlated with the instrument. To advance on this, in light of the model of Antràs and Caballero (2009), regressions control for Ottoman GDP per capita, which can capture a large part of the variation in the marginal product of capital, the return to capital, and thus capital inflows into the Empire. Additionally, we use country-specific time trends together with other controls. We also condition our results on the direct negative effect of 1876 Ottoman default. As a result of default both trade and financial flows can go down regardless of the temporary shocks to trade caused by rainfall (Rose and Spiegel, 2004). We have also created a dummy to control the effect of the establishment of the Ottoman Public Debt Administration (OPDA) in 1881. The OPDA was established after the debt restructuring negotiations for the purpose of paying the creditors. If more trade induces more financial flows since trade serves as an implicit guarantee for the creditors, once an institution is established to pay the creditors (OPDA), there might be less need for trade (See Wright (2004), Mitchener and Weidenmier (2005), Rose and Spiegel (2004), Eaton and Gersovitz (1981b)). Our results are robust to all these tests.

The empirical literature tries to identify whether or not trade and finance are complements or substitutes though the endogeneity issue is hard to solve. Most papers adopt the gravity approach focusing on the cross-sectional relationship and document a positive correlation between the two, such as Aviat and Coeurdacier (2007), Lane and Milesi-Ferretti (2008), and Portes and Rey (2005). Taylor and Wilson (2006) use a similar cross-sectional framework and instrument trade with distance to solve the endogeneity problem, obtaining a positive effect of instrumented-trade on capital flows. However, Guiso et al. (2009), Portes and Rey (2005), and Aviat and Coeurdacier (2007) show that distance determines both trade in assets and trade in goods since distance also captures information asymmetries that are important determinants of capital flows. Our contribution to this literature is to use a unique historical setting to identify the causal relationship running from trade to capital flows, using country-specific export-bundle weighted regional rainfall as an instrument for trade.

The rest of the paper proceeds as follows. Section 2 lays out the historical context and introduces the data. Section 3 discusses the descriptive statistics. Section 4 presents the empirical specification, the results, and the robustness analysis. Section 5 concludes.

3.3 Historical Context and Data

The Ottoman Empire stood at the crossroads of civilizations, stretching from the Balkans to Egypt for six centuries prior to World War I. Given the coverage of our data from 1859–1913, this paper focuses on the borders of the Empire from 1830 until World War I, as shown in Figure 3.1. These borders include northern Greece, Syria, Iraq, and present-day Turkey but exclude Egypt and Libya.

In light of the new evidence from the archives, historians no longer think that the Ottoman Empire was in a state of a permanent decline since the 16th century. It is now realized that the Ottoman state was flexible and pragmatic and was able to adapt to the changing environment. Although the 17th century was a period of crisis, the 18th century witnessed an expansion of trade and an increase in production. The Empire was shrinking starting in the middle of the 18th century due to territorial losses, but at the same time, during most of the 19th century, the Empire became more linked to Europe via commercial and financial networks. The provisioning of the capital city, armed forces and urban areas, taxation, support, regulation of long-distance trade, and the maintenance of a steady supply of money were among the main policy concerns of the state. Hence, the government constantly intervened in economic affairs. The Ottoman Empire is not unique in this respect, as the pursuit of similar policy goals is thought to have led to the emergence of powerful nation states in Europe and Asia (Tilly, 1975).

During our sample period, the world economy had witnessed an enormous expansion of trade between the center and periphery countries. Thanks to the Industrial Revolution, European countries became exporters of manufactured goods. These countries were selling their manufactured products to the third world (periphery) countries, while at the same time buying primary products and raw materials from them.

Among the periphery countries, China and the Ottoman Empire had a unique place since they had a strong central bureaucracy and their governments had the upper hand in the struggle between the bureaucracy and the interest-groups such as merchants and export-oriented landlords (Genc, 1987; Inalcik and Quataert, 1994). These countries were also never colonized. In the case of the Ottoman Empire, the sultans and state officials were aware of the critical role played by merchants. Long-distance trade was very important for the provisioning of the Empire. Foreign merchants were especially welcome since they brought goods that were not available in Ottoman lands, and they were granted various privileges and concessions at the expense of domestic merchants. Historians argue that this is the primary reason why mercantilist ideas never took root in Ottoman lands. While the ideas of domestic merchants and producers were influential in the development of mercantilism in Europe, the priorities of the central bureaucracy dominated economic thought in the Ottoman Empire.

The policy priority was such that only surplus agricultural production could be exported abroad after the army, palace and the urban markets were satiated. This provisionistic policy created a difference in the attitude of sultans towards foreign and domestic merchants, and hence between imports and exports (Genc, 1987; Inalcik and Quataert, 1994).

Trade between the Ottoman Empire and the European countries increased 15-fold between 1820–1914. However, given the provisionistic policy, the share of Ottoman exports in total production did not exceed 6 to 8 percent and – in agricultural production – 12 to 15 percent until 1910 (Pamuk, 1987). By 1910, 25 percent of agricultural production was exported, whereas 80 percent of manufactured goods were imported.

The 19th century was characterized by one-way capital flows from center European countries to periphery third world countries. Our data covers such one-way private capital flows (FDI) from France, Germany, and the U.K. into the Ottoman Empire during 1859–1913 period. These three countries were responsible for practically all FDI inflows over that period. For example, right before World War I, all other countries combined contributed only 4% of total FDI. We also have data on exports from the Ottoman Empire into France, Germany, and the U.K. and imports of the Ottoman Empire from these three center countries. Both sets of data come from Pamuk (2003) and Pamuk (1987), and they are expressed in British pound sterling. Figure 3.2 shows the total Ottoman exports and imports during our sample period, using data from Pamuk (1987). There was an eight-fold increase in imports and a quadrupling of exports, a pattern that led to the accumulation of foreign debt.

The expansion of trade between the center and periphery countries was followed by investment of European powers into the third world. It was not only the case that European governments lent money to the periphery governments, but in addition private foreign money flowed into the periphery countries.[7] Some of this investment was in the form of foreign direct investment (FDI) to finance infrastructure such as railroads, with the aim to expand trade even more. Foreign investment was not solely concentrated on infrastructure. As of 1888, while 33 percent of total foreign investment from Europe in the Ottoman Empire was in railroads, 31 percent was in banking, 9 percent was in utilities, 8 percent in commerce, 12 percent was in industry, and 5 percent was in mining, as shown in Pamuk (1987). Foreign investment in the agricultural sector remained limited until the end of World War I.

[7] Ottoman government bond issues and major purchasers over 1854-1914 are listed in Pamuk (1987) on page 74, Table 4.4

The top panel of Figure 3.3 shows private investment (FDI) from the U.K., France, and Germany into the Empire. Overall, France was the biggest investor followed by the U.K. and Germany. German investment did not start until after the signing of the strategic German-Ottoman partnership, which also marks the start of the construction of the Berlin-Baghdad railroad in 1885. The bottom panel of the same figure shows the country by country decomposition of exports from the previous figure. Again, exports into Germany, in general, are low compared to the U.K. and France, and only slightly increased during the last three decades of our sample period, coinciding with the increased FDI from Germany. Similar to exports and imports in the previous figure, there is a stark decline after 1876 in FDI, up to 60 percent, and then a recovery. This is also true for Ottoman exports by destination country as shown in the bottom panel. Both declines follow the default of the Ottoman Empire on its external debt in 1876.

In the course of the 19th century, the Ottomans undertook many reforms to modernize the economy. They needed foreign capital not only to finance this modernization effort but also to keep their growing fiscal deficit under control given the increased cost of Russian and Balkan wars. The Ottomans borrowed heavily from Europe during the 1850s and 1860s. This did not prevent the financial crisis of 1873 and the subsequent default in 1876 on the sovereign debt. As of 1876, the outstanding debt was 200 million pounds sterling, and debt servicing was taking up half of the budget (Pamuk, 1987). After negotiations, the Ottoman Public Debt Administration (OPDA) was established in 1881 to exercise European control over Ottoman finances and to ensure debt payments. The outstanding debt was reduced to half of its value in nominal terms during the debt restructuring negotiations (Blaisdell, 1929). The OPDA helped to repair the lost reputation of the Ottomans, and hence the Ottoman state gained renewed access to the international capital markets.

3.4 Descriptive Statistics

Table 3.1 shows the descriptive statistics. The longest series for capital inflows is for the U.K., where data is available for the entire sample of 55 years. The magnitude of British investment flows into the Empire, however, was the smallest and constituted on average 0.39 million pounds sterling versus 1.04 and 0.77 million pounds for France and Germany, respectively. We can also see from Table 3.1 that Britain was the biggest trading partner of the Ottoman Empire and purchased, on average, 4.6 million sterling worth of the Empire's exports, while selling about 7.6 million sterling worth of imports, on average. The smallest trade was between the Empire and Germany – only 0.4 million sterling worth of goods were exported into Germany, and 1.1 million sterling was imported by Germany. Unlike the U.K. and Germany, France was the only country (out of three) which had purchased more than it sold, with Ottoman exports into France being 3.8 million and Ottoman imports from France being 2.5 million sterling, respectively. Overall, the Empire was running a current account deficit against all these three countries in total, during our sample period.

The Gross Domestic Product (GDP) of France, Germany, and the U.K. comes from Mitchell (1988). Mitchell (1992) and Maddison (1995) also provide some GDP numbers for Turkey. However, we use the GDP data for the Ottoman Empire that comes from Clemens and Williamson (2004), which is based on Pamuk's GDP estimates.[8] All the GDP data is expressed in local currencies, which we have converted into British sterling using the "Gold Standard" exchange rates (see Table 3.11). During our sample period, 1 sterling corresponded to a fixed 7.3224 grams of fine gold, and thus we implicitly measure all the "monetary" variables in gold. As shown in Table 3.1, the Ottoman Empire was roughly 10 times poorer, per capita, than the European countries.

Population numbers for the Ottoman Empire come from Behar (1996), while the data

[8]Those sources, however, provide comparable GDP estimates as well as relative ratios. For example, while Maddison's UK and Turkey per capita GDP estimates for 1913, expressed in 1990 International Geary-Khamis dollars, are 4,921 and 1,213, Clemens and Williamson estimates, expressed in British Sterling, are 52 and 10.

on the population of France, Germany, and the U.K. comes from Maddison (1995). Table 3.1 shows that at the beginning of the sample in 1859, France was the largest country among those three, with a population of over 37 million. The smallest was Great Britain with about 29 million in population. During 1859–1913, France, Germany, and Great Britain experienced drastic differences in population growth rates. By 1913, Germany's population had increased by 85 percent, and it approached WWI with more than 65 million people. The population of France and the U.K. in the middle of 1913 was 41 and 46 million, respectively.

We impute data on FDI and exports to maximize the sample size in regression analysis.[9] However, we use both raw and imputed data, and the main regression results are based on raw data. Table 3.1 shows statistics for regression variables including both raw and imputed data. Summary statistics between raw and imputed data are close to each other. For each source country, Figures 3.4 and 3.5 show imputed data for FDI-to-GDP ratios and export-to-GDP ratios, respectively, together with raw data.

3.5 OLS Analysis

3.5.1 Empirical Specification

Our benchmark specification is as follows:

$$log\frac{FDI_{it}}{GDP_{it}} = \alpha_i + \lambda_t + \alpha_i t + \beta log\frac{EXPORTS_{it}}{GDP_{it}} + \gamma W_t + \epsilon_{it} \tag{3.1}$$

where α_i indicates country dummies, and λ_t indicates either time dummies or event dummies. Time dummies consist of a series of dummy variables that equal 1 for five consecutive years

[9] We impute missing data on FDI-to-GDP ratios, using the regression of log FDI-to-GDP ratios on log Ottoman government-debt-flow-to-GDP ratios with country fixed effects and country-specific time trends. This regression explains substantial variation in historical FDI-to-GDP ratios with an R-squared of 0.4114. We also impute missing data on Export-to-GDP ratios, using the regression of log Export-to-GDP ratios on log GDP per capita of each source country and log Ottoman GDP per capita with country fixed effects and country-specific time trends. This regression gives an R-squared of 0.8405. Remaining missing values are interpolated using the average of the values in years $t-1$ and $t+1$. If the value in $t+1$ is not feasible, the value in $t+2$ is used. When the value in $t-1$ is missing, we fill the value in t with the value in $t+1$.

without overlapping. Using event dummies, we control for specific events such as a dummy for the creation of the Ottoman Public Debt Administration (OPDA) in 1881, and other dummies characterizing the effect of Empire's default on the foreign debt in 1876, and the Resettlement of the debt in 1903. $\alpha_i t$ controls for country-specific trends.[10] The left-hand side variable is gross FDI inflows from the source countries i, which are France, Germany, and the U.K., into the Ottoman Empire; Exports are Ottoman exports into these countries. Both FDI and Exports are normalized by the GDP of each source country GDP_{it}. A control variable W_t is the Empire's contemporaneous GDP per capita.

3.5.2 OLS Results

We report results from the OLS estimation of equation (1) without time dummies in Table 3.2.[11] Our result in column 1 is strong given our sample size of 87 observations for raw data.[12] In column 2, we use imputed data for FDI-to-GDP ratios and export-to-GDP ratios, and the log export-to-GDP ratio is contemporaneous with the log FDI-to-GDP ratio. In column 3, we use imputed data for FDI-to-GDP ratio and export-to-GDP ratio, and the log export-to-GDP ratio is lagged. In all of the specifications, coefficients of exports turn out to be positive and significant. The results are also economically significant, in which a 10 percent increase in exports is associated with a 2.1-3.1 percent increase in FDI flows.

In Table 3.3, we first present results with time dummies and then replace them with dummies for important events such as default while also allowing for country-specific time trends.[13] To estimate the effect of the Ottoman Empire's default in 1876, we introduce

[10]Country-specific trends are included as the interaction term ($\alpha_i t$) between country dummies α_i and time trend t.

[11]We use Driscoll and Kraay (1998a) standard errors with the lag length 3, which is robust to heteroskedasticity and clustering on year and kernel-robust to common correlated disturbances.

[12]Even though the raw dataset contains 122 FDI observations (for all three countries combined) and 105 Exports observations, for some years, one of the variables is missing while the other is not. As a result, we end up with only 87 complete FDI-Exports pairs, which constitutes the effective sample size.

[13]When we include year fixed effects, the coefficients of exports become insignificant. This is because we have only three countries (trading partners) in panel data, which gives insufficient within-year variation across countries. Event dummies explained in this paragraph (Default, OPDA, and Resettlement) are not collinear with other controls such as country-specific time trends. These event dummies will be collinear

a "Default" dummy, which equals 0 before 1876 and 1 thereafter. As was expected, by defaulting on its foreign debt, the Ottoman Empire discouraged further investment, reducing capital flows into the country. In 1881, the Ottoman government decided to take action toward repayment of the debt, and it established a European-controlled organization, called the Ottoman Public Debt Administration (OPDA), designed to collect taxes, which then were turned over to creditors. We take this event into account by introducing an "OPDA" time dummy, which is equal to 0 before 1881 and 1 after that. In 1903, the creditors voluntarily restructured the remaining debt of the Ottoman Empire, partially reducing its size. We capture that effect by yet another time dummy, "Resettlement," which equals 1 after 1903. All the dummies appear to have expected signs. We also control for GDP per capita of the Ottoman Empire to partial out the effect of exports on FDI via exporter's income channel. This variable does not seem to have an impact, and hence we do not report those results.[14]

To understand structural breaks in the relationship over time, we re-estimate our baseline regression (Table 3.2 column 1) at every 5-year period, using the following specification:

$$log(\frac{FDI_{it}}{GDP_{it}}) = \alpha_i + \beta_j log(\frac{EXPORTS_{it}}{GDP_{it}}) + \gamma W_t + \epsilon_{it},\ t \in j \tag{3.2}$$

where j refers to each 5-year period during the sample period 1885-1913 (the last period has only 4 years), and α_i indicates country dummies. The left-hand side variable is gross FDI inflows (raw data) from the source countries i, which are France, Germany, and the U.K., into the Ottoman Empire; Exports are Ottoman exports into these countries (raw data). Both FDI and exports are normalized by the GDP of each source country GDP_{it}. A control variable W_t is the Empire's contemporaneous GDP per capita in logs. In Table

with year fixed effects, but we do not have year fixed effects in our regressions.

[14]For robustness, we also normalize FDI and exports by the population of source countries instead of their GDP. Note that there is no point in normalizing by the Ottoman GDP and population since that will be a common factor among the three source countries and be absorbed by the constant term. When we normalize by the population of the source country, the results are very similar in magnitude to those described and are available upon request.

3.4, we find that Ottoman exports and FDI inflows into the Ottoman Empire are positively associated during the periods 1885-1889, 1900-1904, and 1910-1913, and these correlations are significant at a 1 percent level. Although correlations during some periods are not significant due to the small sample size, these regression results suggest that there is no evident structural break in the relationship between exports and FDI.

Furthermore, we perform a placebo test to show that bilateral trade matters in explaining bilateral FDI. In Table 3.5 column 2, we switch all three trading partners and rerun the baseline regression of column 1. We find that exports do not explain FDI after switching trading partners, which suggests that bilateral trade matters for bilateral FDI. Also, we investigate whether coefficients in our regressions capture the correlation between FDI and unobserved common time-varying factors. To do this, we construct a measure for the time-varying factor that can capture competition amongst source countries, which leads to the boom-bust cycle in capital flows. We measure this cycle in capital flows (FDI cycle) facing a country i in year t as the average of log FDI-to-GDP ratios of other countries in year t excluding country i. Table 3.6 reproduces the baseline regression in column 1 and adds an FDI cycle to the regression in column 2. We find that the FDI cycle is positively correlated with FDI of each source country only at a 15 percent significance level. Importantly, the coefficient on exports is still significant at a 5 percent level, and the magnitude of this coefficient rarely decreases (from 0.35 to 0.34) after adding the FDI cycle.

3.5.3 Dynamic Responses

To investigate dynamic responses of FDI to exports, we run regressions by local projections (?) as follows:

$$log(\frac{FDI_{it+h}}{GDP_{it+h}}) = \alpha_i + \alpha_i t + \beta_h log(\frac{EXPORTS_{it}}{GDP_{it}}) + \sum_{j=1}^{3} \gamma_j W_{it-j} + \epsilon_{it+h} \tag{3.3}$$

where α_i indicates country dummies, and $\alpha_i t$ controls for country-specific trends. The left-hand side variable is interpolated gross FDI inflows from the source countries i, which are France, Germany, and the U.K., into the Ottoman Empire in time $t + h$; Exports are interpolated Ottoman exports into these countries in time t. Both FDI and Exports are normalized by the GDP of each source country. The set of control variables W_{it} includes FDI-to-GDP ratios, export-to-GDP ratios, and the Empire's GDP per capita (which does not vary across countries), and all of them are included up to past three years.

We find that a rise in exports has persistently significant effects on FDI up to a 3-year ahead horizon at a 5 percent significance level. We collect estimates β_h in Figure 3.6. On impact, a 1 percent increase shock from the export-to-GDP ratio is associated with a 0.18 percent increase in the FDI-to-GDP ratio. After three years, the FDI-to-GDP ratio increases by 0.20 percent in response to the same shock.

3.6 IV Analysis

3.6.1 Rainfall, Agricultural Production, and Trade

In this section, we lay out our argument on the linkage between trade, production, and weather conditions, specifically the regional variation in the amount of rainfall within the Ottoman Empire. We explain in detail how the composition of exports into the U.K., France, and Germany, as well as specialization of the Empire's regions in different types of crops, allows us to construct the instrument.

The first step is to highlight the dependency between the level of exports and production. Excessive output in one particular year leads to a surplus of goods that were available for sale in and out of the country, causing exports to increase. This line of thought mainly comes from the "provisionistic" nature of the Empire's policy. As the government policy at those times was aimed to primarily satisfy the needs of the Ottoman army, the supply of exports was determined not only by the prices but also by the yield in that particular year. If the yield was low, it had to go first towards satisfying the army needs; if there remained any excess over this amount, it could be traded abroad.

As discussed in Pamuk and Williamson (2011), by the beginning of the second half of the 19th century, the de-industrialization of the Ottoman Empire was practically complete. Labor and other resources were pulled out of the industry, and agricultural production constituted the biggest part of the Ottoman Empire's GDP. Altug et al. (2008) state that "Mechanization of agriculture began [only] in the 1950s, making nature one of the most important determinants of people's well-being at those times," and Quataert (1994) adds that "Mechanized factory output was and remained relatively insignificant in the 19th century when compared with domestic and handicraft production."

Agricultural goods made up a significant share of Ottoman exports. Therefore, the amount of rainfall was an important determinant of both domestic production and trade. Indeed, Donaldson (2018) for the case of India during 1861–1930 shows that "a one standard deviation increase in rainfall causes a 27 percent increase in agricultural productivity," thus affecting both quantity and quality of crops. For the case of grapes – one of the most important exports – Hellman (2004) gives an estimated 98 mm of water use per month to maximize the quantity and quality of crops. This estimate is obtained for the most efficient modern drip irrigation system; for the furrow irrigation that historically was used in the Ottoman Empire, ideal water usage doubles to 196 mm. Another important agricultural product of the Empire was cotton. There is substantial evidence that "water deficit during critical growth stages can significantly reduce cotton yields" (Steger et al., 1998; Grimes et al., 1970). For example, in the time of emergence (typically, in October) cotton fields require about 60 mm of monthly water usage. Water requirements increase during the next 5 months, reaching 255 mm a month in late February. Again, one of the main determinants of the yield of dryland (unirrigated) cotton is regular and predictable rainfall. Similar patterns hold for other important agricultural export goods of the Ottoman Empire such as corn, grain, and olives. Agricultural production was critically dependent on rainfall during the sample period, given that the development of irrigation systems occurred in Turkey only at the end of the 20th century (Food and Agriculture Organization of the United Nations, 2009), which is outside the time frame we consider in this paper.

Measuring the effect of rainfall on various types of crops produced, including grain, grape, olives, cotton, and others, is possible since the rainfall data is available on a region by region basis, and different regions specialized in different crops. The area of modern-day Turkey amounts to 300,948 square miles, which equals 779,452 square kilometers. 265,931 square kilometers (a little more than one third) of those lands are used for agricultural purposes (Prime Ministry Republic of Turkey and Turkish Statistical Institute, 2005). In the past, a higher fraction of the land was used for agricultural production, plus there was more land under the Ottoman Empire's boundaries. We will focus on the regions that constitute today's modern Turkey and assume the specialization of regions in crops stays more or less the same in the last 200 years. This assumption is based on the maps provided by the State Institute of Statistics (SIS) historical and contemporaneous yearbooks for grain and orchard production. Hence, we aggregate the products to groups such as "grains" and "orchards" and focus on bigger geographical regions than cities.

Let us explain this in detail. Turkey consists of 80 administrative provinces, 12 statistical regions (SRE) and 7 geographical regions. The first 4 of the 7 geographical regions have the names of the seas which are adjacent to them. Those regions are Black Sea Region, Marmara Region, Aegean Region, and Mediterranean Region. The other 3 regions are named according to their location in the Anatolia: Central Anatolia Region, Eastern Anatolia Region, Southeastern Anatolia Region. In every region, agricultural land is typically split into two parts. The first part is cultivated field land. These cultivated lands are used to grow various types of grain (corn, wheat, barley, rye, etc.), as well as cotton and tobacco. The second type is the area of fruit trees, olive trees, vineyards, vegetable gardens, and an area reserved for tea plantations. For consistency, we call the first type of land "grain" land, and the second type "orchard" land. As shown in Table 3.7, the share of "grain" land varies from 35 percent in the East Black Sea region to as high as 99 percent in North East

Anatolia. These shares of “grain” and “orchard” lands remained roughly the same in the last 200 years.

Let us work out an example. Assume there is extensive rain in the Aegean region and abnormally dry weather in the Mediterranean region. We can conclude that first, this event would have a negligible effect on total “grain” production in the country. Indeed, if we look at Table 3.7, we can see that the area of positively affected “grain” land in the Aegean region equals $2,187$ thousand hectares, and it is fairly close to the negatively affected “grain” area in the Mediterranean region, which equals $2,132$ million hectares. Second, we expect the whole country's output of “orchard” products to increase. The reason is that the “orchard” land in the Aegean region is much bigger than that in the Mediterranean region (828 thousand hectares versus 490 thousand hectares). This simple thought experiment will constitute a basis for the construction of our instrument.

The historical precipitation dataset we employ in this study is assembled based on the “tree-ring” methodology – a technique proposed by A. E. Douglass in the 20th century. This methodology recovers relatively precisely the level of rainfall during a growing season in each particular year based on the width of age rings, where each ring corresponds to a certain year. During droughts, rings are typically narrower, while extensive moisture results in wide rings. This data is not real-time historical data in the sense that it was not collected in the past, but instead is being reconstructed nowadays.[15]

Analyzing tree-ring sites location maps in each study (the maps are available in the original studies), we are able to tie precipitation data series to different statistical regions (SRE), which are listed in Figure 3.7. Historical precipitation time series for North-West and South-Central regions of Turkey (TR8 and TR5) were constructed by Akkemik et al. (2007) and Akkemik and Aras (2007) respectively, and the time span of those series exceeds 300 years. North-West study area – Kastamonu-Pinarbasi and its vicinity – was located on

[15] As a robustness check, we compare reconstructed precipitation data to “true” historical data from the Ottoman Archives. Unfortunately, archival data only covers limited regions. The correlation between the two datasets for the overlapping regions is 0.495.

the southern side of the Kure Mountains. This corresponds to TR8 statistical region. The South-Central sampling area was located in the upper and northern part of the Western Taurus Mountains in proximity to Konya and corresponds to TR5 region. Griggs et al. (2007) dataset covers North Aegean (TR2), specifically, North-East Greece and North-West Turkey and goes back by 900 years. The authors reconstruct (May-June) precipitation based on analysis of oak tree rings. North-West Turkey under consideration corresponded to TR2 statistical region. Touchan et al. (2003) build the dataset which reconstructs Southwestern Turkey (TR3) Spring (May-June) precipitations. Their data starts in 1776, and the sites were located in the TR3 statistical region. Finally, Touchan et al. (2007) is an extensive reconstruction of precipitations in the Eastern-Mediterranean Region for the last 600 years. This study covers not only Turkey but also other countries in the region. The majority of sites located in Turkey are concentrated in TR3 and the West half of TR6.

The rainfall variable constructed from tree-ring methodology might capture overall conditions that affect plant growth. The reason is that measured tree-ring growth in a given year will be higher when temperature or timing of rainfall was ideal. We believe that the rainfall instrument is still valid and relevant, as long as plant growth conditions are exogenous to capital flows and affect exports given the provisionistic policy of the Ottoman Empire.

To identify whether there was unusually rainy weather or unusually dry weather in a region j ($j = 1..J$), and hence whether there was a shock to productivity, we proceed as follows. First, we measure the percentage deviation of yearly precipitation r_{jt} in a region j during year t from their average values over the period under consideration (1859–1913):

$$dr_{jt} = \log(r_{jt}) - \log\left(\frac{1}{T}\sum_{t=1859}^{1913} r_{jt}\right) \tag{3.4}$$

where t indexes years, and T, the sample length, is 55, and dr_{jt} measures the deviation from the average. Positive values of this statistic would indicate that in a year t region j experienced a large amount of rainfall, which most likely would have resulted in high yield.

Having this index and knowing the distribution of land between the "grain" and "orchard" land in each region allow us to construct a variable, which reflects the country-wide "grain" and "orchard" production shocks as a result of a unique rain map over the Ottoman Empire in year t. Let L_j be the agricultural area of region j. It is split into two parts: "grain" land L_j^g and "orchard" land L_j^o, and $L_j = L_j^g + L_j^o$. We can define S_j as the share of "grain" land in the total agricultural area of region j

$$S_j = \frac{L_j^g}{L_j} \tag{3.5}$$

Then the country-wide output shock to "grain" production P_t^g and the output shock to the "orchard" production P_t^o in year t would be the average of the regional shocks, weighted by the share of their area in the total area:

$$P_t^g = \frac{\sum_{j=1}^{J} L_j^g \times dr_{jt}}{\sum_{j=1}^{J} L_j^g} = \frac{\sum_{j=1}^{J} S_j L_j \times dr_{jt}}{\sum_{j=1}^{J} S_j L_j} \tag{3.6}$$

$$P_t^o = \frac{\sum_{j=1}^{J} L_j^o \times dr_{jt}}{\sum_{j=1}^{J} L_j^o} = \frac{\sum_{j=1}^{J} (1 - S_j) L_j \times dr_{jt}}{\sum_{j=1}^{J} (1 - S_j) L_j} \tag{3.7}$$

This set of indices is used to model the deviations in the production of both types of agricultural outputs as a function of the amount *and* location of rainfall in Turkey, under the assumption that both types of crops are similarly affected by rainfall.[16] This gives us the time-series variation in our instrument.

The best way to illustrate this formula is to go over an example. Suppose, we know that some year t was especially rainy. Specifically, the percentage deviation from the usual level of precipitations was 10 percent for the West Marmara region, 20 percent for Aegean, and 6 percent for West Anatolia. All other regions experienced usual level of rainfall. What can we say about the deviations of grain and orchard production from their average values?

[16] We do a robustness check for different sensitivities of crop production with regard to rainfall in Table 3.10.

The answer depends on the size of a region L_j and its agricultural specialization S_j. The values of L_j and S_j come from Table 3.7, and they are equal to {1,736; 0.87}, {3,010; 0.73} and {4,221; 0.96} for the West Marmara, Aegean, and West Anatolia regions, respectively. To find country-wide shocks to the production of "grain" and "orchard," we need to use Eq. (3.6) and Eq. (3.7). After substituting the values, we get $P_t^g = \frac{0.10 \times 1{,}510 + 0.20 \times 2{,}187 + 0.06 \times 4{,}050}{23{,}066} = 3.60 \times 10^{-2}$ and $P_t^o = \frac{0.10 \times 226 + 0.20 \times 828 + 0.06 \times 171}{3{,}526} = 5.63 \times 10^{-2}$. These numbers mean that in year t production of grain has experienced a positive shock of about 4 percent, while the production of the orchard has experienced a positive shock of about 6 percent. Different rain patterns from year to year cause the time variation of production.

Our next step is to introduce cross-sectional variation (meaning between the Empire and the various Northern trading partners) to our instrument. We are able to do this by relying on the fact that the composition of exports differs for Germany, France, and the U.K. Pamuk and Williamson (2011) argue that the Ottoman Empire, while importing manufactures, specialized in the export of primary products. As is evident from Table 3.8, at the beginning of the sample, agricultural products constituted about 70 percent of exports to both Germany and the U.K. For France, this share makes up only 26 percent. We speculate that the reason is that, unlike Germany and the U.K., France used to purchase high volumes of raw silk. Its share constantly made up more than 30 percent of France imports, falling to 18.3 percent only in 1880–1882, right after the default (Pamuk, 2003).

The differences in export bundles allow us to obtain cross-sectional variation of our instrument. Let m index the country, where $m = \{\text{France}, \text{Germany}, \text{U.K.}\}$. And let $\overrightarrow{\theta}_m = (\theta_m^g, \theta_m^o, \theta_m^0)$ represent the decomposition of exports of country m into "grain," "orchard," and "other" according to Table 3.8. It is important that we use initial values (first year in our sample) for these export bundles and do not allow them to vary over time. Hence, these initial export shares can be thought of as structural demand for the Empire's products by the Northern countries.

We construct the variable "Rainfall," R_{mt}, which reflects export-share-weighted plant productivity shocks for trading country m in year t, and thus this variable is able to instrument for country-time varying exports:

$$R_{mt} = \theta^g_{m0} P^g_t + \theta^o_{m0} P^o_t \tag{3.8}$$

where as usual, "g" and "o" denote "grain" and "orchard" production, respectively, and the values of shocks to outputs P^g_t and P^o_t are defined according to Eq. (3.6) and Eq. (3.7).

3.6.2 IV Results and Threats to Identification

The top panel of Table 3.9 shows the two-stage least square (2SLS) results and the bottom panel reports the coefficient on rainfall from the corresponding first-stage regression.[17] We can see that exports are indeed a significant determinant of FDI. This is true when we do not have event dummies (column 1) and when we include event dummies (column 2). In column 2, the coefficient on exports is larger than the OLS counterpart and significant at a 1 percent level. This result shows that the OLS estimates are biased downward, possibly because omitted factors (such as regulations on financial flows) – that increase FDI into the Ottoman Empire – are negatively correlated with Ottoman exports. This also suggests that substitutability between FDI and exports might exist in which the causal relationship runs from FDI to exports. Heckscher-Ohlin-Mundell paradigm can explain this finding in that goods need not be traded to achieve factor price equalization when capital flows into a country.

The first-stage regressions show that rainfall is a significant determinant of exports, in which the first-stage F statistic exceeds the rule-of-thumb threshold level of 10. The value of the coefficient is around 0.46, suggesting that an increase in the rainfall index by about 10 percent (which corresponds to one standard deviation in rainfall from the mean) leads to a 5 percent increase in Ottoman exports. This rise in exports, in turn, causes a 3 percent increase in capital inflows, on average. Figure 3.8 shows the partial plot for column 2 of

[17] For all of 2SLS regressions, we use raw data on exports and FDI.

the first-stage regression, and it is clear that the strong first-stage correlation is not driven by outliers. Moreover, we take a formal test of the exclusion restriction, using the Hansen's overidentifying restriction test. Hansen's J statistics do not reject the null hypothesis that instruments are excludable, which provides suggestive evidence that the rainfall instrument is valid.

In columns 3 and 4, we rerun regressions using the sample in which all observations start in 1885 to alleviate concerns about missing observations before 1885.[18] In column 3 without the "Resettlement" event dummy, we lose some significance due to the small sample size, but the coefficient is still positive and significant at a 10 percent level. In column 4 with the "Resettlement" event dummy, we have a positive causal relationship, which is significant at a 1 percent level.

Guided by the model of Antràs and Caballero (2009), we validate the exclusion restriction that rainfall affects FDI only via the export channel. This means that rainfall is not associated with FDI or unobserved factors that determine FDI, once we control for exports and include our other control variables. In their model, differences in the returns to capital in the agricultural sector between the Ottoman Empire (δ^H) and each source country i (δ_i^F) drive capital flows. When the return to capital in the Ottoman Empire is greater than the one in source countries, capital flows from source countries to the Ottoman Empire. Therefore, we can think of capital inflows into the Ottoman Empire as an increasing function of $\delta^H - \delta_i^F$, for simplicity. Also, δ^H is determined by the Ottoman variables: the marginal product of capital and export revenues per unit $p(1-\tau)$ — in which p is the unit price of exporting goods, and τ is trade costs — together with structural parameters such as the preference for goods and the degree of financial development. Thus, from the perspective of the Ottoman Empire, we can characterize capital flows as a function of the marginal product of capital and export revenues of the Ottoman Empire given constant structural parameters. Regressions include country dummies α_i to control for differences in structural parameters

[18] In the full regression sample using raw data on exports and FDI, observations from France start in 1878; the U.K. in 1871; and Germany in 1885.

in δ_i^F across countries i.

In 2SLS regressions, rainfall generates exogenous variation in trade frictions τ and is correlated with export revenues, given the provisionistic nature of the Ottoman policy. If rainfall was not enough in a given year, and in turn, the production of agricultural goods might have dropped below the threshold, the Ottoman government banned exports (the trade cost was at a maximum level, $\tau = 1$). If the level of production was above the threshold, the trade cost τ would decrease as production increased (rainfall increased), given that a smaller portion of total production is allocated to the Ottoman government and that τ is a unit cost associated with trade frictions.

The main threat to the exclusion test is that rainfall can affect capital flows via the marginal product of capital rather than export revenues. We argue that we can control for the marginal product of capital by including GDP per capita of the Ottoman Empire. Suppose production Y is given by $ZK^{\alpha}L^{(1-\alpha)}$ in which Z is aggregate productivity, K is capital, and L is labor. Then, the marginal product of capital is $\partial Y/\partial K = \alpha Z(K/L)^{(\alpha-1)}$. We can rewrite the marginal product of capital as $(\alpha Y/K) = (\alpha Y/N)\times(N/L)\times(L/K) = \alpha(Y/N)\times 1/(K/N)$ in which N is population. We can control for the part of the marginal product of capital using GDP per capita Y/N. In addition, there is no compelling reason that aggregate capital per capita K/N is systematically correlated with year-on-year variation in country-specific region-weighted rainfall after controlling for trends. Thus, as we include GDP per capita in our regressions, we can control for the bulk of the variation in the marginal product of capital and alleviate the threat to the exclusion restriction. Nevertheless, given the limitation on data, we cannot fully control for unobserved factors that are correlated with our instrument and can affect FDI.

In addition, we use country-specific time trends to account for secular time-varying factors of source countries. Furthermore, using event dummies, we control for events that could drive our causal estimates. Ottoman default in 1876 could lead both trade and financial flows to go down (Rose and Spiegel, 2004). We also include a dummy to control the effect of the establishment of the Ottoman Public Debt Administration (OPDA) in 1881. The OPDA could increase financial flows, while reducing trade (Wright (2004), Mitchener and Weidenmier (2005), Rose and Spiegel (2004), Eaton and Gersovitz (1981b)).

Moreover, we do a robustness check for the rainfall instrument and find that our IV results are robust to alternative weights for grain and orchard in rainfall variables. In Table 3.10, we reproduce IV regression results in columns 1 and 2, which are without and with event dummies, respectively. Then, we reconstruct a rainfall variable ($R_{mt} = \theta^g_{m0}\omega^g P^g_t + \theta^o_{m0}\omega^o P^o_t$) such that sensitivities for grain ω^g and orchard ω^o are 1.5 and 0.5, and we replace the baseline rainfall variable with the reconstructed rainfall variable in columns 3 and 4. Columns 5 and 6 present results with another rainfall variable such that sensitivities for grain and orchard are 0.5 and 1.5, respectively. Also, we construct a rainfall variable ($R_{mt} = \theta^g_{m0} P^g_t + \theta^o_{m0} P^o_t$) such that export shares of grain θ^g_{m0} are increased by 20% and export shares of orchard θ^o_{m0} are decreased by 20% for all source countries m. Again, we replace the baseline rainfall variable with the reconstructed rainfall variable in columns 7 and 8. Columns 9 and 10 show results with another rainfall variable such that θ^g_{m0} are decreased by 20% and θ^o_{m0} are increased by 20% for all source countries m. We find that coefficients in the first and the second stage regressions rarely change across columns and that reconstructed instruments are still relevant (all first-stage F statistics exceed 10).

3.7 Conclusion

This paper investigates the causal effect of trade on financial flows using a historical quasi-natural experiment from the Ottoman Empire. We use fluctuations in regional rainfall within the Ottoman Empire to capture the exogenous variation in exports from the Empire to Germany, France, and the U.K., during 1859–1913. The provisionistic policy of the Ottoman Empire provides the basis for our identification. This policy dictates that only surplus production was allowed to be exported. Since different products grow in different sub-regions of the empire, there will be differences in the surplus production based on the differences in regional variation in rainfall. The trading partners of the Empire, namely, France, Germany, and the U.K., have different demands and hence import different products. As a result, we can link regional variation in rainfall to exogenous cross-sectional variation in exports over time to these three countries.

When a given region of the Empire gets more rainfall than others, the resulting surplus production is exported to countries with higher ex-ante export shares for those products, and this leads to higher investment by those countries in the Ottoman Empire. We find that a one standard deviation increase in rainfall from the mean leads to a 5 percent increase in Ottoman exports, which in turn causes a 3 percent increase in capital inflows, on average. This result holds also after accounting for the negative effect of the Ottoman 1876 default on foreign investment and trade. Our findings are supportive of trade theories predicting the complementarity between trade and capital flows as a result of causality running from exports to foreign direct investment.

Tables

Tables of Chapter 1

	Mean	Std. Dev.	Min	Max	$N_{Observations}$
Panel A. 9 Eurozone Countries					
Sovereign Spread (%p)	0.68	1.47	-0.10	11.39	489
GDP Growth (%)	0.35	0.99	-7.09	4.90	489
Sovereign Debt/GDP (%)	74	27	24	137	489
Corporate Debt/GDP (%)	107	30	52	227	489
Panel B. Italy, Spain, Portugal, Ireland					
Sovereign Spread (%p)	1.21	2.10	-0.10	11.39	210
GDP Growth (%)	0.27	1.12	-3.86	4.90	210
Sovereign Debt/GDP (%)	75	31	24	131	210
Corporate Debt/GDP (%)	103	40	52	227	210
Panel C. Belgium, Finland, France, Austria, Netherlands					
Sovereign Spread (%p)	0.29	0.34	-0.05	2.53	279
GDP Growth (%)	0.41	0.87	-7.09	3.30	279
Sovereign Debt/GDP (%)	72	24	29	137	279
Corporate Debt/GDP (%)	109	21	73	163	279

Notes: This table summarizes statistics for observations in nine Eurozone countries (Italy, Spain, Portugal, Belgium, Finland, France, Ireland, Austria, and Netherlands) during the period 1999q1-2012q4. Quarter-on-quarter GDP growth is measured as a log difference.

Table 1.1: Summary Statistics: Spread Regression Sample (1999q1-2012q4)

	Mean	Std. Dev.	Min	Max	$N_{Observation}$
Sovereign Spread (%p)	0.89	1.68	0.00	9.05	60
GDP Growth (%)	0.86	2.59	-8.63	5.06	60
Sovereign Debt/GDP (%)	80	29	32	125	60
Corporate Debt/GDP (%)	107	23	59	152	60
Bank Leverage (%)	16	7	5	46	60
Granular Residuals (Γ, %)	0.03	0.32	-0.86	0.93	60
Tax Revenue Growth (%)	1.04	3.89	-10.99	6.56	60

Notes: This table summarizes statistics for observations in Italy, Spain, Portugal, Belgium, Finland, and France during the period 2002–2012. Observations during the period 2000-2005 from Portugal are dropped due to insufficient firm-level observations used to calculate the granular residuals (weighted sum of idiosyncratic shocks to top 50 large firms) in each country. As the IV regression uses lagged variables up to two years back as explanatory variables using the sample ranging from 2000 to 2012, the final observations used in regressions run from 2002 to 2012 for Italy, Spain, Belgium, Finland, and France (55 observations) and from 2008 to 2012 for Portugal (5 observations).

Table 1.2: Summary Statistics: IV Regression

Dependent Variable:	Sovereign Spread$_{c,t}$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP Growth$_{c,t-1}$	-0.45**	-0.28*	-0.35**	-0.29	-0.30*	-0.48**	-0.43**
	(0.19)	(0.16)	(0.16)	(0.20)	(0.16)	(0.23)	(0.19)
Sovereign Debt/GDP$_{c,t-1}$	0.08***	0.07***	0.07***	0.07***	0.08***	0.04**	0.06***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Corporate Debt/GDP$_{c,t-1}$		0.04***	0.04***	0.04***	0.04***		0.05***
		(0.01)	(0.01)	(0.01)	(0.01)		(0.01)
log(VIX)$_{t-1}$			-0.33				
			(0.21)				
TED Spread$_{t-1}$				-0.08			
				(0.30)			
Term Spread$_{t-1}$					-0.11		
					(0.09)		
Within R^2	0.3659	0.4448	0.4474	0.4429	0.4488	0.4774	0.5180
$N_{Observations}$	248	248	248	248	248	248	248
Country Fixed Effects	yes	yes	yes	yes	yes	yes	yes
Quarter Fixed Effects	no	no	no	no	no	yes	yes

Notes: Driscoll and Kraay (1998b) standard errors (robust to heteroskedasticity and clustering on date and kernel-robust to common correlated disturbances) with a lag length of 4 quarters are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. The regression sample is quarterly and covers the same countries as in annual IV regressions (Italy, Spain, Portugal, Belgium, Finland, and France) over the period 2002q1–2012q4.

Table 1.3: OLS Sovereign Spread Regression with six Eurozone Countries

	(1)	(2)	(3)	(4)
	Baseline		Bank Control	
	OLS	IV	OLS	IV
	A. Second-Stage Regression			
Dependent Variable:	Sovereign $\text{Spread}_{c,t}$			
Corporate $\text{Debt/GDP}_{c,t-1}$	0.03**	0.15**	0.04***	0.11**
	(0.01)	(0.06)	(0.02)	(0.05)
Sovereign $\text{Debt/GDP}_{c,t-1}$	0.03	0.10**	0.04*	0.08**
	(0.02)	(0.05)	(0.02)	(0.03)
GDP $\text{Growth}_{c,t-1}$	-0.23**	-0.08	-0.25**	-0.19**
	(0.12)	(0.13)	(0.11)	(0.09)
Bank $\text{Leverage}_{c,t-1}$			0.07***	0.09***
			(0.01)	(0.02)
	B. First-Stage Regression			
Dependent Variable:	Corporate $\text{Debt/GDP}_{c,t-1}$			
Granular $\text{Residual}_{c,t-1}$	n/a	-5.10**	n/a	-5.86**
		(2.37)		(2.32)
Granular $\text{Residual}_{c,t-2}$	n/a	-3.88*	n/a	-4.67**
		(2.18)		(2.00)
Adjusted R^2	0.6547	0.4800	0.6833	0.6275
$N_{Observation}$	60	60	60	60
Country Fixed Effect	yes	yes	yes	yes
Time Fixed Effect	yes	yes	yes	yes
Hansen J (p-value)	n/a	0.5528	n/a	0.3880
First-stage F^{eff}	n/a	3.43	n/a	5.15
CLR (p-value, $H_0 : \beta_{corp} = 0$)	n/a	0.0250	n/a	0.0628

Notes: Annual sovereign spreads are regressed on lagged explanatory variables over the period 2002–2012. In instrumental variable (IV) regressions, excluded instruments for corporate debt are 1 and 2 years lagged granular residuals, which are based on idiosyncratic total factor productivity shocks to large firms estimated by the method of Wooldridge (2009). The granular residual is a weighted sum of idiosyncratic shocks to top 50 firms in each country c, using lagged Domar weights ($\text{sales}_{i,c,t-1}/\text{GDP}_{c,t-1}$) for a given firm i. Idiosyncratic shocks are residuals from the regression of firm-level productivity on 4-digit sector×year fixed effects. In column 2, lagged GDP growth, the lagged government debt to GDP ratio, country fixed effects, and year fixed effects are included in both the first and second stage regressions. Lagged bank leverage is added to the first and second stage regressions in column 4. The Hansen (1982) J statistic tests the null that instruments are excludable. The first-stage effective F statistic of Olea and Pflueger (2013) tests the null that the excluded instruments are not relevant. The p-value for CLR statistic (Andrews et al. (2019)) is reported to test the null hypothesis that the coefficient on corporate debt in the second stage regression is zero. This test is robust to weak instruments. Robust standard errors (calculated using the 2-step GMM method and robust to arbitrary clusters for IV regressions) are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 1.4: IV Spread Regression

	(1) OLS	(2) IV	(3) OLS	(4) IV
	A. Second-Stage Regression			
Dependent Variable:	Tax Revenue Growth$_{c,t}$		Tax Revenue Growth$_{c,t}$	
Corporate Debt/GDP$_{c,t-1}$	-0.22***	-0.32***	-0.20***	-0.29**
	(0.07)	(0.12)	(0.07)	(0.12)
Sovereign Debt/GDP$_{c,t-1}$	-0.08	-0.14*	-0.08	-0.12
	(0.05)	(0.08)	(0.05)	(0.08)
GDP Growth$_{c,t}$			0.43*	0.34
			(0.26)	(0.30)
GDP Growth$_{c,t-1}$	0.39*	0.26	0.28	0.18
	(0.21)	(0.22)	(0.19)	(0.21)
Bank Leverage$_{c,t-1}$	-0.05	-0.08	0.05	-0.07
	(0.06)	(0.07)	(0.06)	(0.07)
	B. First-Stage Regression			
Dependent Variable:	Corporate Debt/GDP$_{c,t-1}$			
Granular Residual$_{c,t-1}$	n/a	-5.86**	n/a	-5.30**
		(2.32)		(2.32)
Granular Residual$_{c,t-2}$	n/a	-4.67**	n/a	-4.49**
		(2.00)		(2.05)
Adjusted R^2	0.6247	0.5928	0.6356	0.6106
$N_{Observation}$	60	60	60	60
Country Fixed Effect	yes	yes	yes	yes
Time Fixed Effect	yes	yes	yes	yes
Hansen J (p-value)	n/a	0.2373	n/a	0.1511
First-stage F^{eff}	n/a	5.15	n/a	4.25
CLR (p-value, $H_0 : \beta_{corp} = 0$)	n/a	0.0879	n/a	0.1936

Notes: Annual real tax revenue growth is regressed on lagged explanatory variables over the period 2000–2012. In instrumental variable (IV) regressions, excluded instruments for corporate debt are 1 and 2 years lagged granular residuals, which are based on idiosyncratic total factor productivity shocks to large firms estimated by the method of Wooldridge (2009). The granular residual is a weighted sum of idiosyncratic shocks to top 50 firms in each country c, using lagged Domar weights (sales$_{i,c,t-1}$/GDP$_{c,t-1}$) for a given firm i. Idiosyncratic shocks are residuals from the regression of firm-level productivity on 4-digit sector×year fixed effects. In column 2, lagged GDP growth, the lagged government debt to GDP ratio, country fixed effects, and year fixed effects are included in both the first and second stage regressions. Lagged bank leverage is added to the first and second stage regressions in column 4. The Hansen (1982) J statistic tests the null that instruments are excludable. The first-stage effective F statistic of Olea and Pflueger (2013) tests the null that the excluded instruments are not relevant. The p-value for CLR statistic (Andrews et al. (2019)) is reported to test the null hypothesis that the coefficient on corporate debt in the second stage regression is zero. This test is robust to weak instruments. Robust standard errors (calculated using the 2-step GMM method and robust to arbitrary clusters for IV regressions) are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 1.5: Tax Revenue Regression

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:			Tax Payment$_{i,t}$			
HighLev$_i$ × Crisis$_t$	-0.39***	-0.39***	-0.38***	-0.30***	-0.30***	-0.28***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.06)
$log(z_{i,t-1})$	1.56***	1.56***	1.47***	1.53***	1.53***	1.45***
	(0.13)	(0.13)	(0.14)	(0.13)	(0.13)	(0.14)
$log(k_{i,t-1})$	-0.16***	-0.16***	-0.17***	-0.13***	-0.13***	-0.14***
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.04)
$log(b_{i,t-1})$	-0.02**	-0.02**	-0.02**	-0.00	-0.00	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Interest Payment$_{i,t}$				-0.18***	-0.18***	-0.19***
				(0.02)	(0.02)	(0.02)
$N_{Observation}$	35,187	35,187	34,463	35,187	35,187	34,463
R^2	0.65	0.65	0.65	0.65	0.65	0.65
Firm Fixed Effects (FE)	yes	yes	yes	yes	yes	yes
Country and Year FE	yes	n/a	n/a	yes	n/a	n/a
Country×Year FE	no	yes	n/a	no	yes	n/a
Country×Sector×Year FE	no	no	yes	no	no	yes

Notes: Standard errors are in parentheses and clustered at the 4-digit sector level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. z is total factor productivity estimated by the Wooldridge (2009) method. k is tangible fixed assets. b is the sum of loans and long-term debt. Leverage is measured as a debt-to-value-added ratio (b/y), where value added y is measured as operating revenue minus materials cost. Interest payments are measured as the ratio of interest paid to value added. The Crisis$_t$ dummy equals 1 in or after 2008 and 0 otherwise. The HighLev$_i$ dummy equals 1 if average leverage before 2008 of a given firm is higher than the aggregate median before 2008 and 0 otherwise. The regression sample covers the period 2004–2012 in six Eurozone countries (Italy, Portugal, Spain, Belgium, Finland, and France).

Table 1.6: Firm Tax Payment Regression

Panel A. Parameters set independently			
interpretation	**symbol**	**value**	**source**
capital income share	α	0.35	standard literature
labor income share	θ	0.50	
risk aversion	ν	2	
capital depreciation rate	δ	0.06	
corporate discount factor	β	0.98	Arellano et al. (2019)
government discount factor	β_g	0.90	
risk-free rate	r	0.019	average German real interest rate
corporate income tax rate	τ^y	0.327	average corporate income tax rate
government debt recovery rate	R^g	0.63	Cruces and Trebesch (2013)
corporate debt recovery rate	R^f	0.70	World Bank Doing Business Database
equity issuance cost	κ	0.426	Jermann and Quadrini (2012)
volatility of taste shocks	σ_ϵ	0.001	Dvorkin et al. (forthcoming)
Panel B. Parameters set by simulation			
interpretation	**symbol**	**value**	**target (6 European countries)**
productivity persistence	ρ_z	0.85	autocorrelation of log GDP
productivity volatility	σ_z	0.015	std. dev. of log GDP
capital adjustment cost	ψ	28	std. dev. of log fixed assets
corporate default value	μ_{ν^d}	0.011	average corporate spread
average government default cost	μ_ξ	0.35	average government spread
government default cost volatility	σ_ξ	0.1	std. dev. of government spread
sensitivity of investor sentiment	γ	1.7	std. dev. of government spread

Table 1.7: Parameterization

Panel A. Targeted Moments	Model	Data
autocorrelation of log GDP	0.454	0.470
std. dev. of log GDP	0.025	0.026
std. dev. of log fixed assets	0.024	0.024
average corporate spread	136 bp	139 bp
average government spread	79 bp	74 bp
std. dev. of government spread	108 bp	107 bp
Panel B. Non-targeted Moments	**Model**	**Data**
corporate default rate (%)	4.4	4.1
government default rate (%)	1.9	1.5
std. dev. of corporate spread	79 bp	60 bp
average corporate debt to GDP ratio	0.86	1.03
average government debt to GDP ratio	1.02	0.79
Government Spread Regression Coefficients:		
corporate debt/GDP	0.017	0.03
	[0.015 0.018]	(0.01)
government debt/GDP	0.021	0.03
	[0.019 0.023]	(0.02)
GDP Growth	-0.121	-0.23
	[-0.124 -0.117]	(0.12)

Notes: For the model-smiulated regression, 5th and 95th percentiles of estimates out of 1,000 simulations are in brackets together with their median above the brackets. For the empirical regression, robust standard errors are in parentheses together with estimates above the parentheses.

Table 1.8: Moments from Model and Data

	No Policy	Optimal Policy	Best Constant Debt Tax	Best Cyclical Debt Tax
Welfare Gain (%)	-	12.8	2.1	3.8
Mean(Consumption)	0.812	0.867	0.811	0.821
Std.Dev.(Consumption)	0.200	0.074	0.169	0.157
Corporate Debt/Output (%)	86	107	91	93
Firm Default Rate (%)	4.4	0.0	7.0	7.3
Tax Revenue	0.350	0.356	0.406	0.413
Government Spread (bp)	78	35	66	60
Government Default Frequency	0.020	0.009	0.017	0.016

Notes: For each welfare gain, a permanent increase in consumption by implementing optimal policy and different debt policies is calculated. For each policy, the average welfare gains from 100,000 simulations of 200 periods after dropping first 100 periods for each simulation are presented. For optimal policy, I calculate the welfare gain from the optimal constant debt tax with lump-sum taxes and investment credits. For debt tax policies, the debt tax rate is given by $\tau_t^b = max[\bar{\tau}^b + \beta_\tau(b_t/Y_t - \bar{b}/\bar{Y}), 0]$. The target corporate leverage ratio $\bar{b}/\bar{Y}$ is set to 0.91. For the best constant debt tax, β_τ is set to zero. For the best cyclical debt tax, $\bar{\tau}^b$ is set to 6%, and the debt tax slope β_τ is set to -1. Other business cycle statistics are calculated using the average of 100,000 statistics from the same simulated series.

Table 1.9: Model Simulation: Welfare Gains and Statistics

	No Policy	Optimal Policy	Constant Debt Tax	Cyclical Debt Tax
	A. Identical Discount Factor ($\beta = \beta_g = 0.98$)			
Welfare Gain (%)	-	18.8	2.0	4.1
Mean(Consumption)	0.805	0.913	0.806	0.818
Std.Dev.(Consumption)	0.199	0.135	0.175	0.161
Corporate Debt/Output (%)	86	57	91	93
Firm Default Rate (%)	4.4	0.0	7.0	7.3
Tax Revenue	0.350	0.384	0.406	0.413
Government Spread (bp)	3	2	2	2
Govt Default Frequency	0.001	0.000	0.001	0.001
	B. Small Defaultable Tax ($\zeta = 0.5$)			
Welfare Gain (%)	-	12.2	2.3	4.1
Mean(Consumption)	0.815	0.867	0.816	0.827
Std.Dev.(Consumption)	0.197	0.072	0.167	0.156
Corporate Debt/Output (%)	86	107	91	93
Firm Default Rate (%)	4.4	0.0	7.0	7.3
Tax Revenue	0.354	0.360	0.406	0.413
Government Spread (bp)	74	34	63	57
Govt Default Frequency	0.019	0.009	0.017	0.015
	C. Zero Investor's Sentiment ($\gamma = 0$)			
Welfare Gain (%)	-	12.8	2.0	3.7
Mean(Consumption)	0.811	0.867	0.810	0.821
Std.Dev.(Consumption)	0.197	0.069	0.168	0.155
Corporate Debt/Output (%)	86	107	91	93
Firm Default Rate (%)	4.4	0.0	7.0	7.3
Tax Revenue	0.350	0.356	0.406	0.413
Government Spread (bp)	75	34	65	58
Govt Default Frequency	0.020	0.009	0.017	0.016

Notes: This table presents average statistics from 100,000 simulations of 200 periods after dropping first 100 periods for each simulation. Welfare gains are calculated as the averages of a permanent increase in consumption from implementing different debt policies across simulations. The debt tax rate is given by $\tau_t^b = max[\bar{\tau}^b + \beta_\tau(b_t/Y_t - \bar{b}/\bar{Y}), 0]$. The target corporate leverage ratio $\bar{b}/\bar{Y}$ is set to 0.91. The constant debt tax rate $\bar{\tau}^b$ is 6% (β_τ is set to zero), For the cyclical debt tax rate, $\bar{\tau}^b$ is set to 6%, and the debt tax slope β_τ is set to -1. In each panel, I change only one parameter relative to the baseline parameterization. In Panel A, I assume that corporate and government discount factors are identical. Panel B shows the case when only the half of the corporate income tax is defaultable, that is, firms cannot default on the fraction $\zeta = 0.5$ of their income tax, and the government receives non-defaultable corporate income tax from defaulting firms. In Panel C, investors are assumed to be risk neutral.

Table 1.10: Model Sensitivity

Tables of Chapter 2

Dependent Variable:	Financial Debt to Total Assets Ratio					
	Advanced Economies (1)	Emerging Market Economies (2)	High FX debt (3)	Low FX debt (4)	Managed Float (5)	Free Float (6)
Bank Inflows/GDP(c,t)	0.02	0.24***	0.16**	0.00	0.22***	-0.02
	(0.02)	(0.05)	(0.05)	(0.04)	(0.05)	(0.09)
Corporate Inflows/GDP(c,t)	-0.12	0.04	0.08	-0.10	0.09*	-0.20**
	(0.07)	(0.03)	(0.05)	(0.11)	(0.05)	(0.10)
Public Inflows/GDP(c,t)	0.04	-0.07	0.05	0.02	-0.07	0.18
	(0.04)	(0.08)	(0.08)	(0.04)	(0.07)	(0.19)
Adjusted R^2	0.8685	0.7583	0.7621	0.8829	0.7634	0.8680
Number of Observations	22,352	631,593	605,705	17,078	611,365	4,163
Number of Countries	22	17	15	15	23	6
Country FE	yes	yes	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes	yes	yes

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Firm-year two-way clustered standard errors are in parentheses. We run the following regression: $Leverage_{i,c,t} = \beta_1 BankInflows_{c,t} + \beta_2 CorporateInflows_{c,t} + \beta_3 PublicInflows_{c,t} + \gamma_i + \delta_c + \epsilon_{i,c,t}$, in which leverage is measured as financial debt (loans and debt instruments which is proxied by items "loans" and "longtermdebt") to assets ratio or each firm i in a given country c and year t. Leverage is winsorized at 1st and 99th percentile. γ_i and δ_c are firm and country fixed effects, respectively. We include country-specific aggregate sectoral debt inflows as explanatory variables. Country's foreign currency (FX) debt share (obtained from Kalemli-Özcan et al. (2018b)) is considered to be high if average FX debt share in the non-financial corporate sector of that country during the sample period is above the median among all countries and low otherwise. Using Ilzetzki et al. (2017)'s exchange regime classification, we classify a country as a managed float if the classification code is 2 or 3 and a free float if the code is 4, 5, or 6.

Table 2.1: Firm Leverage Regression

Measure (Stocks)	Counterparty Sector	Currency Type	Sample Period
Cross-border claims of reporting banks	All sectors	All currencies	1996-2014
	All sectors	Foreign currency	1996-2014
Cross-border liabilities of reporting banks	All sectors	All currencies	1996-2014
	All sectors	Foreign currency	1996-2014

Table 2.2: BIS Data List

Tables of Chapter 3

Variable	# of Obs	Mean	Std. Dev.	Min	Max
France					
GDP	55	1137.10	272.21	706.34	1965.43
FDI	41	1.04	1.54	0.04	9.23
Imports from France	40	2.49	4.84	1.58	3.56
Exports into France	40	3.77	0.59	2.32	4.92
Population	55	39.47	1.26	37.24	41.46
UK					
GDP	55	1401.04	405.29	761.00	2354.00
FDI	55	0.39	0.43	0.03	2.12
Imports from the UK	40	7.62	1.47	3.43	9.93
Exports into the UK	40	4.58	1.00	2.49	6.34
Population	55	36.63	5.18	28.66	45.64
Germany					
GDP	55	1259.98	633.49	431.60	2782.56
FDI	26	0.77	0.76	0.09	3.40
Imports from Germany	40	1.11	1.39	0.02	4.66
Exports into Germany	40	0.43	0.51	0.00	1.46
Population	55	47.50	8.69	35.63	65.05
Ottoman Empire					
GDP	49	153.27	36.70	73.97	208.64
Population	55	16.54	3.10	10.17	21.89
Regression Variables (Pooled Panel Sample)					
FDI/GDP (raw)	122	0.001	0.001	0.000	0.008
FDI/GDP (imputed)	165	0.001	0.002	0.000	0.009
Exports/GDP (raw)	105	0.002	0.002	0.000	0.005
Exports/GDP (imputed)	165	0.003	0.002	0.000	0.009
Source GDP per capita	165	30.43	8.479	12.11	51.57
Host GDP per capita	147	8.825	1.424	5.128	10.89
Rainfall	165	-0.024	0.141	-0.716	0.268

Notes: For France, the U.K., Germany, and the Ottoman Empire, all variables except population are measured in millions of British Sterling. The population is measured in million people. Imports and Exports are the Ottoman Empire Imports and Exports. FDI denotes Private Capital Inflows from source countries (France, Germany and the U.K.) into the Ottoman Empire during 1859–1913. Data comes from Pamuk (1987), Table A3.3. Exports and Imports are values of goods exported from and imported into the Ottoman Empire with three trading partners (France, Germany and the U.K.) over 1859–1913, from Pamuk (2003) Table 7.5 and Pamuk (1987) Table 2.3, with values converted from Turkish Golden Lira into British sterlings using Gold Standard exchange rates from Table 3.11. GDP of each of source country comes from Mitchell (1992) Table J1. The table includes data on GDP for France and the U.K. and the NNP data for Germany. NNP figures for Germany were converted into GDP following the procedure described in Maddison (1992). Ottoman GDP data comes from Clemens and Williamson (2004) dataset. Population figures for the Ottoman Empire are from Behar (1996). The data on population of France, Germany, and the U.K. comes from the Maddison dataset. The rainfall variable ($R_{mt} = \theta^g_{m0} P^g_t + \theta^o_{m0} P^o_t$) is calculated as the weighted sum of rainfall shocks to grain P^g_t and orchard P^o_t in time t, where weights are initial export shares of grain θ^g_{m0} and orchard θ^o_{m0} for each source country m.

Table 3.1: Descriptive Statistics by Source Country: 1859–1913

	Dependent Variable: log(FDI/GDP)$_{it}$		
	(1) Contemp. Raw	(2) Contemp. Imputed	(3) Lag. Imputed
log(Exports/GDP)	0.31** (0.13)	0.27*** (0.08)	0.21** (0.09)
Adjusted R^2	0.2875	0.4655	0.4450
Number of Observations	87	147	144
Country Dummies	yes	yes	yes
Time Dummies	no	no	no
Country-specific Trends	yes	yes	yes
Controls	GDP p.c.	GDP p.c.	GDP p.c.

Notes: Exports and FDI are normalized by the GDP of each source country (France, Germany, and the UK). In column 1, we use raw data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. In column 2, we use imputed data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. In column 3, we use imputed data for FDI-to-GDP ratio and export-to-GDP ratio, and log Exports/GDP is lagged. Time dummies consist of a series of dummy variables that equal 1 for five consecutive years without overlapping. Country dummies, country-specific trends, and the log of the Ottoman GDP per capita are included as controls. The log of the Ottoman GDP per capita is contemporaneous with log FDI/GDP in columns 1 and 2 and lagged in column 3. ***, **, and * indicate significance at 1, 5, and 10% levels, respectively. Driscoll and Kraay (1998a) standard errors (robust to heteroskedasticity and clustering on years and kernel-robust to common correlated disturbances with the lag length 3) are in parentheses.

Table 3.2: Ottoman Exports and FDI Inflows

	Dependent Variable: log(FDI/GDP)$_{it}$		
	(1) Contemp. Imputed	(2) Contemp. Imputed	(3) Contemp. Raw
log(Exports/GDP)$_{it}$	0.15**	0.22***	0.35**
	(0.07)	(0.08)	(0.17)
Default		-1.05**	-1.42**
		(0.42)	(0.71)
OPDA		0.57	1.30**
		(0.47)	(0.64)
Resettlement		0.30	0.92
		(0.53)	(0.68)
Adjusted R^2	0.5184	0.4954	0.3247
Number of Observations	147	147	87
Country Dummies	yes	yes	yes
Time Dummies	yes	no	no
Country-specific Trends	yes	yes	yes
Controls	GDP p.c.	GDP p.c.	GDP p.c.

Notes: Exports and FDI are normalized by the GDP of each source country (France, Germany, and the UK). In columns 1 and 2, we use imputed data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. In column 3, we use raw data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. Time dummies consist of a series of dummy variables that equal 1 for five consecutive years without overlapping, which are included in column 1. In columns 2 and 3, we include event dummies: Default, OPDA, and Resettlement. Default is a time dummy variable which equals 1 after the default of the Ottoman Empire in 1876. OPDA is a time dummy variable which equals 1 after the establishment of the Ottoman Public Debt Administration (OPDA) in 1881. Resettlement is a time dummy variable which equals 1 after 1903 when the Ottoman external debt decreased significantly after negotiations with creditors. Country dummies, country-specific trends, and the log of the Ottoman GDP per capita are included as controls. ***, **, and * indicate significance at 1, 5, and 10% levels. Driscoll and Kraay (1998a) standard errors (robust to heteroskedasticity and clustering on years and kernel-robust to common correlated disturbances with the lag length 3) are in parentheses.

Table 3.3: Ottoman Exports and FDI Inflows with Time or Event Dummies

	Dependent Variable: log(FDI/GDP)$_{it}$					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample Period:	1885-1889	1890-1894	1895-1899	1900-1904	1905-1909	1910-1913
log(Exports/GDP)$_{it}$	0.25***	-0.76	-1.67	0.89***	0.84	2.35***
	(0.08)	(0.50)	(1.18)	(0.00)	(1.08)	(0.43)
Adjusted R^2	0.0622	0.5922	0.2327	0.9568	0.1841	0.7806
Number of Observations	12	15	15	6	15	12
Country Dummies	yes	yes	yes	yes	yes	yes
Controls	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.

Notes: We use raw data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. Country dummies and the log of the Ottoman GDP per capita are included as controls. ***, **, and * indicate significance at 1, 5, and 10% levels, respectively. Driscoll and Kraay (1998a) standard errors (robust to heteroskedasticity and clustering on years and kernel-robust to common correlated disturbances with the lag length 2) are in parentheses.

Table 3.4: Ottoman Exports and FDI Inflows: Regressions at Every 5-year Period

	Dependent Variable: log(FDI/GDP)$_{it}$	
	(1) Baseline	(2) Placebo
log(Exports/GDP)$_{it}$	0.35**	0.01
	(0.17)	(0.09)
Adjusted R^2	0.3247	0.3078
Number of Observations	87	87
Country Dummies	yes	yes
Event Dummies	yes	yes
Country-specific Trends	yes	yes
Controls	GDP p.c.	GDP p.c.

Notes: Exports and FDI are normalized by the GDP of each source country (France, Germany, and the UK). We use raw data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. In column 1, we reproduce the baseline regression in Table 3.3 column 3, and countries which send capital into the Ottoman Empire are also the countries to which the Ottoman Empire exports. In column 2, we switch trading partners. FDI from France is matched to exports into the UK, the UK is matched to Germany, and Germany is matched to France. Using event dummies, we control for specific events such as a dummy for the creation of the Ottoman Public Debt Administration (OPDA) in 1881, and other dummies characterizing the effect of Empire's default on the foreign debt in 1876, and the Resettlement of the debt in 1903. Country and event dummies, country-specific trends, and the log of the Ottoman GDP per capita are included as controls. ***, **, and * indicate significance at 1, 5, and 10% levels, respectively. Driscoll and Kraay (1998a) standard errors (robust to heteroskedasticity and clustering on years and kernel-robust to common correlated disturbances with the lag length 3) are in parentheses.

Table 3.5: Placebo Test

	Dependent Variable: log(FDI/GDP)$_{it}$	
	(1) baseline	(2) FDI cycle
log(Exports/GDP)$_{it}$	0.35**	0.34**
	(0.17)	(0.13)
FDI cycle$_{it}$		0.25
		(0.16)
Adjusted R^2	0.3247	0.4431
Number of Observations	87	69
Country Dummies	yes	yes
Event Dummies	yes	yes
Country-specific Trends	yes	yes
Controls	GDP p.c.	GDP p.c.

Notes: Exports and FDI are normalized by the GDP of each source country (France, Germany, and the UK). We use raw data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. In column 1, we reproduce the baseline regression in Table 3.3 column 3. In column 2, we add an FDI cycle variable for country i in year t, which is calculated as the average of log FDI-to-GDP ratios of other countries in year t, excluding country i. Using event dummies, we control for specific events such as a dummy for the creation of the Ottoman Public Debt Administration (OPDA) in 1881, and other dummies characterizing the effect of Empire's default on the foreign debt in 1876, and the Resettlement of the debt in 1903. Country and event dummies, country-specific trends, and the log of the Ottoman GDP per capita are included as controls. ***, **, and * indicate significance at 1, 5, and 10% levels. Driscoll and Kraay (1998a) standard errors (robust to heteroskedasticity and clustering on years and kernel-robust to common correlated disturbances with the lag length 3) are in parentheses.

Table 3.6: A Test of FDI cycle

	Agricultural Land by SRE, thousand Hectare			
Region	Total Land	Cultivated Field Area	Non Cultivated Area	Share of Cultivated Land in Total Land
	L_j	"Grain Land"	"Orchard Land"	S_j (percent)
Istanbul (TR1)	83	76	7	92
Marmara				
West Marmara (TR2)	1,736	1,510	226	87
East Marmara (TR4)	1,564	1,226	338	78
Aegean (TR3)	3,010	2,187	828	73
Mediterranean (TR6)	2,623	2,132	490	81
Black Sea				
West Black Sea (TR8)	2,251	1,996	256	87
East Black Sea (TR9)	736	259	476	35
Anatolia				
West Anatolia (TR5)	4,221	4,050	171	96
Central Anatolia (TR7)	4,003	3,872	131	97
North East Anatolia (TRA)	1,461	1,443	18	99
Central East Anatolia (TRB)	1,451	1,328	123	92
South East Anatolia (TRC)	3,453	3,992	461	87
Total	26,593	23,066	3,526	87

Notes: The data comes from Prime Ministry Republic of Turkey and Turkish Statistical Institute (2005) Table 11.11 on page 177. "Grain" produce include corn, wheat, barley, and rye. Also, we included cotton into this category, because cotton is typically rotated with the grain. "Orchard" produce include grape, fig, unspecified fruits and vegetables, vine, olive oil, acorn, hazelnuts, and peanuts. "Other" produce include animal products such as sheep, goat and lamb wool, leather, silk, and several minor categories.

Table 3.7: Agricultural Land of Turkey by Statistical Region (SRE)

	Decomposition of Exports, percent		
	France	U.K.	Germany
Grain produce	16.9	44.8	41.4
Orchard produce	9.2	21.0	31.4
Other	73.9	34.2	27.2
Total	100.0	100.0	100.0

Notes: "Grain" produce include corn, wheat, barley, and rye. Also, we included cotton into this category, because cotton is typically rotated with the grain. "Orchard" produce include grape, fig, unspecified fruits and vegetables, vine, olive oil, acorn, hazelnuts, and peanuts. "Other" produce include animal products such as sheep, goat and lamb wool, leather, silk, and several minor categories. Export shares data comes from Pamuk (2003), page 62, Table 7.2. For the UK and France, the percentage shares are the averages over 1860-1862; for Germany, we take averages over 1880-82. This way, for all three countries, we are using the initial export shares that correspond to the beginnings of the respective samples.

Table 3.8: Ottoman Decomposition of Exports

A. Second Stage Regression

	Full Sample		Starting in 1885	
	Dependent Variable: log(FDI/GDP)$_{it}$			
	(1)	(2)	(3)	(4)
log(Exports/GDP)$_{it}$	0.33**	0.57***	0.31*	0.60***
	(0.13)	(0.18)	(0.16)	(0.17)

B. First Stage Regression

	Dependent Variable: log(Exports/GDP)$_{it}$			
	(1)	(2)	(3)	(4)
Rainfall$_{it}$	0.46***	0.46***	0.37**	0.37**
	(0.17)	(0.17)	(0.16)	(0.16)
Adjusted R^2	0.2696	0.2796	0.2911	0.3303
Number of Observations	73	73	66	66
Country Dummies	yes	yes	yes	yes
Event Dummies	no	yes	no	yes
Country-specific Trends	yes	yes	yes	yes
First-stage F	13.34	11.20	14.13	12.51
F (p-value)†	0.0000	0.0000	0.0000	0.0000
Hansen J (p-value)††	0.1927	0.2482	0.1695	0.2903
Controls	GDP p.c.	GDP p.c.	GDP p.c.	GDP p.c.

Notes: We use raw data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. Event dummies are "Default," "OPDA," and "Resettlement." Default is a time dummy variable which equals 1 after the default of the Ottoman Empire in 1876. OPDA is a time dummy variable which equals 1 after the establishment of the Ottoman Public Debt Administration (OPDA) in 1881. Resettlement is a time dummy variable which equals 1 after 1903 when the Ottoman external debt decreased significantly after negotiations with creditors. Country dummies, country-specific trends, and the log of the Ottoman GDP per capita are included as controls. ***, **, and * indicate significance at 1, 5, and 10% levels, respectively. Driscoll and Kraay (1998a) standard errors (robust to heteroskedasticity and clustering on years and kernel-robust to common correlated disturbances with the lag length 3) are in parentheses. Adjusted R^2 is calculated for second stage regressions. † This p-value – which is associated with the Sanderson and Windmeijer (2016) first-stage F test – is used to test the null that instruments are weak. †† This p-value – which is associated with Hansen's overidentifying test – is used to test the null that instruments are excludable. The rainfall variable ($R_{mt} = \theta^g_{m0} P^g_t + \theta^o_{m0} P^o_t$) is calculated as the weighted sum of rainfall shocks to grain P^g_t and orchard P^o_t in time t, where weights are initial export shares of grain θ^g_{m0} and orchard θ^o_{m0} for each source country m. Contemporaneous rainfall and two lagged variables of each of rainfall and log Exports/GDP are used as instruments. The first stage regression is as follows: $\text{log(Exports/GDP)}_{it} = \beta \text{Rainfall}_{it} + \gamma_j \sum_{j=1}^{2} \text{Rainfall}_{it-j} + \delta_j \sum_{j=1}^{2} \text{log(Exports/GDP)}_{it-j} + \omega \text{log(GDP per capita)}_t + \alpha_i + \lambda_t + \alpha_i t + \epsilon_{it}$ where α_i indicates country dummies; λ_t indicates event dummies; $\alpha_i t$ refers to country-specific trends. We use a full regression sample in columns 1 and 2 (observations from France start in 1878; the U.K. in 1871; and Germany in 1885.), while we use the sample starting in 1885 in columns 3 and 4.

Table 3.9: Ottoman Exports and FDI Inflows (2SLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Second Stage Regression										
Dependent Variable: log(FDI/GDP)$_{it}$										
	Baseline		*Sensitivity: Grain* 1.5 *& Orchard* 0.5		*Sensitivity: Grain* 0.5 *& Orchard* 1.5		*Exports: Grain* +20% *& Orchard* −20%		*Exports: Grain* −20% *& Orchard* +20%	
log(Exports/GDP)$_{it}$	0.33**	0.57***	0.33**	0.57***	0.33**	0.57***	0.33**	0.57***	0.33**	0.57***
	(0.13)	(0.18)	(0.13)	(0.18)	(0.14)	(0.18)	(0.13)	(0.18)	(0.14)	(0.18)
B. First Stage Regression										
Dependent Variable: log(Exports/GDP)$_{it}$										
Rainfall$_{it}$	0.46***	0.46***	0.38***	0.38***	0.56***	0.56***	0.43***	0.43***	0.49***	0.49***
	(0.17)	(0.17)	(0.14)	(0.14)	(0.21)	(0.21)	(0.16)	(0.16)	(0.18)	(0.18)
Adjusted R^2	0.2696	0.2796	0.2696	0.2797	0.2698	0.2798	0.2696	0.2796	0.2697	0.2796
Number of Observations	73	73	73	73	73	73	73	73	73	73
Country Dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Event Dummies	no	yes	no	yes	no	yes	no	yes	no	yes
Country-specific Trends	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
First-stage F	13.34	11.20	12.92	10.87	13.82	11.59	13.16	11.06	13.52	11.35
F (p-value)†	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hansen J (p-value)††	0.1927	0.2482	0.2007	0.2346	0.1857	0.2717	0.1960	0.2420	0.1896	0.2560

Notes: We use raw data for FDI-to-GDP ratios and export-to-GDP ratios, and log Exports/GDP is contemporaneous with log FDI/GDP. Event dummies are "Default," "OPDA," and "Resettlement." Default is a time dummy variable which equals 1 after the default of the Ottoman Empire in 1876. OPDA is a time dummy variable which equals 1 after the establishment of the Ottoman Public Debt Administration (OPDA) in 1881. Resettlement is a time dummy variable which equals 1 after 1903 when the Ottoman external debt decreased significantly after negotiations with creditors. Country and event dummies, country-specific trends, and the log of the Ottoman GDP per capita are included as controls. ***, **, and * indicate significance at 1, 5, and 10% levels. Driscoll and Kraay (1998a) standard errors (robust to heteroskedasticity and clustering on years and kernel-robust to common correlated disturbances with the lag length 3) are in parentheses. Adjusted R^2 is calculated for second stage regressions. † This p-value – which is associated with the Sanderson and Windmeijer (2016) first-stage F test – is used to test the null that instruments are weak. †† This p-value – which is associated with Hansen's overidentifying test – is used to test the null that instruments are excludable. The rainfall variable ($R_{mt} = \theta^g_{m0}P^g_t + \theta^o_{m0}P^o_t$) is calculated as the weighted sum of rainfall shocks to grain P^g_t and orchard P^o_t in time t, where weights are initial export shares of grain θ^g_{m0} and orchard θ^o_{m0} for each source country m. Contemporaneous rainfall and two lagged variables of each of rainfall and log(Exports/GDP) are used as instruments. The first stage regression is as follows: $\log(\text{Exports/GDP})_{it} = \beta\text{Rainfall}_{it} + \gamma_j \sum_{j=1}^{2} \text{Rainfall}_{it-j} + \delta_j \sum_{j=1}^{2} \log(\text{Exports/GDP})_{it-j} + \omega\log(\text{GDP per capita})_{it} + \alpha_i + \lambda_t + \alpha_i t + \epsilon_{it}$ where α_i indicates country dummies; λ_t indicates event dummies; $\alpha_i t$ refers to country-specific trends. We reproduce IV regression results from Table 3.9 in columns 1 and 2, which are without and with event dummies, respectively. Then, we reconstruct a rainfall variable ($R_{mt} = \theta^g_{m0}\omega^g P^g_t + \theta^o_{m0}\omega^o P^o_t$) such that sensitivities for grain ω^g and orchard ω^o are 1.5 and 0.5, and we replace the baseline rainfall variable with the reconstructed rainfall variable in columns 3 and 4. Columns 5 and 6 present results with another rainfall variable such that sensitivities for grain and orchard are 0.5 and 1.5, respectively. Also, we reconstruct a rainfall variable ($R_{mt} = \theta^g_{m0}P^g_t + \theta^o_{m0}P^o_t$) such that export shares of grain θ^g_{m0} are increased by 20% and export shares of orchard θ^o_{m0} are decreased by 20% for all countries m, and we replace the baseline rainfall variable with the reconstructed rainfall variable in columns 7 and 8. Columns 9 and 10 show results with another rainfall variable such that θ^g_{m0} are decreased by 20% and θ^o_{m0} are increased by 20% for all countries m.

Table 3.10: Ottoman Exports and FDI Inflows (2SLS) with Alternative Instruments

Country	France	United Kingdom	Germany	Ottoman Empire
Currency	Franc	Pound Sterling	Mark	Gold Lira
Adopted	04/07/1803	05/01/1821	12/04/1871	01/05/1844
Abandoned	08/05/1914	08/06/1914	08/04/1914	08/03/1914
Grams of Fine Gold	0.2903	7.3224	0.3584	6.6152
Sterling Exchange Rate	25.2215	1.0000	20.4290	1.1069
Dollar Exchange Rate	5.1827	0.2055	4.1979	0.2275

Notes: These data come from Global Financial Data, and available for download at http://www.globalfinancialdata.com/gh/GHC_XRates.xls

Table 3.11: Gold Standard Exchange Rates

Appendix Tables

Dependent Variable:	Sovereign Spread$_{c,t}$						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP Growth$_{c,t-1}$	-0.28***	-0.15*	-0.13	-0.14	-0.15*	-0.17*	-0.13
	(0.09)	(0.08)	(0.09)	(0.09)	(0.08)	(0.09)	(0.09)
Sovereign Debt/GDP$_{c,t-1}$	0.06***	0.05***	0.05***	0.05***	0.05***	0.05***	0.03***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Corporate Debt/GDP$_{c,t-1}$		0.02***	0.02***	0.02***	0.02***		0.02***
		(0.00)	(0.00)	(0.00)	(0.00)		(0.01)
log(VIX)$_{t-1}$			0.12				
			(0.15)				
TED Spread$_{t-1}$				0.05			
				(0.12)			
Term Spread$_{t-1}$					-0.02		
					(0.04)		
Within R^2	0.4150	0.4853	0.4850	0.4844	0.4844	0.5191	0.5435
$N_{Observations}$	489	489	489	489	489	489	489
Country Fixed Effect	yes	yes	yes	yes	yes	yes	yes
Quarter Fixed Effect	no	no	no	no	no	yes	yes

Notes: Driscoll and Kraay (1998b) standard errors (robust to heteroskedasticity and clustering on date and kernel-robust to common correlated disturbances) with a lag length of 4 quarters are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. The regression sample consists of observations for nine Eurozone countries (Austria, Belgium, Finland, France, Ireland, Italy, Netherlands, Portugal, and Spain) during the period 1999q1–2012q4.

Table A.1: OLS Sovereign Spread Regression with nine Eurozone Countries

Dependent Variable:	Sovereign Spread$_{c,t}$								
	IT (1)	ES (2)	PT (3)	IE (4)	BE (5)	FI (6)	FR (7)	AT (8)	NL (9)
GDP Growth$_{t-1}$	-0.30	-1.16***	-0.78	-0.13***	-0.13**	-0.04***	-0.16***	-0.11**	-0.08***
	(0.23)	(0.43)	(0.48)	(0.05)	(0.06)	(0.01)	(0.05)	(0.05)	(0.02)
Sovereign Debt/GDP$_{t-1}$	-0.00	0.05***	0.02	0.03**	-0.00	-0.00	0.01**	0.00	0.01***
	(0.02)	(0.01)	(0.03)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Corporate Debt/GDP$_{t-1}$	0.03	0.04**	0.07***	0.02*	0.02***	0.01***	-0.01	0.03**	-0.01***
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
$N_{Observations}$	79	94	80	67	80	80	80	79	80
Trend	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Newey-West standard errors with a lag length of 4 quarters are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Regressions use all available data for each country. IT: Italy, ES: Spain, PT: Portugal, IE: Ireland, BE: Belgium, FI: Finland, FR: France, AT: Austria, NL: Netherland.

Table A.2: Country-by-country Spread Regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Baseline				Bank Control		
	OLS	IV (Size)	IV (Weight)	IV (T100)	OLS	IV (Size)	IV (Weight)	IV (T100)
				A. Second-Stage Regression				
Dependent Variable:				Sovereign Spread$_{c,t}$				
Corporate Debt/GDP$_{c,t-1}$	0.03**	0.11**	0.10	0.14**	0.04***	0.07*	0.10*	0.11**
	(0.01)	(0.05)	(0.06)	(0.07)	(0.02)	(0.03)	(0.06)	(0.05)
Sovereign Debt/GDP$_{c,t-1}$	0.03	0.08**	0.07	0.10**	0.04*	0.05*	0.08*	0.08**
	(0.02)	(0.04)	(0.05)	(0.05)	(0.02)	(0.03)	(0.05)	(0.04)
GDP Growth$_{c,t-1}$	-0.23**	-0.12	-0.15	-0.09	-0.25**	-0.22**	-0.20*	-0.18**
	(0.12)	(0.10)	(0.12)	(0.13)	(0.11)	(0.10)	(0.10)	(0.09)
Bank Leverage$_{c,t-1}$					0.07***	0.08***	0.09***	0.09***
					(0.01)	(0.02)	(0.02)	(0.02)
				B. First-Stage Regression				
Dependent Variable:				Corporate Debt/GDP$_{c,t-1}$				
Granular Residual$_{c,t-1}$	n/a	-5.50**	-0.73	-4.84**	n/a	-6.47**	-0.67	-5.43**
		(2.69)	(0.47)	(2.29)		(2.62)	(0.49)	(2.28)
Granular Residual$_{c,t-2}$	n/a	-4.25*	-0.96**	-3.31	n/a	-5.30**	-0.95**	-3.81*
		(2.45)	(0.41)	(2.09)		(2.17)	(0.41)	(1.95)
Adj. R-squared	0.6547	0.5765	0.5930	0.4887	0.6833	0.6737	0.6308	0.6232
Number of Observations	60	60	60	60	60	60	60	60
Country Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes
Time Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes
First-stage F	n/a	2.89	3.26	3.18	n/a	4.69	2.96	4.33
Hansen J (p-value)	n/a	0.5674	0.5165	0.5922	n/a	0.3460	0.3846	0.4638
CLR (p-value, $H_0 : \beta_{corp} = 0$)	n/a	0.0919	0.1640	0.0337	n/a	0.2289	0.1435	0.0706

Notes: Annual sovereign spreads are regressed on lagged explanatory variables over the period 2002–2012. In instrumental variable (IV) regressions, excluded instruments for corporate debt are 1 and 2 years lagged granular residuals, which are based on idiosyncratic total factor productivity shocks to large firms estimated by the method of Wooldridge (2009). The granular residual for IV (Size) is a weighted sum of idiosyncratic shocks to top 50 firms in each country c, using lagged Domar weights ($\text{sales}_{i,c,t-1}/\text{GDP}_{c,t-1}$) for a given firm i. Idiosyncratic shocks are residuals from the regression of firm-level productivity on sector×size×year fixed effects, in which sector dummies represent 4-digit sectors, and size dummies are quintiles determined by sales of each firm. The granular residual for IV (Weight) is a simple average of idiosyncratic shocks to top 50 firms in each country c, using residuals from the regression of firm-level productivity on sector×year fixed effects. The granular residual for IV (T100) is a weighted sum of idiosyncratic shocks to top 100 firms in each country c, using lagged Domar weights and residuals from the regression of firm-level productivity on sector×year fixed effects. In IV regressions, lagged GDP growth, the lagged government debt to GDP ratio, country fixed effects, and year fixed effects are included in both the first and second stage regressions. Lagged bank leverage is added to the first and second stage regressions in columns 5-8. The Hansen (1982) J statistic tests the null that instruments are excludable. The first-stage effective F statistic of Olea and Pflueger (2013) tests the null that the excluded instruments are not relevant. The p-value for CLR statistic (Andrews et al. (2019)) is reported to test the null hypothesis that the coefficient on corporate debt in the second stage regression is zero. This test is robust to weak instruments. Robust standard errors (calculated using the 2-step GMM method and robust to arbitrary clusters for IV regressions) are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

Table A.3: Spread Regression with Alternative Instruments

	(1)	(2)	(3)	(4)
	Baseline IV		Alternative IV	
	A. Second-Stage Regression			
Dependent Variable:	Sovereign Spread$_{c,t}$			
Corporate Debt/Corporate Value Added$_{c,t-1}$	0.07**	0.06**	0.06**	0.04*
	(0.03)	(0.03)	(0.03)	(0.02)
Sovereign Debt/GDP$_{c,t-1}$	0.10**	0.08**	0.08**	0.06*
	(0.04)	(0.04)	(0.04)	(0.03)
GDP Growth$_{c,t-1}$	-0.11	-0.19*	-0.14	-0.22**
	(0.11)	(0.10)	(0.10)	(0.11)
Bank Leverage$_{c,t-1}$		0.07***		0.07***
		(0.02)		(0.01)
	B. First-Stage Regression			
Dependent Variable:	Corporate Debt/Corp Value Added$_{c,t-1}$			
Granular Residual$_{c,t-1}$	-9.65**	-10.37**	-10.50**	-11.44**
	(4.21)	(4.34)	(4.55)	(4.62)
Granular Residual$_{c,t-2}$	-7.78**	-8.53**	-8.32*	-9.34**
	(3.83)	(3.79)	(4.18)	(3.98)
Adjusted R^2	0.4594	0.5590	0.5512	0.6296
$N_{Observation}$	60	60	60	60
Country Fixed Effect	yes	yes	yes	yes
Time Fixed Effect	yes	yes	yes	yes
Hansen J (p-value)	0.5137	0.4003	0.5528	0.3813
First-stage F^{eff}	4.10	4.68	3.58	4.39
CLR (p-value, $H_0 : \beta_{corp} = 0$)	0.0230	0.0618	0.0831	0.2154

Notes: Columns (1) and (2) present instrumental variable regression results of Table 1.4, using alternative corporate leverage (the ratio of non-financial corporations total debt (BIS) to non-financial corporations value added (Eurostat)). Columns (3) and (4) present similar regression results of Table A.3 IV (Size), using alternative corporate leverage. Robust standard errors (calculated using the 2-step GMM method and robust to arbitrary clusters) are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

Table A.4: Spread Regression with Alternative Corporate Leverage

	(1)	(2)	(3)	(4)
	Baseline IV		Alternative IV	
	A. Second-Stage Regression			
Dependent Variable:	Sovereign $\text{Spread}_{c,t}$			
Corporate $\text{Debt/GDP}_{c,t-1}$	0.12***	0.08***	0.12**	0.07**
	(0.05)	(0.03)	(0.06)	(0.03)
Sovereign $\text{Debt/GDP}_{c,t-1}$	0.07**	0.05**	0.07*	0.04*
	(0.04)	(0.02)	(0.04)	(0.02)
GDP $\text{Growth}_{c,t-1}$	-0.24**	-0.31***	-0.22**	-0.28**
	(0.09)	(0.11)	(0.09)	(0.11)
Bank $\text{Leverage}_{c,t-1}$		0.08***		0.08***
		(0.02)		(0.02)
Household $\text{Debt/GDP}_{c,t-1}$	-0.16***	-0.12***	-0.16**	-0.10**
	(0.05)	(0.04)	(0.06)	(0.04)
	B. First-Stage Regression			
Dependent Variable:	Corporate $\text{Debt/GDP}_{c,t-1}$			
Granular $\text{Residual}_{c,t-1}$	-5.30**	-6.14***	-4.75*	-5.74**
	(2.32)	(2.05)	(2.77)	(2.49)
Granular $\text{Residual}_{c,t-2}$	-5.34**	-6.24***	-4.63*	-5.71***
	(2.31)	(1.59)	(2.64)	(2.01)
Adjusted R^2	0.6556	0.7155	0.6637	0.7174
$N_{Observation}$	60	60	60	60
Country Fixed Effect	yes	yes	yes	yes
Time Fixed Effect	yes	yes	yes	yes
Hansen J (p-value)	0.3195	0.1743	0.3642	0.1491
First-stage F^{eff}	4.61	9.99	2.43	5.21
CLR (p-value, $H_0 : \beta_{corp} = 0$)	0.0309	0.1117	0.1152	0.4602

Notes: Columns (1) and (2) present instrumental variable regression results of Table 1.4, adding the ratio of household total debt to GDP (BIS). Columns (3) and (4) present similar regression results of Table A.3 IV (Size), adding the same household leverage. Robust standard errors (calculated using the 2-step GMM method and robust to arbitrary clusters) are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

Table A.5: Spread Regression with Household Debt

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:			Sovereign Spread$_{c,t}$			
Corporate Debt/GDP$_{c,t-1}$	0.03**	0.02	-0.01	0.04***	0.03*	-0.00
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Government Debt/GDP$_{c,t-1}$	0.03	0.03	0.00	0.04*	0.04*	-0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
GDP Growth$_{c,t-1}$	-0.23**	-0.21*	-0.03	-0.25**	-0.23**	-0.03
	(0.12)	(0.11)	(0.05)	(0.11)	(0.11)	(0.05)
Tax Revenue Growth$_{c,t}$		-0.06	-0.02		-0.05	-0.02
		(0.06)	(0.03)		(0.06)	(0.03)
Tax Revenue Growth$_{c,t+1}$			-0.10			-0.09
			(0.07)			(0.07)
Bank Leverage$_{c,t-1}$			0.07***	0.07***	0.05**	
				(0.01)	(0.01)	(0.03)
Adjusted R^2	0.6547	0.6542	0.5797	0.6833	0.6806	0.5834
$N_{Observations}$	60	60	54	60	60	54
Country Fixed Effect	yes	yes	yes	yes	yes	yes
Time Fixed Effect	yes	yes	yes	yes	yes	yes

Notes: Columns (1) and (4) present OLS regression results of Table 1.4. Columns (2), (3), (5), and (6) present similar regression results, adding real tax revenue growth in years t and $t+1$. Robust standard errors are in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. Using Driscoll and Kraay (1998b) standard errors gives similar results.

Table A.6: Spread Regression: Importance of the Tax Revenue Channel

	Mean	Std. Dev.	Min	Max	N_{obs}
Tax Payment / Value Added (%)	4.15	3.79	0.00	12.76	35,187
Log(TFP)	5.24	1.01	0.80	10.45	35,187
Log(Tangible Fixed Assets)	13.20	2.01	2.20	20.98	35,187
Log(Debt)	10.39	6.20	0.00	22.40	35,187
High Leverage Dummy	0.47	0.50	0.00	1.00	35,187
Interest Payment / Value Added (%)	2.48	3.91	0.00	19.38	35,187

Notes: Total factor productivity (TFP) is estimated by the Wooldridge (2009) method. Debt is the sum of loans and long-term debt. The HighLev$_i$ dummy equals 1 if average leverage before 2008 of a given firm is higher than the aggregate median before 2008 and 0 otherwise. Firm leverage is measured as the ratio of debt to value added. Value added is measured as operating revenue minus materials cost. The sample covers the period 2004–2012 in six Eurozone countries (Italy, Portugal, Spain, Belgium, Finland, and France).

Table A.7: Summary Statistics: Firm-level Regression Sample

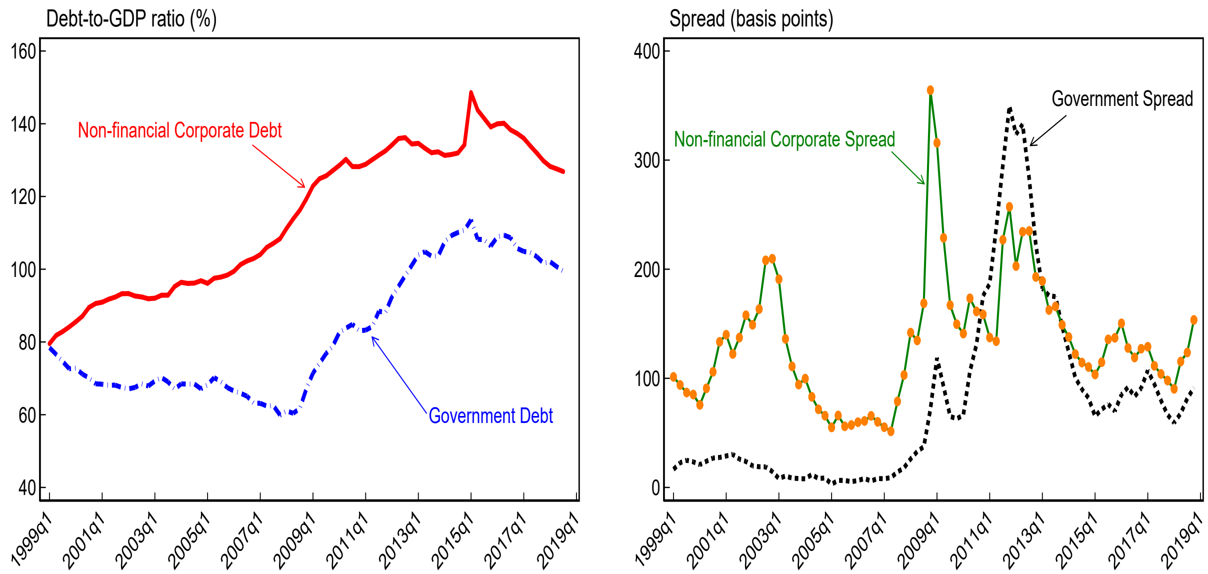
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:	Tax Payment$_{i,t}$					
HighLev$_i$ × Crisis$_t$	-0.54***	-0.54***	-0.51***	-0.41***	-0.41***	-0.37***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
$log(z_{i,t-1})$	1.58***	1.58***	1.61***	1.56***	1.56***	1.55***
	(0.13)	(0.13)	(0.16)	(0.13)	(0.13)	(0.15)
$log(k_{i,t-1})$	-0.15***	-0.15***	-0.13**	-0.12**	-0.12**	-0.09**
	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)
$log(b_{i,t-1})$	-0.04***	-0.04***	-0.04***	-0.02**	-0.02**	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
$log(z_{i,t-1})$ × Crisis$_t$	-0.07	-0.07	-0.28**	-0.07	-0.07	-0.21*
	(0.05)	(0.05)	(0.11)	(0.05)	(0.05)	(0.11)
$log(k_{i,t-1})$ × Crisis$_t$	-0.01	-0.01	-0.05	-0.01	-0.01	-0.06*
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
$log(b_{i,t-1})$ × Crisis$_t$	0.03***	0.03***	0.03***	0.03**	0.03**	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Interest Payment$_{i,t}$				-0.18***	-0.18***	-0.18***
				(0.02)	(0.02)	(0.02)
$N_{Observation}$	35,187	35,187	34,463	35,187	35,187	34,463
R^2	0.65	0.65	0.65	0.65	0.65	0.65
Firm Fixed Effect (FE)	yes	yes	yes	yes	yes	yes
Country and Year FE	yes	n/a	n/a	yes	n/a	n/a
Country×Year FE	no	yes	n/a	no	yes	n/a
Country×Sector×Year FE	no	no	yes	no	no	yes

Notes: Standard errors are in parentheses and clustered at the 4-digit sector level. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively. z is total factor productivity estimated by the Wooldridge (2009) method. k is tangible fixed assets. b is the sum of loans and long-term debt. Leverage is measured as a debt-to-value-added ratio (b/y), where value added y is measured as operating revenue minus materials cost. Interest payments are measured as the ratio of interest paid to value added. The Crisis$_t$ dummy equals 1 in or after 2008 and 0 otherwise. The HighLev$_i$ dummy equals 1 if average leverage before 2008 of a given firm is higher than the aggregate median before 2008 and 0 otherwise. The sample covers the period 2004-2012 in six Eurozone countries (Italy, Portugal, Spain, Belgium, Finland, and France).

Table A.8: Robustness Check: Firm Tax Payment Regression

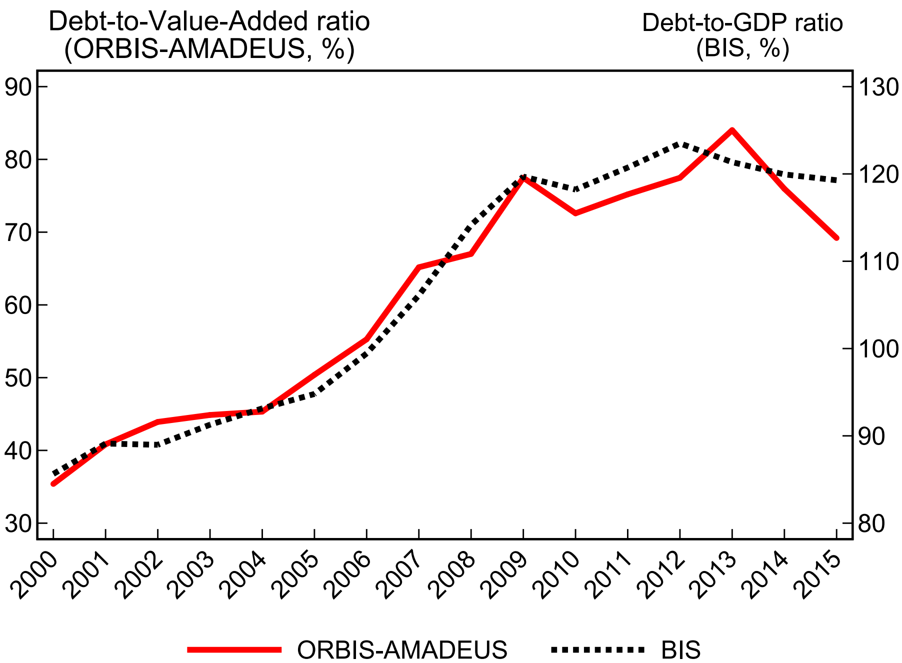
Figures

Figures of Chapter 1



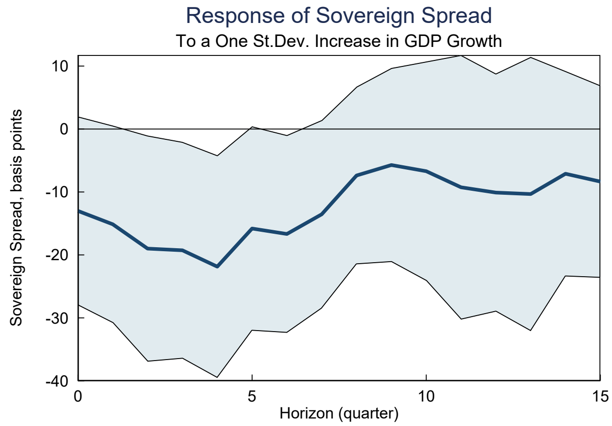
Source: BIS, Bloomberg, Gilchrist and Mojon (2017)
Notes: The figure shows the averages of debt-to-GDP ratios and sovereign spreads of 9 Eurozone countries (Austria, Belgium, Finland, France, Ireland, Italy, Netherlands, Portugal, and Spain). Debt is core debt (BIS), which consists of the following financial instruments as defined in the System of National Accounts (SNA): debt securities, loans, and currency and deposits. Core debt excludes special drawing rights, insurance, pensions, standardized guarantee schemes, and other accounts payable. Sovereign spreads (Bloomberg) are measured as the difference between the 10-year government bond yield of each country and that of Germany. Both government bond yields are denominated in euro and are daily averages by quarters. The corporate spread of Euro area non-financial corporate bonds (Euro area Bund NFC) is obtained from Gilchrist and Mojon (2017).

Figure 1.1: Eurozone Leverage and Interest Rate Spreads

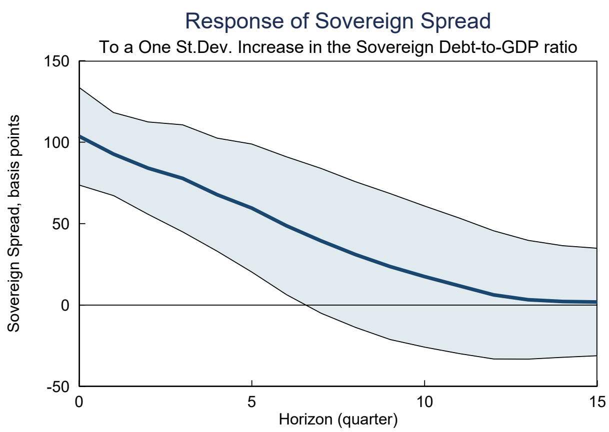


Source: Author's calculation based on ORBIS-AMADEUS and BIS
Notes: The figure shows the averages of debt-to-value-added ratios (ORBIS-AMADEUS) and debt-to-GDP ratios (BIS) for six Eurozone countries (Italy, Spain, Portugal, Belgium, Finland, and France). For the ORBIS-AMADEUS data, debt is financial debt measured as the sum of loans and long-term debt, which excludes other accounts payable. Leverage is calculated as the average leverage of six Eurozone countries, where each country's leverage is calculated as the sum of individual firms' debt over the sum of value added, where value added is operating revenue minus materials cost. For BIS statistics, debt is core debt (BIS), which consists of the following financial instruments as defined in the System of National Accounts (SNA): debt securities, loans, and currency and deposits. Core debt excludes special drawing rights, insurance, pensions, standardized guarantee schemes, and other accounts payable.

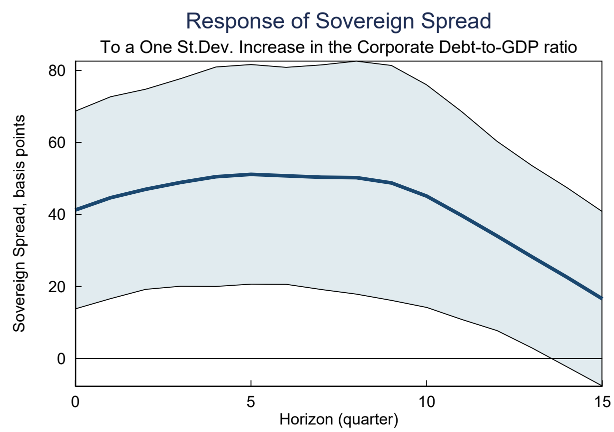
Figure 1.2: Corporate Debt: ORBIS vs. BIS Comparison



(a) GDP Growth



(b) Sovereign Debt



(c) Corporate Debt

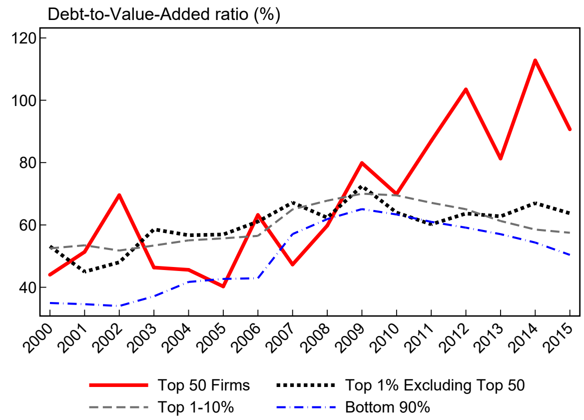
Source: Author's calculation

Notes: I run the following Jordà (2005)-style local projections regression:

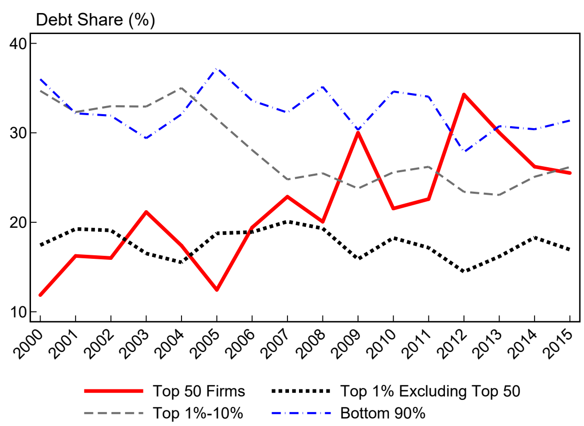
$$\begin{aligned} \text{Spread}_{c,t+h} = &\ \beta_{y,h}\text{Growth}_{c,t} + \beta_{gov,h}\text{Govt Debt/GDP}_{c,t} \\ &+ \beta_{corp,h}\text{Corp Debt/GDP}_{c,t} + \delta_c + \gamma_t + \epsilon_{c,t+h} \end{aligned}$$

for each horizon $h = 0, 1, 2...$, where δ_c and γ_t are country and time fixed effects. The figures plot regression coefficients for (a) GDP growth ($\beta_{y,h}$), (b) sovereign debt ($\beta_{gov,h}$), and (c) corporate debt ($\beta_{corp,h}$) that are multiplied by a one standard shock to GDP growth, sovereign debt, and corporate debt, respectively. The shaded area presents 95 percent confidence intervals, calculated using Driscoll and Kraay (1998b) standard errors (robust to heteroskedasticity and clustering on date and kernel-robust to common correlated disturbances) with a lag length of 4 quarters. The regression sample consists of observations for nine Eurozone countries (Austria, Belgium, Finland, France, Ireland, Italy, Netherlands, Portugal, and Spain) during the period 1999q1–2012q4.

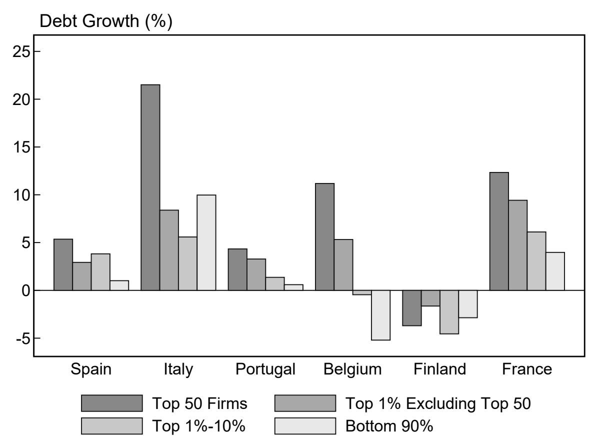
Figure 1.3: Sovereign Spread Regression Coefficients with Different Horizons



(a) Leverage



(b) Debt Share

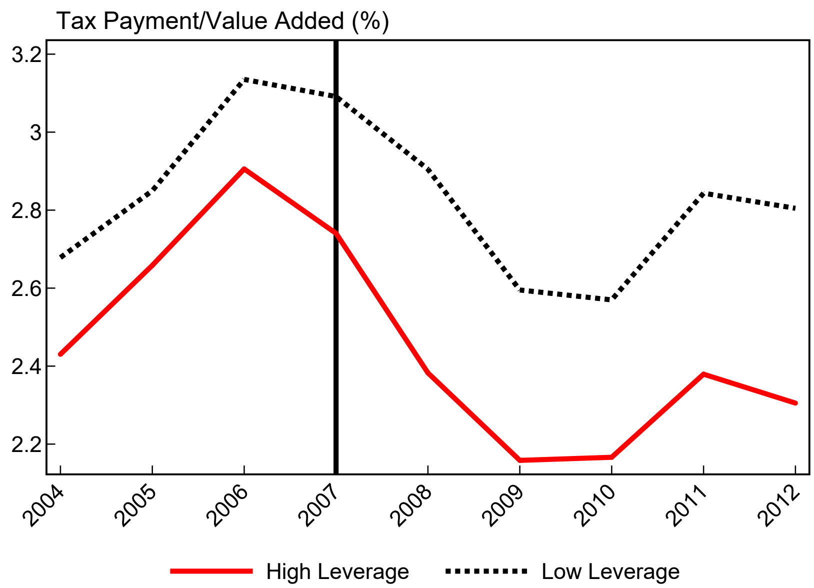


(c) Debt Growth

Source: Author's calculation based on ORBIS-AMADEUS

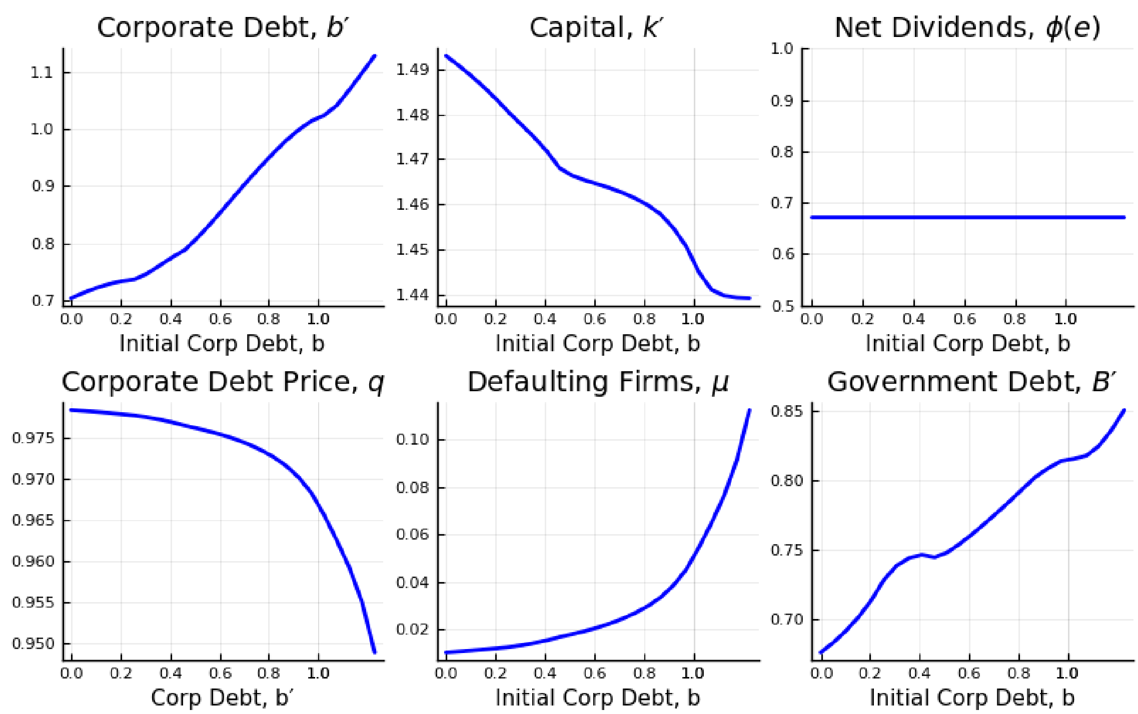
Notes: Debt is financial debt measured as the sum of loans and long-term debt, which excludes other accounts payable. Leverage reported in panel (a) is calculated as the average over six Eurozone countries (Finland, France, Italy, Spain, Belgium, and Portugal), where each country's leverage is calculated as the weighted average of individual firms' debt-to-value-added ratio within each size class, where value added is operating revenue minus materials cost, and weights are sales of each firm in a given year. In panel (b), I measure the debt share by each size class in a given country as the sum of financial debt within each size class over the sum of financial debt of all firms in a given country. I plot the average debt share of six Eurozone countries for each size class. To obtain debt growth rates in panel (c), I deflate debt using 2-digit sector gross output prices (EU KLEMS) and calculate growth rates — measured as $(\text{debt}_t - \text{debt}_{t-1})/(0.5\times(\text{debt}_t + \text{debt}_{t-1}))$ — for each firm. Debt growth rates of each size class are weighted averages within each size class during the period 2000–2015, where weights are sales of each firm in a given year $t-1$. These time-varying weights are consistent with the weights used later in constructing the granular residual, which reflect the time-varying contribution of large firms. Size classes are determined by percentiles of sales.

Figure 1.4: Corporate Debt in Average Eurozone Countries by Firm Size Class



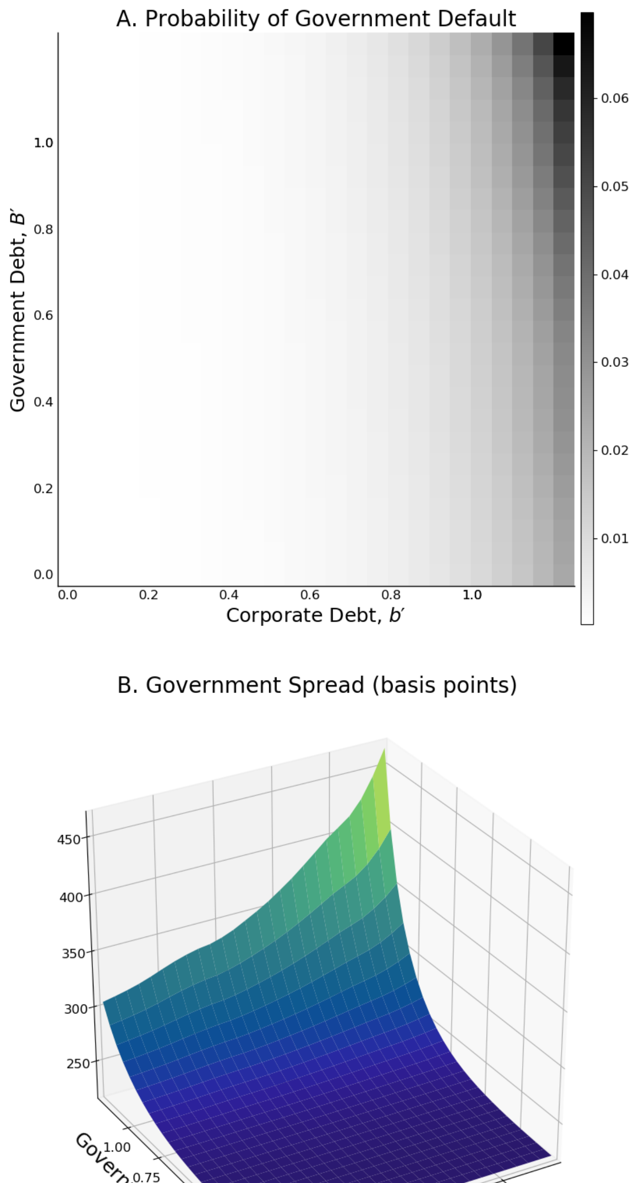
Source: Author's calculation based on ORBIS-AMADEUS
Notes: I plot averages of firm tax payment across firms within each leverage group in a given year using a sample of six Eurozone countries (Italy, Portugal, Spain, Belgium, Finland, and France). Firm tax payment for each firm i is the ratio of tax payment to value added (operating revenue − materials cost). Leverage is the ratio of financial debt to value added in which financial debt b is the sum of loans and long-term debt. A firm belongs to the high leverage group if average firm leverage before 2008 of a given firm is higher than the aggregate median before 2008. I use a full sample during the period 2000–2007 in six Eurozone countries to calculate average firm leverage of each firm and aggregate median leverage.

Figure 1.5: Firm Tax Payment by Leverage Group



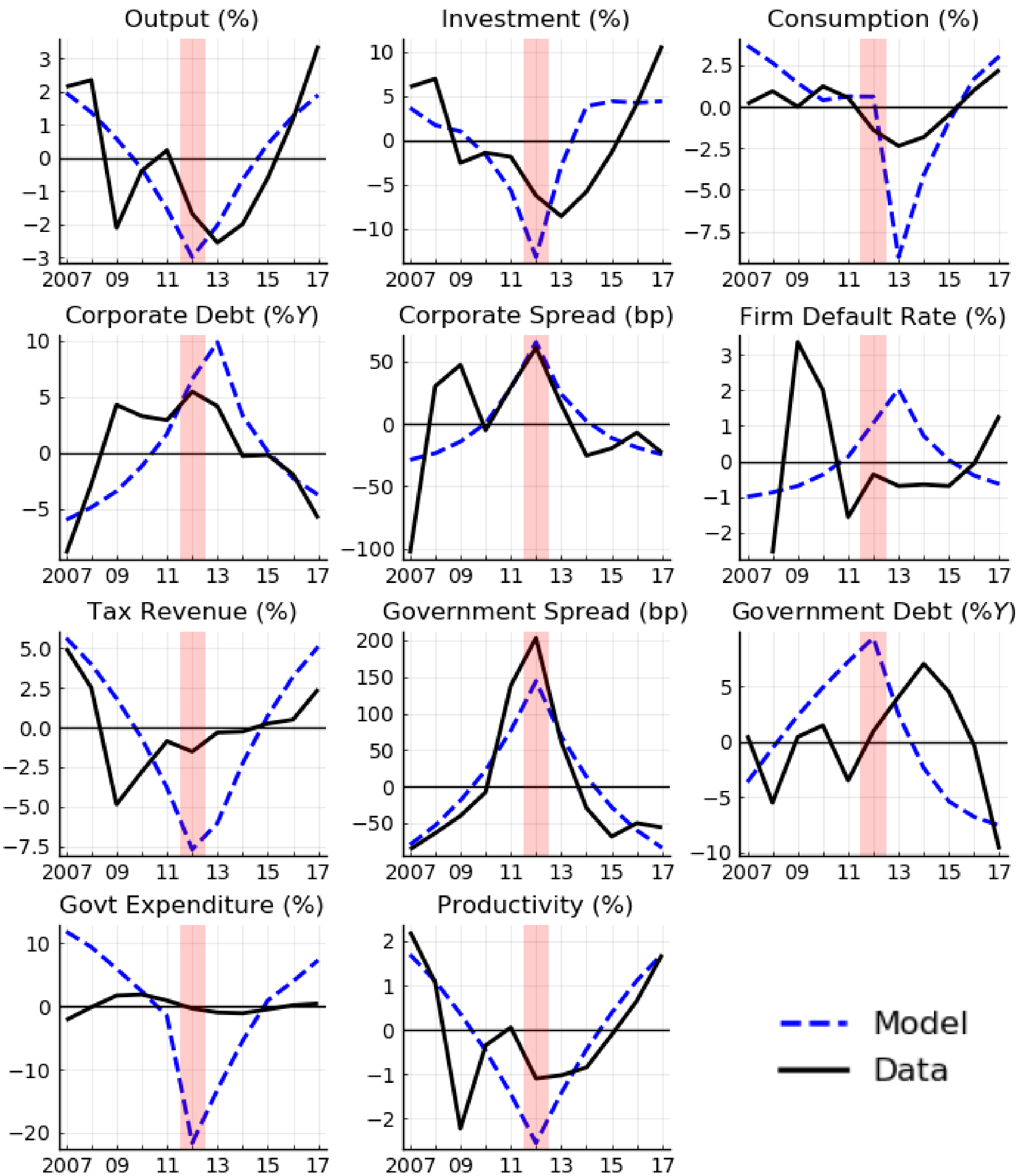
Notes: The figure shows decision rules in the competitive equilibrium of the quantitative model. Productivity z and capital k are set to the minimum level so that substantial firm default risk exists, and government debt B is set to the median level. Decision rules are averaged over the distribution of taste shocks.

Figure 1.6: Decision Rules



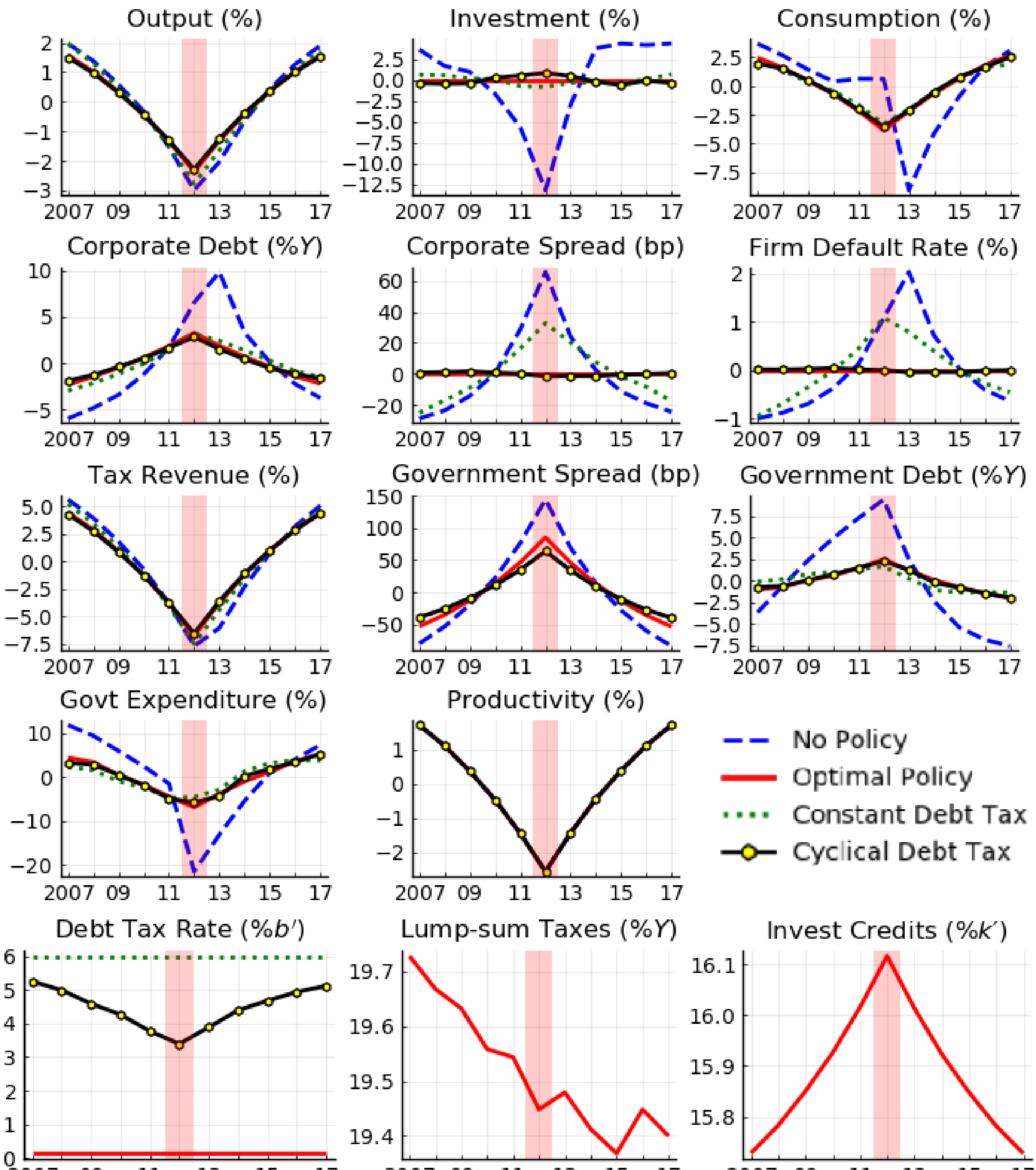
Notes: The figure shows government default probabilities and the spread function in the competitive equilibrium of the quantitative model. Productivity z and capital k are set to the minimum level so that substantial firm default risk exists.

Figure 1.7: Government Default Probability and Spread Function



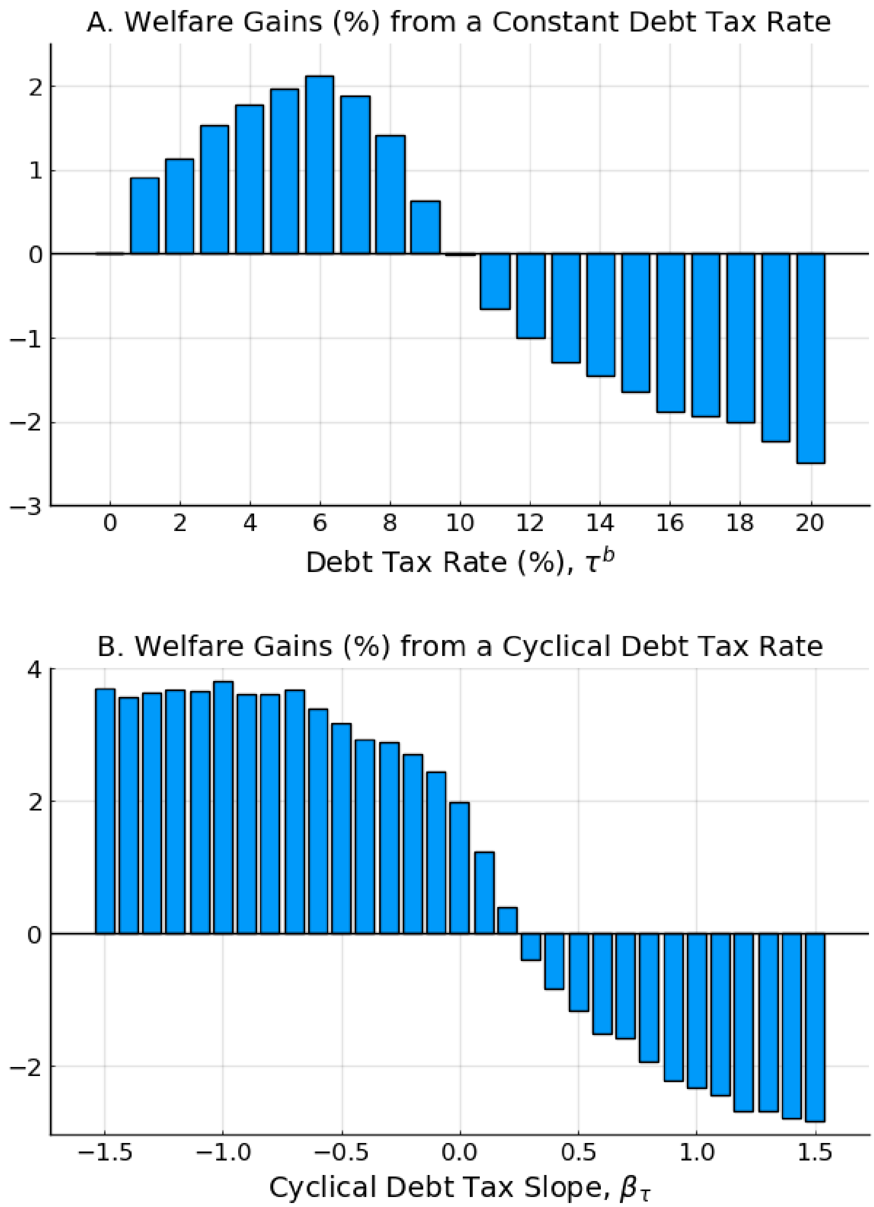
Notes: For model-simulated time series, I simulate an economy (competitive equilibrium) for a million periods and drop the first 500 periods. I identify a period t as a sovereign debt crisis if government spreads at time t increase by more than three standard deviations of government spreads across all periods. Next, I obtain the paths of variables within each event window ranging from $t-5$ to $t+5$, and I calculate the deviation of each variable from its average within each event window. Time t is marked with the shaded area which corresponds to the year of 2012. I plot the average of the demeaned variables across event windows. See the notes of Figure 1.9 for more details. Data counterparts are linearly detrended series during the period of 2007-2017. See Data Appendix for more details.

Figure 1.8: Event Study: Sovereign Debt Crisis



Notes: I simulate each economy with different policies, using the same path of productivity and the timing of the crisis events as shown in Figure 1.8. Crisis time t is marked with the shaded area which corresponds to the year of 2012. I plot the average of the demeaned variables across event windows. Output, investment, consumption, corporate income tax revenue, government expenditure, productivity are demeaned and normalized by their steady state values and are expressed in percentage deviations. Corporate debt and government debt are initially normalized by output and are demeaned later. Corporate spreads and government spreads are demeaned and are in basis points. The fraction of defaulting firms is demeaned and is in percentage. The debt tax rate τ_t^b, the ratio of lump-sum taxes to output $-T_t/Y_t$, and investment credits τ_t^k are plotted as their original levels in percentage.

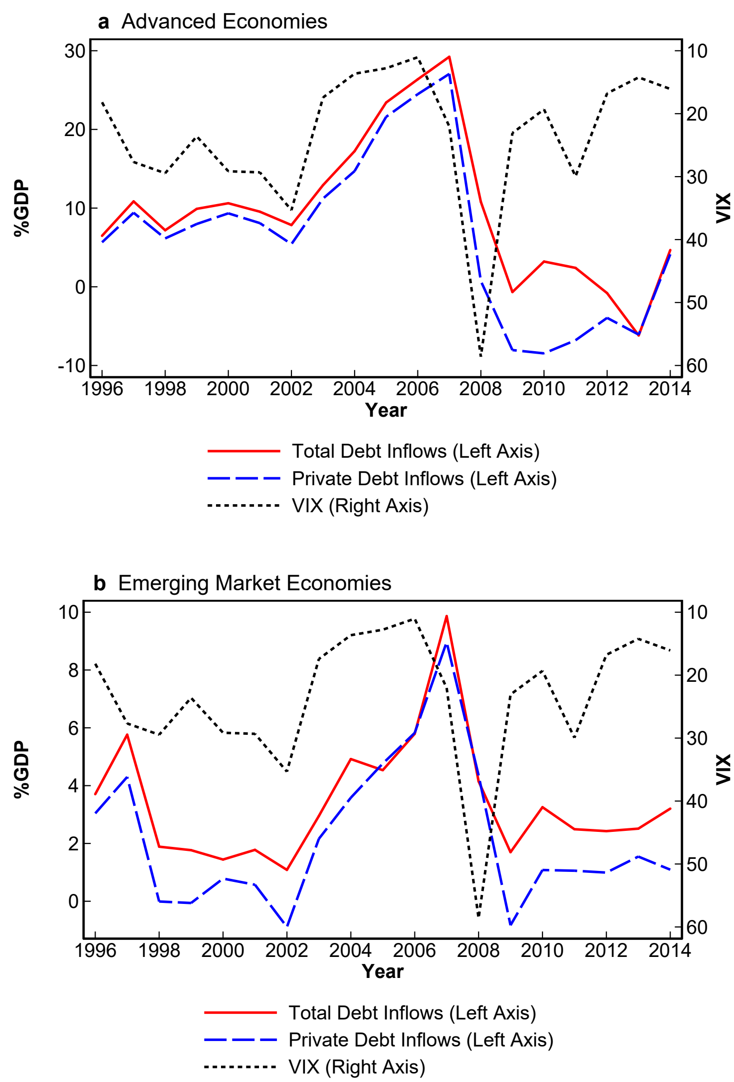
Figure 1.9: Event Study: Policy Analysis



Notes: A permanent increase in consumption by implementing different debt policies is calculated. For each policy, the average welfare gains from 100,000 simulations of 200 periods after dropping first 100 periods for each simulation are presented. The debt tax rate is given by $\tau_t^b = max[\bar{\tau}^b + \beta_\tau(b_t/Y_t - \bar{b}/\bar{Y}), 0]$. The target corporate leverage ratio $\bar{b}/\bar{Y}$ is set to 0.91. In Panel A, β_τ is set to zero, and only the constant debt tax rate $\bar{\tau}^b$ changes. In Panel B, $\bar{\tau}^b$ is set to 6%, and the debt tax slope β_τ changes.

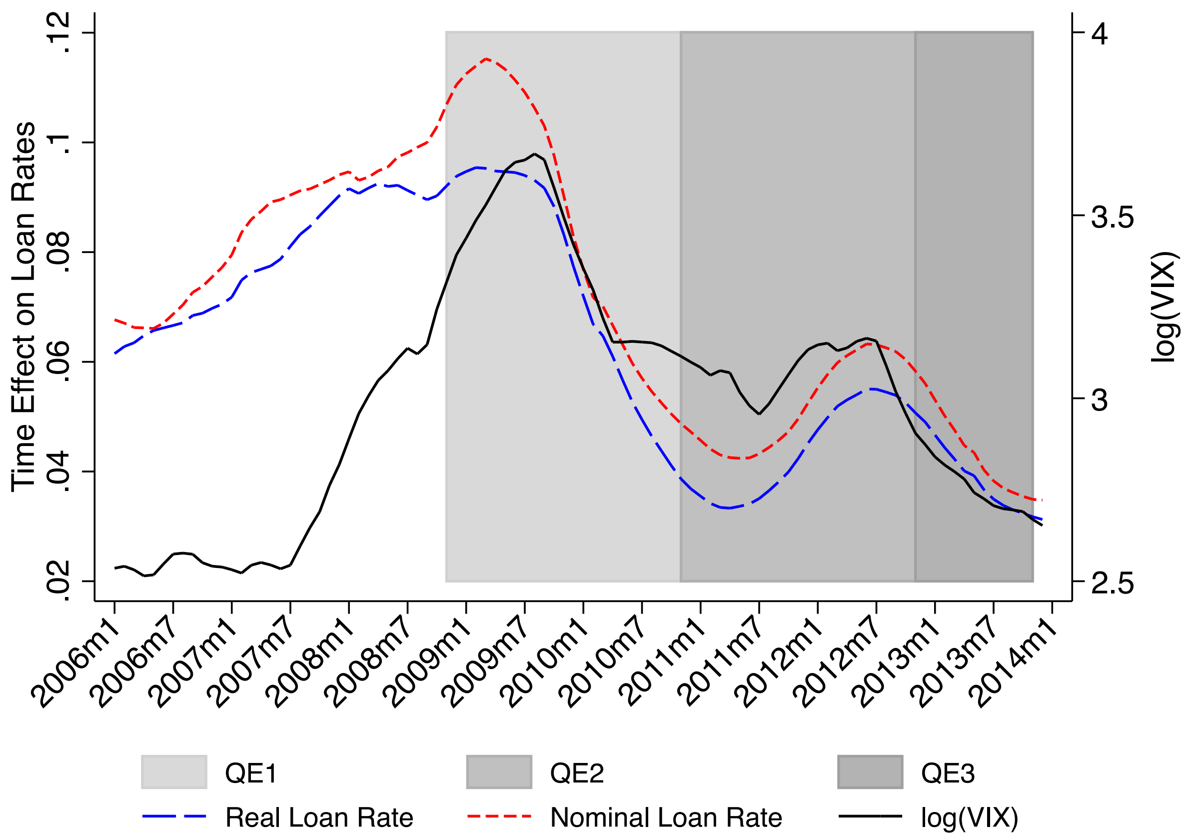
Figure 1.10: Welfare Gains From Simple Debt Tax Policies

Figures of Chapter 2



Notes: (a) Advanced Economies. (b) Emerging Market Economies. We calculate debt inflows to GDP ratios as the average over the country group in a given year. Figures constructed using data from Avdjiev et al. (2018).

Figure 2.1: Total vs Private Average Debt Inflows (% GDP) and VIX



Notes: Figure adapted with permission from Giovanni et al. (2017).

Figure 2.2: VIX, US Monetary Policy and Turkish Firms' Borrowing Costs

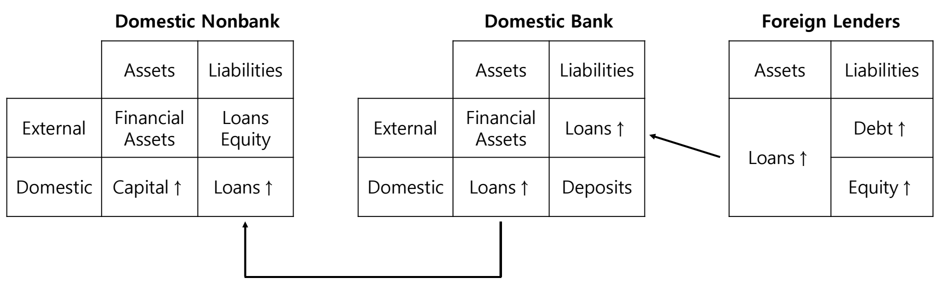
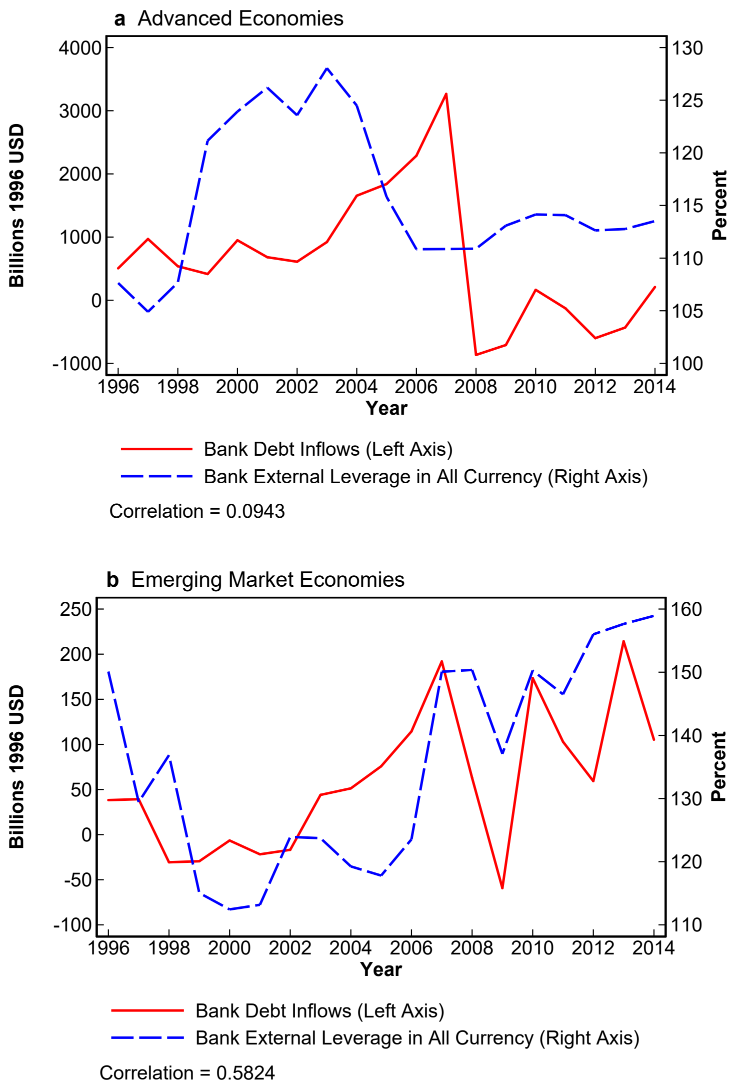
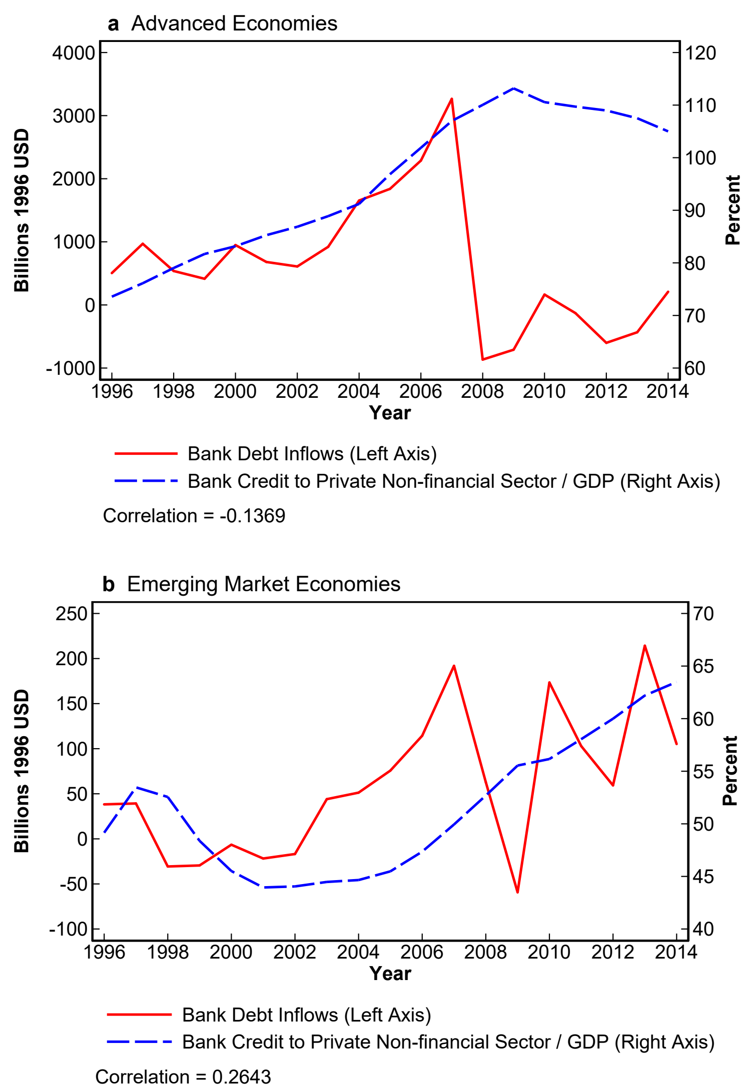


Figure 2.3: Balance Sheets and Capital Inflows



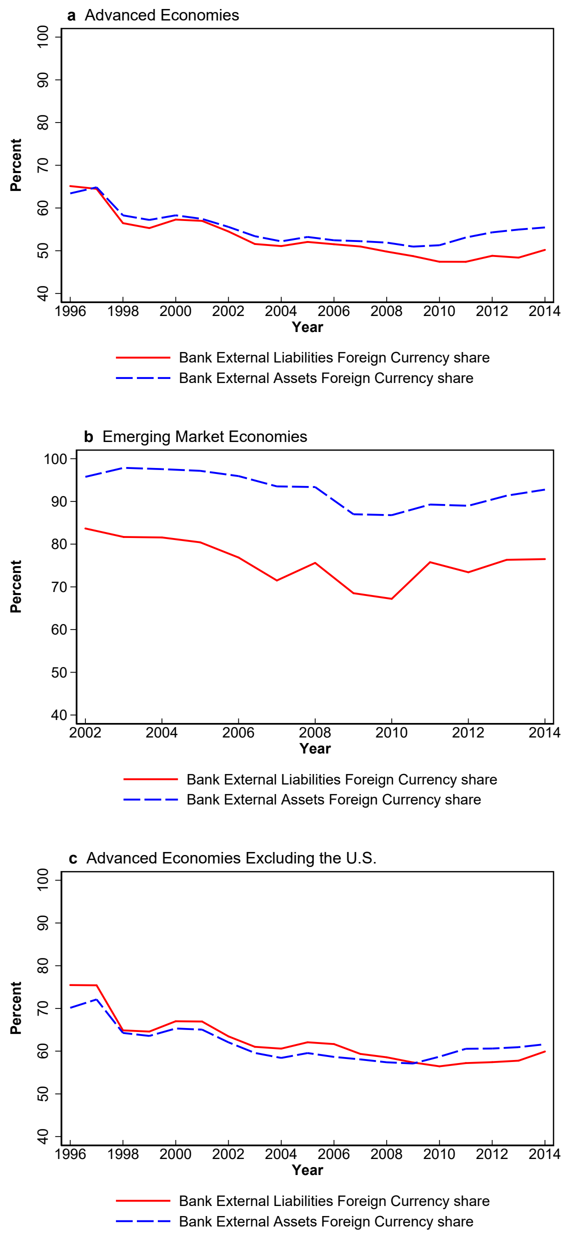
Notes: (a) Advanced Economies. (b) Emerging Market Economies. We calculate aggregate debt inflows into the bank sector in a given year as the sum of deflated debt inflows (billions 1996 USD) over the country group in a given year. We calculate external leverage of the bank sector in a given year as the sum of the bank sector's external liabilities over the country group in a given year divided by the counterpart of external assets. Figures constructed using data from Avdjiev et al. (2018).

Figure 2.4: Bank Debt Inflows and Bank External Leverage in All Currencies



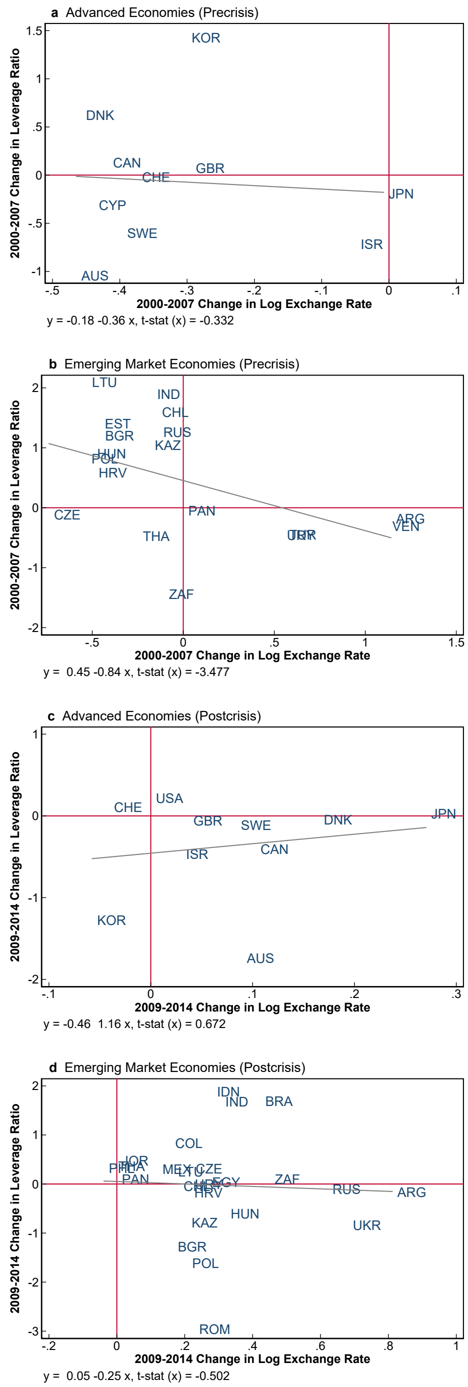
Notes: (a) Advanced Economies. (b) Emerging Market Economies. We calculate aggregate debt inflows into the bank sector in a given year as the sum of deflated debt inflows (billions 1996 USD) over the country group in a given year. We use the average of bank credit to the private non-financial sector to GDP ratios over the country group in a given year as the measure of the private non-financial sector's leverage. Figures constructed using data from Avdjiev et al. (2018) and BIS Credit Statistics.

Figure 2.5: Inflows and Bank Credit to the Private Non-financial Sector to GDP ratio



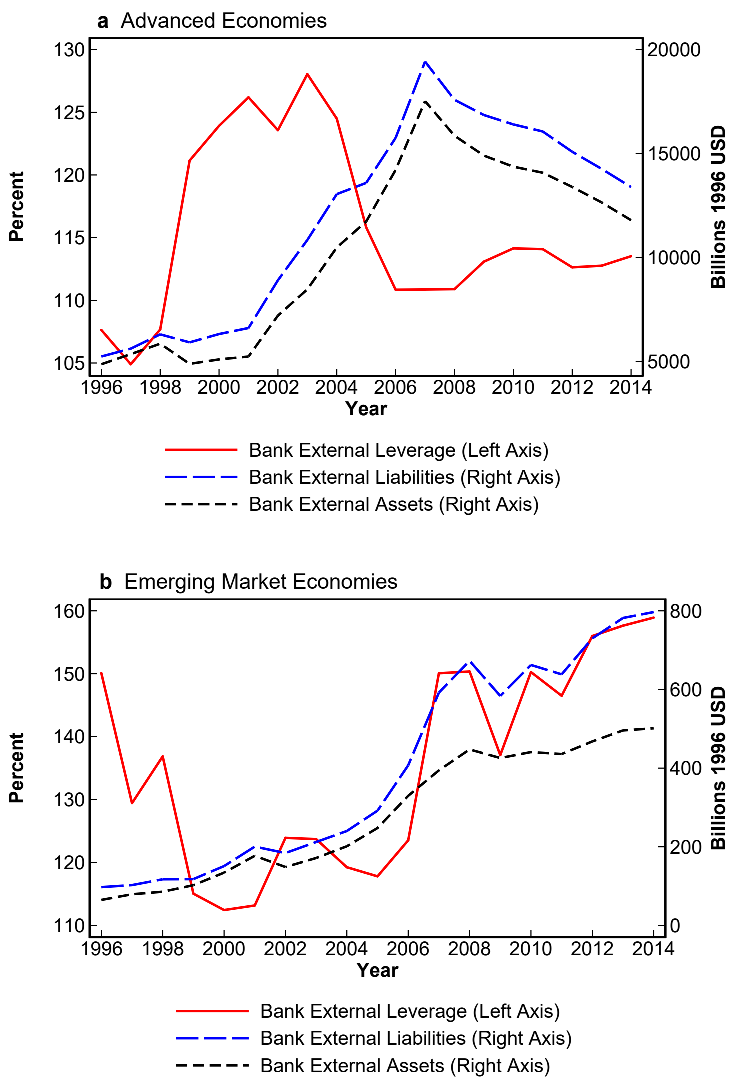
Notes: (a) Advanced Economies. (b) Emerging Market Economies. (c) Advanced Economies Excluding the U.S. We calculate the share of foreign currency liabilities as the sum of the liabilities in foreign currency across countries divided by the sum of total liabilities across countries. The share of foreign currency assets is calculated in the same fashion. Figures constructed using data from BIS Locational Banking Statistics.

Figure 2.6: Foreign Currency Share of Bank External Liabilities and Assets



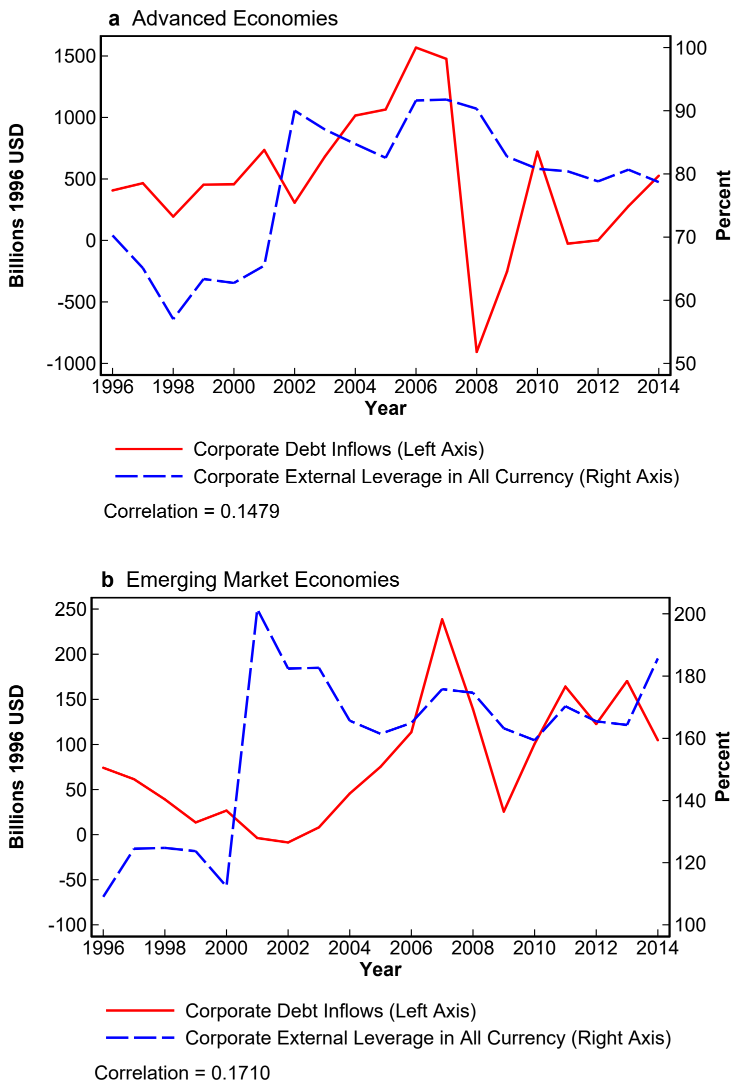
Notes: (a) Advanced Economies (Precrisis). (b) Emerging Market Economies (Precrisis). (c) Advanced Economies (Postcrisis). (d) Emerging Market Economies (Postcrisis). The change in bank external leverage ratio is the difference between bank external-liabilities-to-assets ratio in 2007 and the one in 2000 for the pre-crisis period. The exchange rate is the price of the US dollar in local currency. The change in the log exchange rate is the difference between the log exchange rate in 2007 and the one in 2000. We use 2009–2014 changes for the post-crisis period. We drop country observations if a change in bank external leverage ratio is larger than 3 or smaller than -3 in a given country. Figures constructed using data from IMF International Financial Statistics and Avdjiev et al. (2018).

Figure 2.7: Bank External Leverage and Exchange Rate



Notes: (a) Advanced Economies. (b) Emerging Market Economies. We calculate external leverage of the bank sector in a given year as the sum of the bank sector's external liabilities over the country group in a given year divided by the counterpart of external assets. Figures constructed using data from Avdjiev et al. (2018).

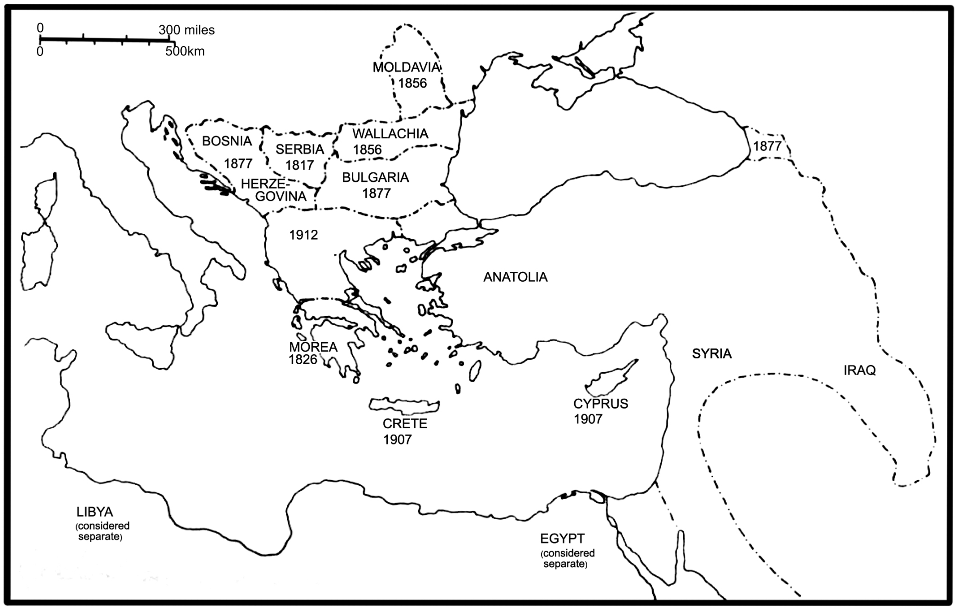
Figure 2.8: Bank External Liabilities and Assets in All Currencies



Notes: (a) Advanced Economies. (b) Emerging Market Economies. We calculate aggregate debt inflows into the corporate sector in a given year as the sum of deflated debt inflows (billions 1996 USD) over the country group in a given year. We calculate external leverage of the corporate sector in a given year as the sum of the corporate sector's external liabilities over the country group in a given year divided by the counterpart of external assets. Figures constructed using data from Avdjiev et al. (2018).

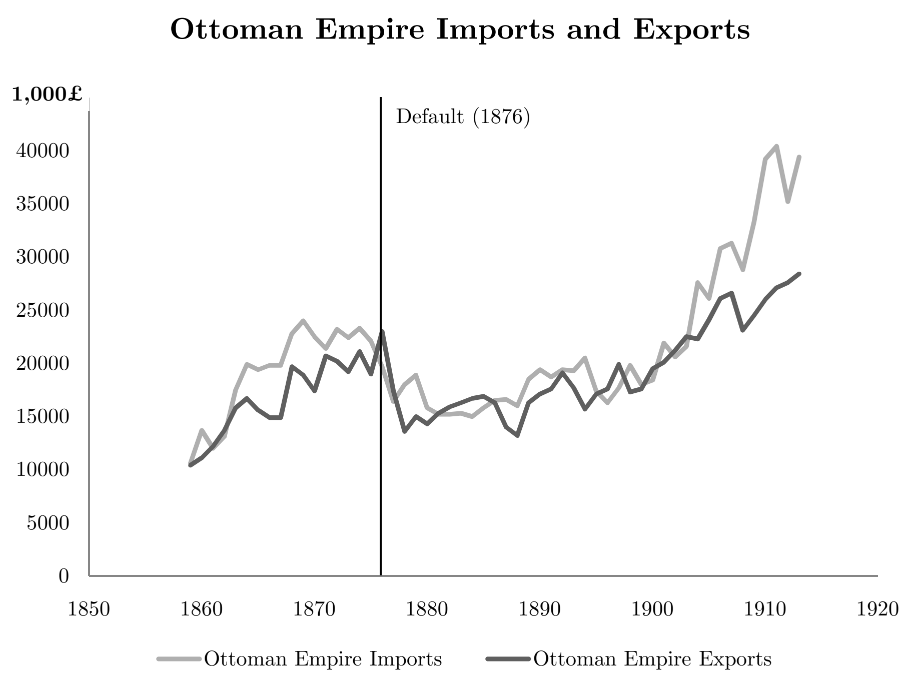
Figure 2.9: Corporate Debt Inflows and Corporate External Leverage in All Currencies

Figures of Chapter 3



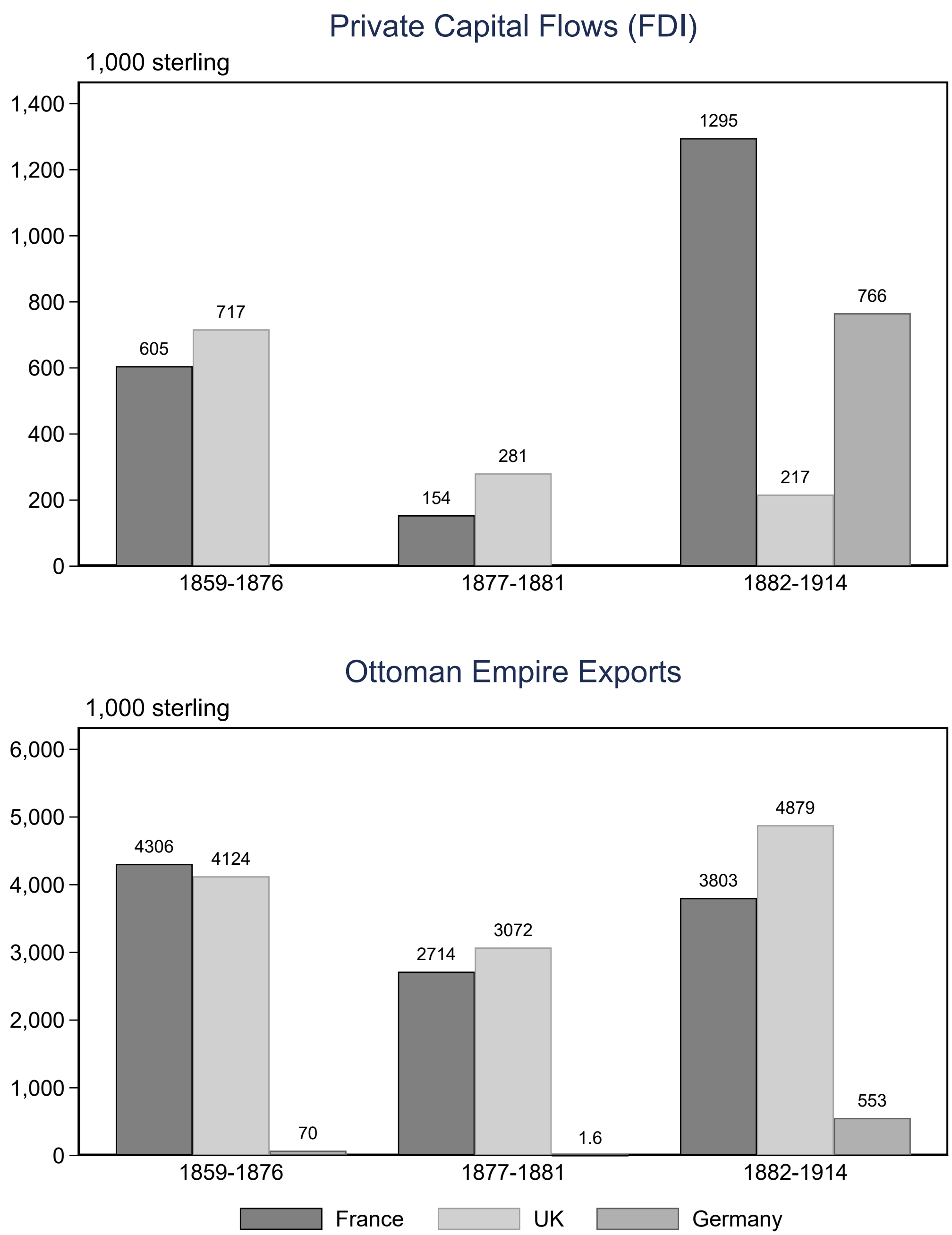
Notes: This map is taken from Pamuk (1987).

Figure 3.1: Ottoman Borders: 1830–1913



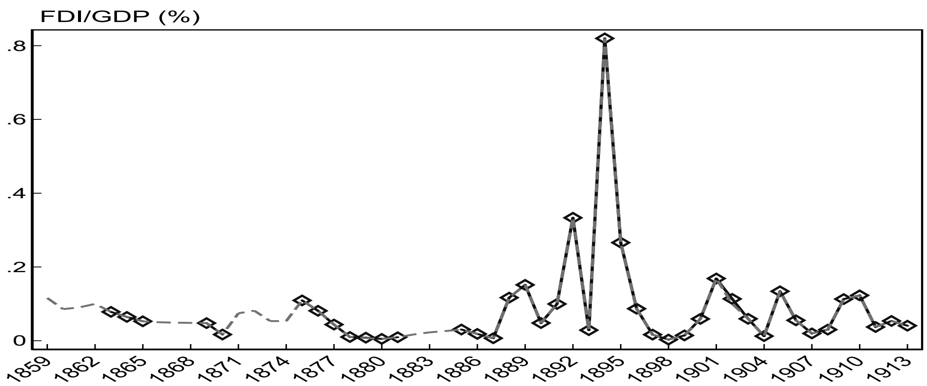
Notes: This data is taken from Pamuk (1987). All variables are measured in thousand sterling.

Figure 3.2: Aggregate Imports and Exports of the Ottoman Empire during 1859–1913

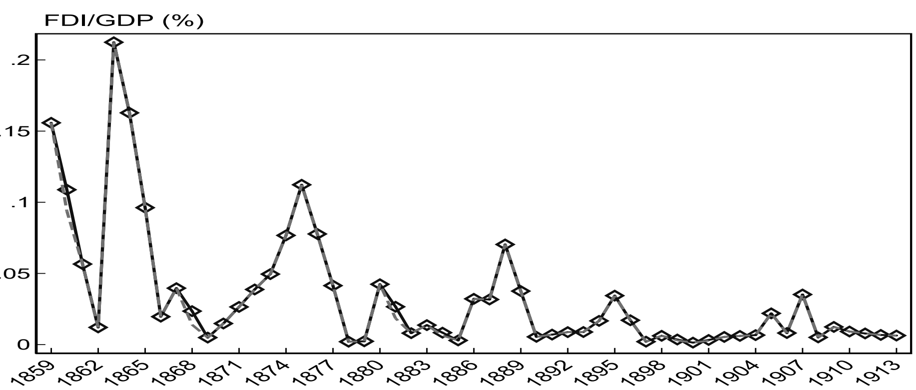


Notes: This data is taken from Pamuk (1987). All variables are measured in thousand sterling and averaged over each period.

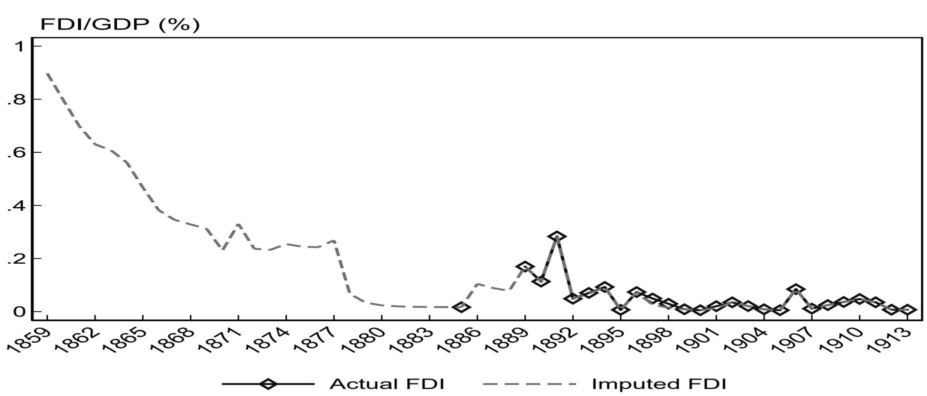
Figure 3.3: Private Capital Inflow (FDI) and Exports of the Ottoman Empire during 1859–1913



(a) France



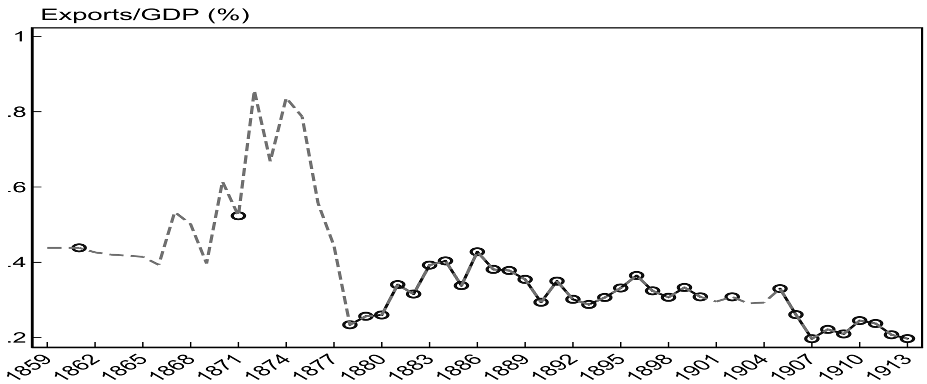
(b) United Kingdom



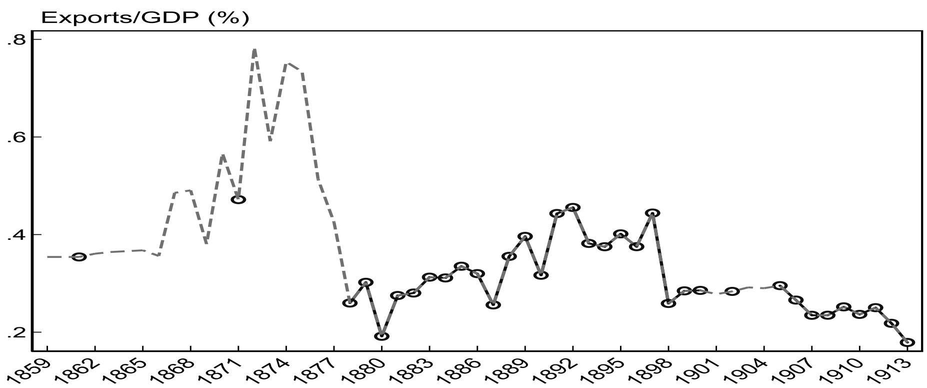
(c) Germany

Notes: Raw data is taken from Pamuk (1987). We impute missing data on FDI-to-GDP ratios, using the regression of log FDI-to-GDP ratios on log Ottoman government-debt-flow-to-GDP ratios with country fixed effects and country-specific time trends. This regression explains substantial variation in historical FDI-to-GDP ratios with an R-squared of 0.4114. Remaining missing values are interpolated using the average of the values in years $t-1$ and $t+1$. If the value in $t+1$ is not feasible, the value in $t+2$ is used. When the value in $t-1$ is missing, we fill the value in t with the value in $t+1$.

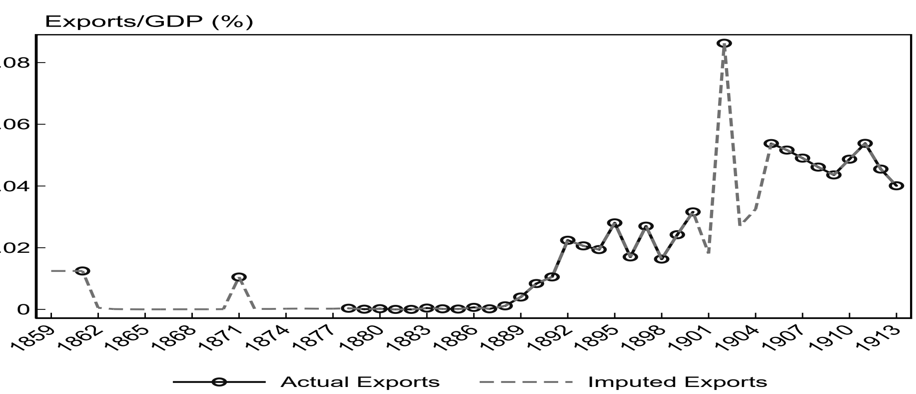
Figure 3.4: Foreign Direct Investment (FDI) from Source Countries to the Ottoman Empire during the Period 1859–1913



(a) France



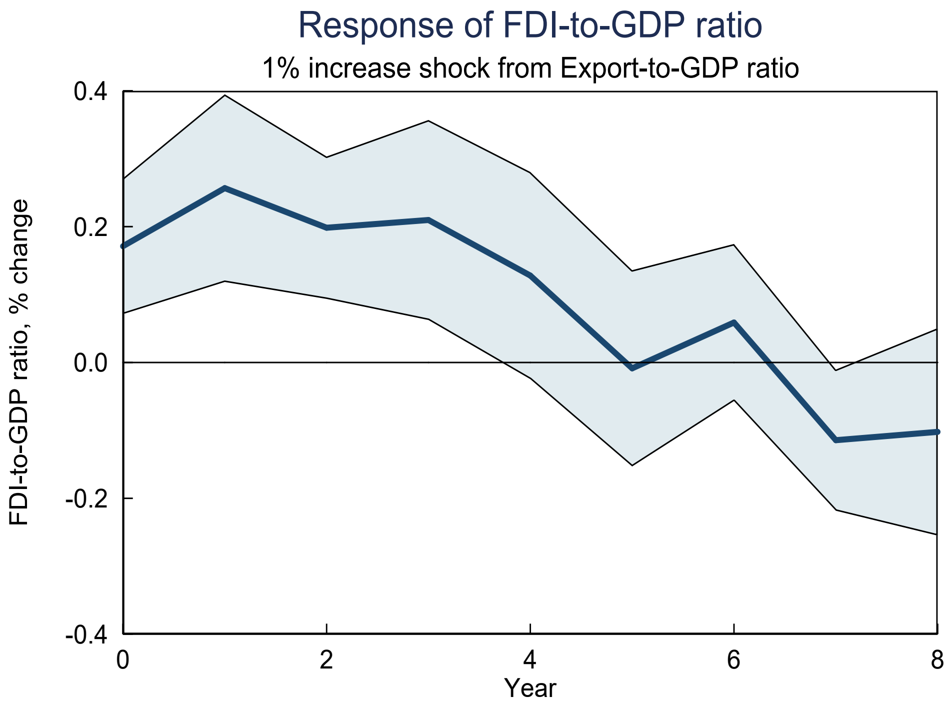
(b) United Kingdom



(c) Germany

Notes: Raw data is taken from Pamuk (1987). We impute missing data on Export-to-GDP ratios, using the regression of log Export-to-GDP ratios on log GDP per capita of each source country and log Ottoman GDP per capita with country fixed effects and country-specific time trends. This regression gives an R-squared of 0.8405. Remaining missing values are interpolated using the average of the values in years $t-1$ and $t+1$. If the value in $t+1$ is not feasible, the value in $t+2$ is used. When the value in $t-1$ is missing, we fill the value in t with the value in $t+1$.

Figure 3.5: Exports from the Ottoman Empire to Source Countries during the Period 1859–1913

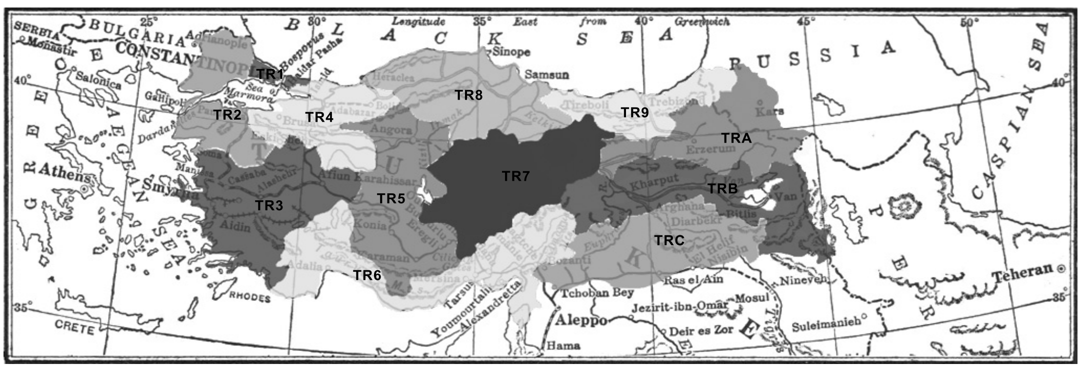


Notes: We run regressions by local projections (**?**) as follows:

$$align \log\left(\frac{FDI_{it+h}}{GDP_{it+h}}\right) = \alpha_i + \alpha_i t + \beta_h \log\left(\frac{EXPORTS_{it}}{GDP_{it}}\right) + \gamma W_{it} + \epsilon_{it+h}$$

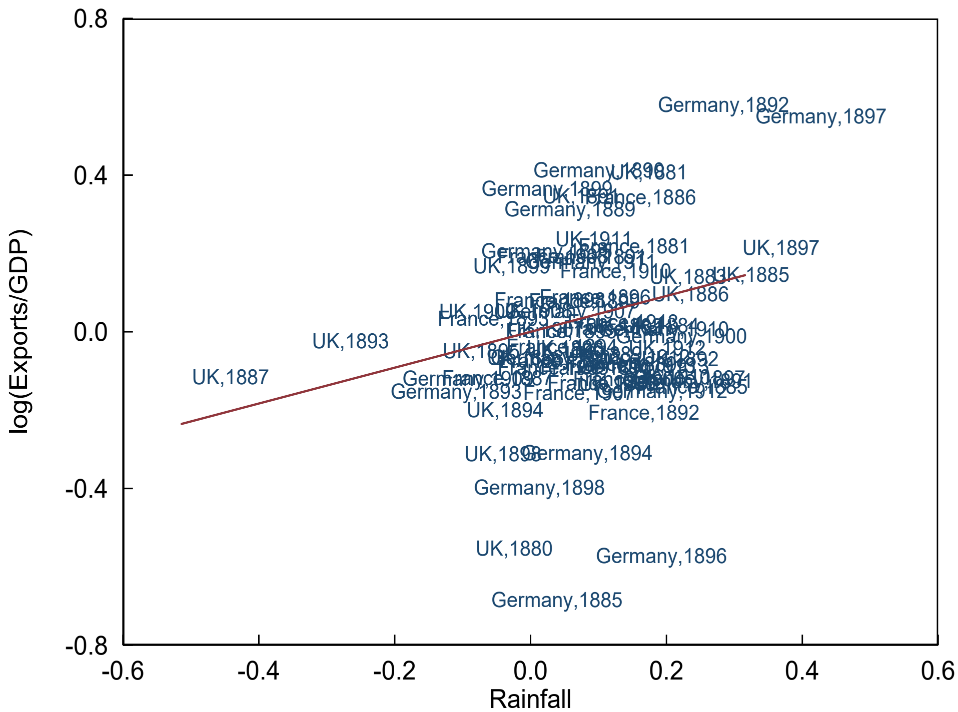
where α_i indicates country dummies, and $\alpha_i t$ controls for country-specific trends. The left-hand side variable is gross FDI inflows from the source countries (denoted as i), which are France, Germany and the U.K., into the Ottoman Empire in time $t+h$; Exports are Ottoman exports into these countries in time t. The set of control variables W_{it} includes three lagged variables of each of FDI-to-GDP ratios, export-to-GDP ratio, and the Empire's GDP per capita. Estimates β_h are plotted as a solid line connecting the estimate in each horizon h. The shaded area shows 95% confidence interval with Driscoll and Kraay (1998a) standard error (lag length 3).

Figure 3.6: Dynamic Responses of Foreign Direct Investment (FDI) from Source Countries to the Ottoman Empire



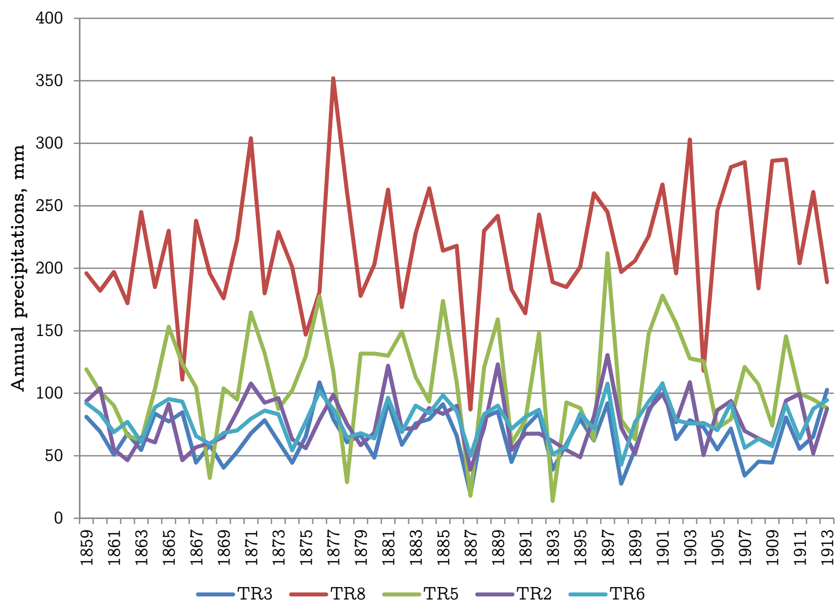
Notes: The figure shows the location of the statistical regions (SRE). TR1-Istanbul, TR2-West Marmara, TR3-Aegean, TR4-East Marmara, TR5-West Anatolia, TR6-Mediterranean, TR7-Central Anatolia, TR8-West Black Sea, TR9-East Black Sea, TRA-North East Anatolia, TRB-Central East Anatolia, TRC-South East Anatolia. Names of the statistical regions and their tags accord to Prime Ministry Republic of Turkey and Turkish Statistical Institute (2005), page 413 "Classification of statistical regions (SRE)". Long-term rainfall data is available for TR2 statistical region (Griggs et al., 2007), TR3 region (Touchan et al., 2003), TR5 region (Akkemik and Aras, 2007), TR6 region Touchan et al. (2007), and TR8 region (Akkemik et al., 2007)

Figure 3.7: Statistical Regions of Turkey with Long-term Rainfall Data



Notes: The scatterplot and the solid line correspond to the first-stage regression in Table 3.9 column 2 with the partial effect of rainfall on exports being equal to 0.46 with the standard error of 0.17. The log export-to-GDP ratio and rainfall variables are purged out of control variables in the first-stage regression.

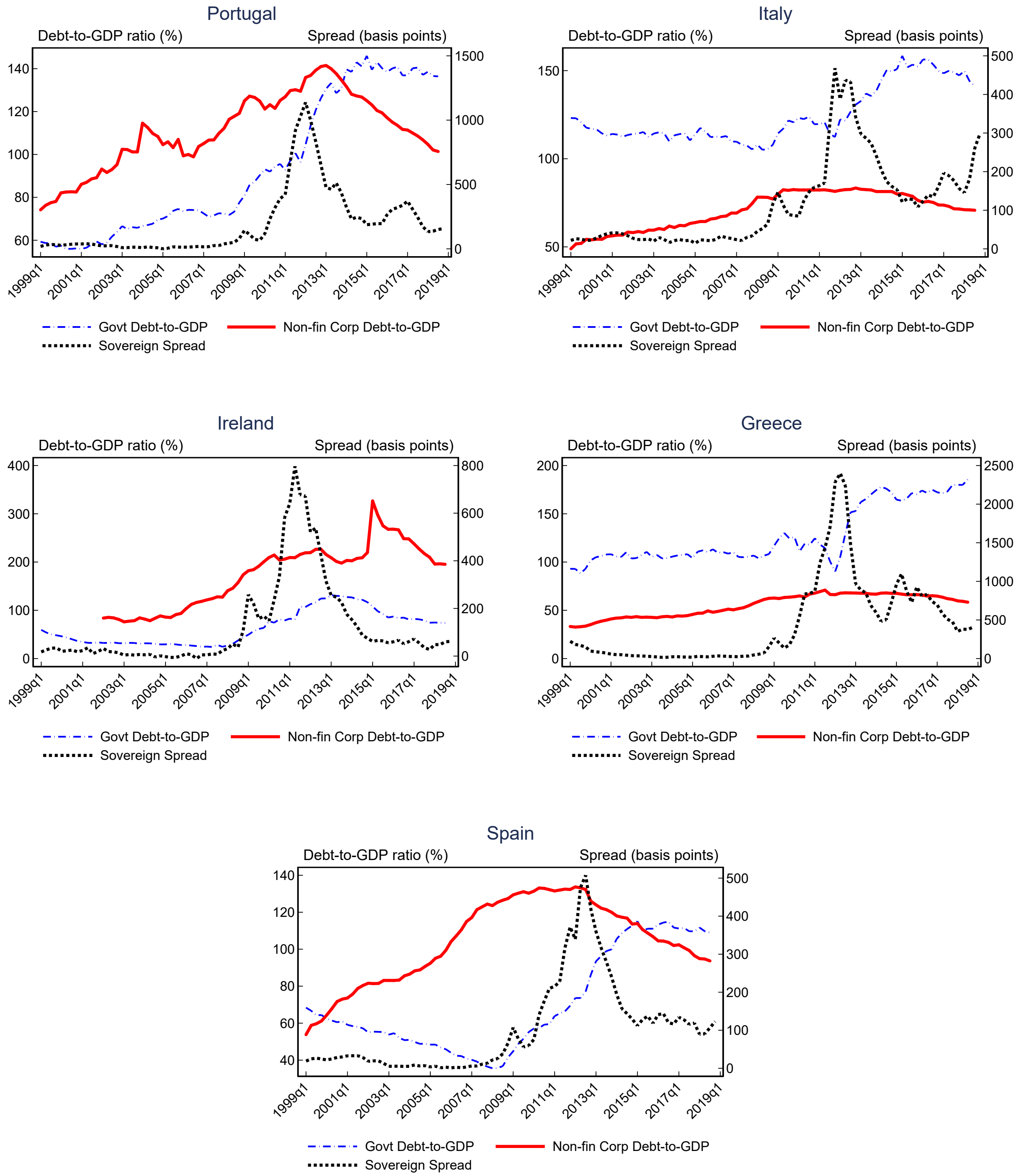
Figure 3.8: The Partial Effect Scatterplot of Rainfall and the Ottoman Empire Exports



Notes: For definition of the statistical regions, refer to Section 3.6.1.

Figure 3.9: Annual Precipitation in Various Statistical Regions of the Former Ottoman Empire

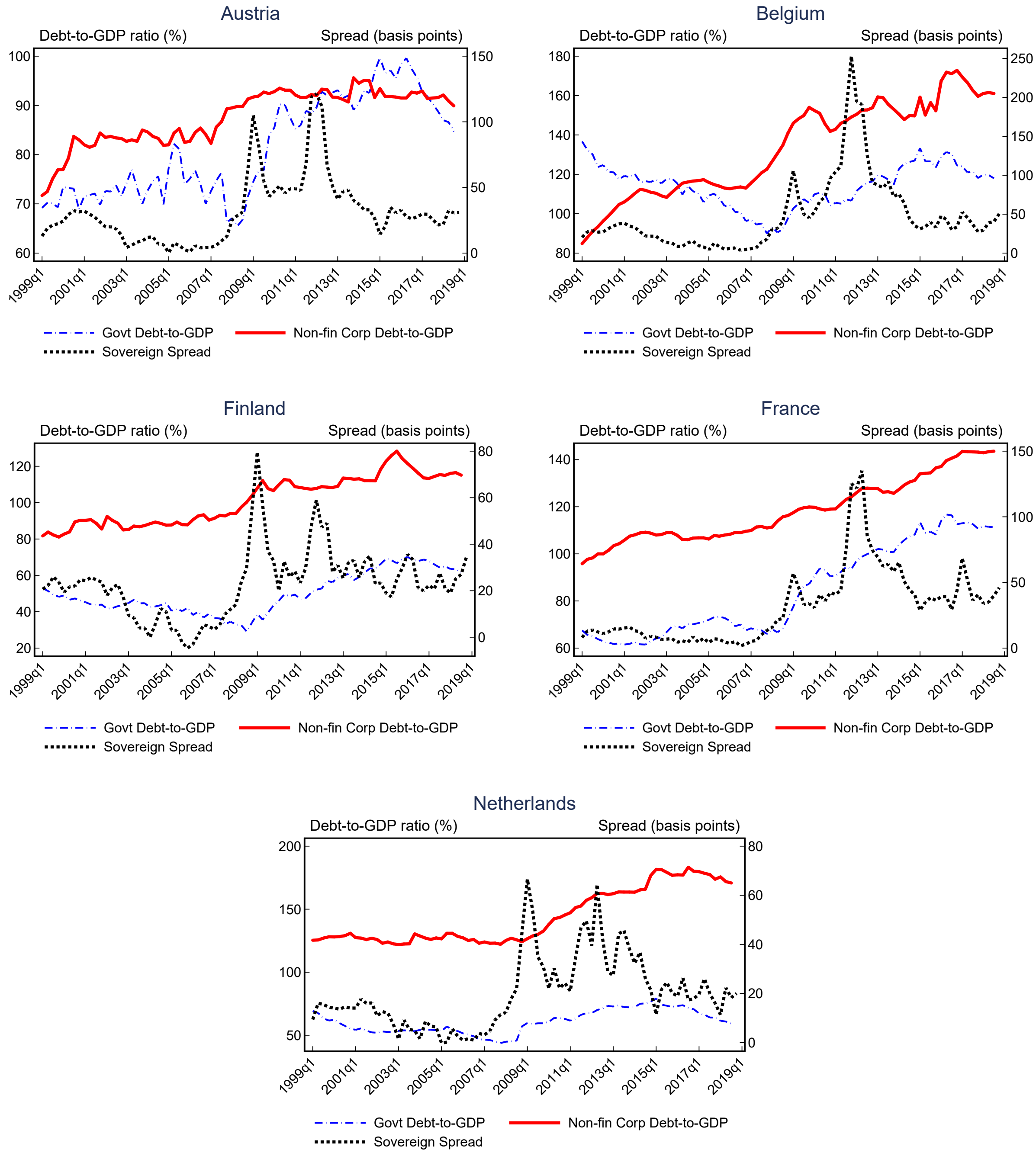
Appendix Figures



Source: BIS, Bloomberg

Notes: See Figure A.1 for notes.

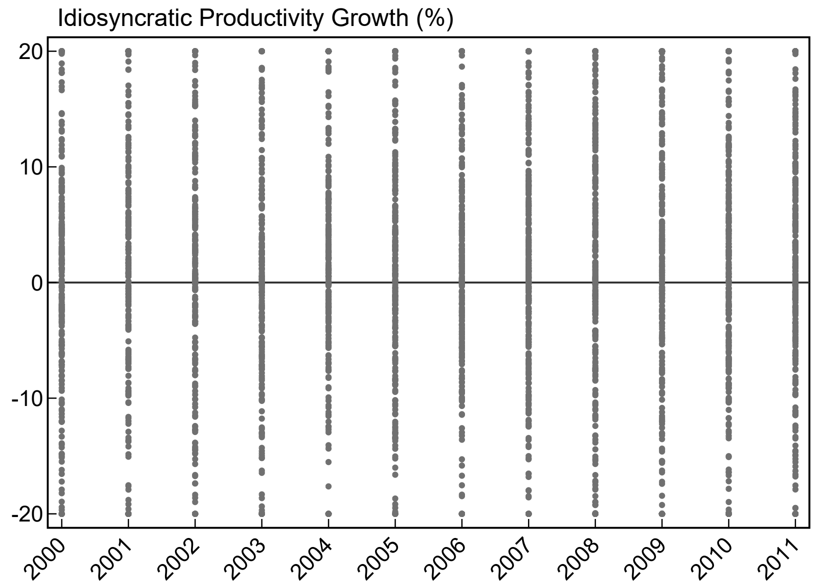
Figure A.1: Leverage and Sovereign Spread in Peripheral Countries



Source: BIS, Bloomberg

Notes: The figure shows debt-to-GDP ratios and sovereign spreads for each country. Debt is core debt (BIS) which consists of the following financial instruments as defined in the System of National Accounts (SNA): debt securities, loans, and currency and deposits. Core debt excludes special drawing rights, insurance, pension, standardized guarantee schemes, and other accounts payable. Sovereign spreads (Bloomberg) are measured as the difference between the 10-year government bond yield of each country and that of Germany. Both government bond yields are denominated in euro and daily averages of the period.

Figure A.2: Leverage and Sovereign Spread in Non-Peripheral Countries

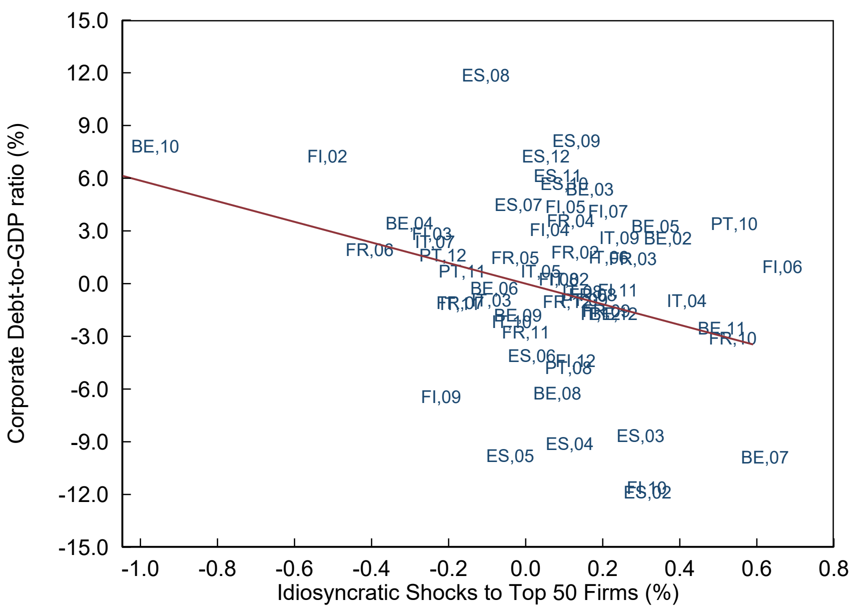


Source: Author's calculation based on ORBIS-AMADEUS
Notes: To construct idiosyncratic shocks, I estimate the following firm-level productivity growth ($g_{i,t}$) decomposition:

$$g_{i,t} = \beta_{s,q}\eta_t + u_{i,t}$$

where η_t is an aggregate shock, and $u_{i,t}$ is an idiosyncratic shock to firm i at time t. I plot estimated residuals $\hat{u}_{i,t}$ for top 50 large firms in each Eurozone country (Italy, Spain, Portugal, Belgium, Finland, and France) together. I assume that (i) the responsiveness ($\beta_{s,q}$) of firm-level productivity growth ($g_{i,t}$) with regard to an aggregate shock (η_t) is identical within a 4-digit sector s and a firm size quntile q, and that (ii) aggregate and idiosyncratic shocks are separable in the growth decomposition. Under this assumption, regressing firm-level productivity growth on sector $\times$ size $\times$ year fixed effects gives residuals ($\hat{u}_{i,t}$) that are consistent estimators for idiosyncratic shocks ($u_{i,t}$). These residuals are calculated using top 50 largest firms in each 4-digit sector and winsorized at 20 and -20 percent following Gabaix (2011).

Figure A.3: Idiosyncratic Shocks to Top 50 Firms in Six Eurozone Countries



Source: Author's calculation based on BIS and ORBIS-AMADEUS

Notes: The figure plots the weigthed idiosyncratic shocks to top 50 firms in each country against corporate debt-to-GDP ratios for six Eurozone countries using the first-stage regression in Table 1.4, column (4). These variables are purged of GDP growth, government debt-to-GDP ratio, lagged bank leverage, lagged granular residual, and country- and year- fixed effects. Labels denote the two-digit letter country code combined with two-digit years in the 2000s. IT: Italy, PT: Portugal, ES: Spain, BE: Belgium, FI: Finland, FR: France.

Figure A.4: First-stage Regression Plot

Data Appendix for Chapter 1

1. Firm-level Data Cleaning

ORBIS-AMADEUS data is constructed following Kalemli-Ozcan et al. (2019) unless stated otherwise.

- I limit the sample to the period of 1999 to 2015 and exclude the financial sector (NACE code 64–66) and the mining and oil-related sector (NACE code 05–09). I only use unconsolidated balance sheets, as many firms do not report consolidated balance sheets.

- I drop firm-year observations if any of the following variables are missing or negative in a given year for each firm: total assets, operating revenue (turnover), sales, number of employees, costs of employees, material costs, and financial debt. Also, I drop entire firm observations if any of the following variables are negative for each firm: total assets, sales, tangible fixed assets, and number of employees. If the number of employees exceeds 2 millions for any year observations in a given firm, I drop entire observations of this firm.

- To further mitigate measurement errors arising from reporting mistakes and associated outliers, I perform the following procedure. First, I calculate growth rates of a variable x at time t as $(x_{it} - x_{it-1})/(0.5 \times (x_{it} + x_{it-1}))$ for each firm i and year t. Next, if the growth rate at time t is greater than 150% and the growth rate at time $t+1$ is smaller than -150%, the value x_t is replaced with a simple average $(x_{t-1} + x_{t+1})/2$. I repeat this procedure three times for the following variables: total assets, operating revenue (turnover), sales, number of employees, costs of employees, material costs, and financial debt. I also winsorize these variables at the bottom 1st percentile. Moreover, I manually check whether variables have obvious mistakes and correct data accordingly.

For example, if a firm's sales are \$100 for three years, increase to \$10,000 and go back to \$100 in subsequent years, I replace the value of \$10,000 with \$100.

- To obtain estimates for production function parameters used for total factor productivity (TFP) calculation, I follow Gopinath et al. (2017a) that impose stricter criteria in data cleaning and drop many observations, as quality of data needs to be much higher for TFP estimation. Final firm-level TFP is constructed by plugging cleaned data described above into the production function estimated using cleaned data as in Gopinath et al. (2017a).

2. Alternative Measure of Idiosyncratic Shocks

Beside estimating equation 1.5 in a similar vein with Gabaix and Koijen (2020), an alternative way of estimating firm-level idiosyncratic shocks is as follows. An econometrican regresses firm-level total factor productivity $z_{i,t}$ for each firm i and year t on its lagged value using the following equation:

$$log(z_{i,t}) = \mu + \rho log(z_{i,t-1}) + u_{i,t} \tag{9}$$

Residuals $\hat{u}_{i,t}$ estimated from the above equation are innovations to productivity and could be called idiosyncratic shocks. However, the problem of this procedure is that the OLS estimator of ρ is biased due to the nature of autoregressive process, and thus the estimates $\hat{u}_{i,t}$ are also biased. Even if residuals are measured precisely, the granular residuals constructed using the above procedure are less likely to be relevant instruments for corporate leverage. The reason is that firms are more likely to make financing decisions, mainly based on productivity changes instead of unexpected innovations to productivity. Notice that firms' decision rules in my model depend on the level of their productivity z rather than innovations.

3. Event Study

To obtain detrended series for event study in Figure 1.8, I regress the following variables of each six Eurozone countries (Italy, Spain, Portugal, Belgium, Finland, and France) on a common linear trend and get residuals, using the sample of the period 2007-2017. In the figure, I plot the cross-country average of each series over time.

- Output: log of annual gross domestic product (chain linked volumes, Eurostat)
- Investment: log of annual gross fixed capital formation (chain linked volumes, Eurostat)
- Consumption: log of the sum of the annual final consumption expenditure of households and general government (chain linked volumes, Eurostat), which is consistent with the model assumption that household utility depends on the sum of dividends, labor income, and government expenditure
- Government expenditure: log of the sum of the annual final consumption expenditure of general government (chain linked volumes, Eurostat)
- Tax revenue: log of total receipts from taxes and social contributions (Eurostat) where real tax revenue is calculated as nominal revenue divided by the GDP deflator (obtained from Eurostat)
- Productivity: log of total factor productivity of the total economy obtained from European Commission AMECO Database
- Corporate debt: annual average of quarterly total credit to non-financial corporations to GDP ratios (BIS total credit statistics)
- Government debt: annual average of quarterly total credit to the government sector at market value to GDP ratios (BIS total credit statistics)

- Corporate spread: annual average of monthly corporate spreads of Euro area non-financial corporate bonds (Euro area Bund NFC), using spread data obtained from Gilchrist and Mojon (2017)
- Government spread: annual average of the difference between a country's 10-year government bond rate and the 10-year German government bond rate where both bond rates are denominated in euro (daily, Bloomberg)
- Firm default rate: annual average of monthly speculative-grade non-financial corporate default rates of Europe obtained from "Moody's 1Q 2020 Asia-Pacific Default Report - Non-financial High-Yield Corporate Default Rates Data" (only the aggregate European default rate from 2008 to 2020 is publicly available in this report)

Appendix A of Chapter 1. Proof of Proposition 1

Consider the time after firms choose k_{t+1} together with b_{t+1} given B_{t+1} and before productivity z_{t+1} realizes. I show that the cumulative probability of the government revenue TR_{t+1} being equal the level of TR with low firm debt b^l_{t+1} is smaller than the one with high firm debt b^h_{t+1}, which means $H(TR|b^l_{t+1}) \leq H(TR|b^h_{t+1})$ for every TR. By the proposition 6.D.1 of Mas-Colell et al.(1995),[19] this statement is true if and only if the distrubution $H(TR|b^h_{t+1})$ first-order stochastically dominates $H(TR|b^l_{t+1})$, which means that the following equation holds:

$$\int U(TR)dH(TR|b^l_{t+1}) \geq \int U(TR)dH(TR|b^h_{t+1}) \tag{10}$$

for every nondecreasing function $U : \mathbb{R} \to \mathbb{R}$.

The government revenue decreases in firm debt b_{t+1} as follows:

$$\frac{\partial[TR_{t+1}]}{\partial b_{t+1}} = -\frac{\partial \mu(X_{t+1})}{\partial b_{t+1}} F(z_{t+1}, k_{t+1}) \leq 0 \tag{11}$$

for every z_{t+1}, where $\frac{\partial \mu(X_t)}{\partial b_t} \geq 0$ by the proposition 2.

This implies that $TR(z_{t+1}, b^l_{t+1}) = TR(z_{t+1}, b^h_{t+1}) + \epsilon(z_{t+1}, b^h_{t+1})$ for every z_{t+1} and any $\epsilon(z_{t+1}, b^h_{t+1}) \geq 0$.

Thus, I have $H(TR|b^l_{t+1}) \leq H(TR|b^h_{t+1})$ for every TR:

$$\begin{aligned} H(TR|b^l_{t+1}) &= P[TR(z_{t+1}, b^l_{t+1}) \leq TR] = P[TR(z_{t+1}, b^h_{t+1}) + \epsilon(z_{t+1}, b^h_{t+1}) \leq TR] \\ &= P[TR(z_{t+1}, b^h_{t+1}) \leq TR - \epsilon(z_{t+1}, b^h_{t+1})] = H(TR - \epsilon|b^h_{t+1}) \leq H(TR|b^h_{t+1}) \end{aligned} \tag{12}$$

Q.E.D.

[19] Mas-Colell, Andreu, Michael D. Whinston, and Jerry R. Green, *Microeconomic Theory*, Oxford University Press, 1995

Appendix B of Chapter 1. Proof of Proposition 2

I show $\frac{Q(z_t,k_{t+1},b_{t+1},B_{t+1})}{b_{t+1}} \leq 0$. From the government's optimization problem 1.22, the government default probability is given by

$$Pr[D(X_{t+1})=1] = \int_{\xi_{t+1}} D(X_{t+1},\xi_{t+1})d\Xi(\xi_{t+1}) = \\ Pr[\xi_{t+1} < V^g(0;X_{t+1}) - V^g(B_{t+1};X_{t+1}) = \bar{\xi}_{t+1}] = \Xi[\bar{\xi}_{t+1}] \tag{13}$$

where Ξ is the cumulative distribution function of *i.i.d.* government default costs.

If the threshold government default cost shock $\bar{\xi}$ increases in firm debt b such that $\frac{\partial\bar{\xi}_{t+1}}{\partial b_{t+1}} \geq 0$, then the goverment default probability increases in firm debt $\frac{\partial Pr[D(X_{t+1})=1]}{\partial b_{t+1}} \geq 0$, and in turn the government debt price Q decreases in firm debt according to the debt pricing equation:

$$Q(z_t,k_{t+1},b_{t+1},B_{t+1}) = \frac{1-\int_{z_{t+1}}\int_{\xi_{t+1}} D(X_{t+1},\xi_{t+1})d\Pi(z_{t+1}|z_t)d\Xi(\xi_{t+1})}{1+r} \\ = \frac{1-\int_{z_{t+1}} Pr[D(X_{t+1})=1]d\Pi(z_{t+1}|z_t)}{1+r} \tag{14}$$

To show $\frac{\partial\bar{\xi}}{\partial b} \geq 0$, first, I show that the government's value $V^g(B_{t+1};X_{t+1})$ is decreasing in firm debt b_{t+1}. The envelope condition implies that

$$\frac{\partial V^g(B_t;X_t)}{\partial b_t} = -\Big[\frac{\partial\mu(X_t)}{\partial b_t}\phi(e_t) + \big(1-\mu(X_t)\big)\lambda_t\Big]u'(C_t) \leq 0 \tag{15}$$

where I use $\frac{\partial\mu(X_t)}{\partial b_t} \geq 0$, $\phi(e_t) \geq 0$, $\lambda_t \geq 0$, and $u'(C_t) > 0$. $\frac{\partial\mu(X_t)}{\partial b_t} \geq 0$ follows from the relationship that the firms' value function is decreasing in firm debt as follows:

$$\frac{\partial V^f(k_t,b_t;X_t)}{\partial b_t} = -\phi_e(e_t) = -\lambda_t \leq 0 \tag{16}$$

where I use the firms' optimality condition (1.18) and $\lambda_t \geq 0$. Then, combined with (1.15), I have $\frac{\partial \bar{\nu}^d(X_t)}{\partial b_t} \leq 0$. This means $\frac{\partial d(X_t, \nu^d_{i,t})}{\partial b_t} \geq 0$ and $\frac{\partial \mu(X_t)}{\partial b_t} \geq 0$.

Next, I need to show the following:

$$\frac{\partial \bar{\xi}_{t+1}}{\partial b_{t+1}} = \frac{\partial V^g(0; X_{t+1})}{\partial b_{t+1}} - \frac{\partial V^g(B_{t+1}; X_{t+1})}{\partial b_{t+1}} \geq 0 \tag{17}$$

It can be shown that $u'(C_{t+1}|B_{t+1} \geq 0) \geq u'(C_{t+1}|B_{t+1} = 0)$ and that firm variables $\left[\frac{\partial \mu(X_t)}{\partial b_t}\phi(e_t) + \big(1 - \mu(X_t)\big)\lambda_t\right]$ in the equation (15) do not change with B_t, when firm values $V^f(k, b; X)$ are independent of government debt B. Thus, the above inequality holds.

Q.E.D.

Appendix C of Chapter 1. Proof of Proposition 3

The complete problem of the constrained social planner is as follows:

$$V^g(z, k, b, B) = \max_{e, k', b', B', D', C} \quad u(C) + \beta \mathbb{E} \max_{D'} \left\langle V^g(z', k', b', B'), V^g(z', k', b', 0) - \xi' \right\rangle$$

subject to

$$C = [1 - \mu(z, k, b)]\big(F(z, k) + (1 - \delta)k - k' - b + q(z, k', b')b' - \kappa(e - \bar{e})^2\big)$$
$$+ Q(z, k', b', B')B' - B \tag{SP1}$$

$$q(z, k', b') = \frac{1 - \int_{z'} \mu(z', k', b') d\Pi(z'|z)}{1 + r} \tag{SP2}$$

$$\mu(z', k', b') = \int_{\bar{\nu}^d(z', k', b')}^{\nu^d_{max}} d\Omega(\nu'^d_i) \tag{SP3}$$

$$Q(z, k', b', B') = \frac{1 - \int_{z'} \int_{\xi'} D(z', k', b', B', \xi') d\Pi(z'|z) d\Xi(\xi')}{1 + r} \tag{SP4}$$

Let's define a complete Ramsey problem. The Ramsey problem with debt taxes (τ^b), transfers to firms (T), and investment credits (τ^k) solves the following:

$$V^g(z,k,b,B) = \max_{\tau^b,T,\tau^k,B',D',G,C} \quad u(C) + \beta \mathbb{E} \max_{D'} \left\langle V^g(z',k',b',B'), V^g(z',k',b',0) - \xi' \right\rangle$$

$$\text{subject to} \quad e = (1-\tau^y)F(z,k) \tag{RP1}$$

$$+ (1-\delta)k - (1-\tau^k)k' - b + \big(q(z,k',b') - \tau^b\big)b' + T$$

$$C = s\big([1-\mu(z,k,b)]\phi(e) + p\big) - s'p + G \tag{RP2}$$

$$G + B = \big(1-\mu(z,k,b)\big)[\tau^y F(z,k) - \tau^k k' + \tau^b b' - T] \tag{RP3}$$

$$+ Q(z,k',b',B')B'$$

$$s = 1 \tag{RP4}$$

$$\lambda = \phi_e(e) \tag{RP5}$$

$$[1 - \tau_t^k - \frac{\partial q(z_t,k_{t+1},b_{t+1})}{\partial k_{t+1}} b_{t+1}]\lambda_t = \int_{z_{min}}^{z_{max}} \int_{\nu^d_{min}}^{\bar{\nu}^d(X_{t+1})} \tag{RP6}$$

$$\big[m(X_t,X_{t+1})\big((1-\tau^y_{t+1})F_k(z_{t+1},k_{t+1}) + (1-\delta)\big)\lambda_{t+1}\big] d\Omega(\nu^d_{i,t+1}) d\Pi(z_{t+1}|z_t)$$

$$\big(\frac{\partial[q(z_t,k_{t+1},b_{t+1})b_{t+1}]}{\partial b_{t+1}} - \tau^b_t\big)\lambda_t = \tag{RP7}$$

$$\int_{z_{min}}^{z_{max}} \int_{\nu^d_{min}}^{\bar{\nu}^d(X_{t+1})} \big[m(X_t,X_{t+1})\lambda_{t+1}\big] d\Omega(\nu^d_{i,t+1}) d\Pi(z_{t+1}|z_t)$$

$$q(z,k',b') = \frac{1 - \int_{z'} \mu(z',k',b') d\Pi(z'|z)}{1+r} \tag{RP8}$$

$$\mu(z',k',b') = \int_{\bar{\nu}^d(z',k',b')}^{\nu^d_{max}} d\Omega(\nu'^d_i) \tag{RP9}$$

$$Q(z,k',b',B') = \frac{1 - \int_{z'} \int_{\xi'} D(z',k',b',B',\xi') d\Pi(z'|z) d\Xi(\xi')}{1+r} \tag{RP10}$$

$$p(X,X') = \tag{RP11}$$

$$\int_{z_{min}}^{z_{max}} \int_{\xi_{min}}^{\xi_{max}} m(X,X')\big[[1-\mu(z',k',b')]\phi(e') + p(X',X'')\big] d\Pi(z'|z) d\Xi(\xi')$$

$$m(X,X') = \beta \frac{u'(C')}{u'(C)} \tag{RP12}$$

First, I prove that the allocations in the Ramsey problem satisfy the equations in the constrained social planner problem. Notice that the objective functions of these two problems are identical. Combining equations (RP1), (RP2), (RP3), and (RP4) leads to the social planner's resource constraint (SP1) with the definition of net dividends $\phi(e) = e - \kappa(e - \bar{e})^2$. Variables $\{\lambda, \tau^k, \tau^b, m\}$ can be set so that allocations satisfying the implementability constraints (RP5), (RP6), and (RP7) given the stochastic discount factor (RP12) are identical to allocations in the social planner problem. Implementability constraints (RP8), (RP9), and (RP10) are common to the problems of Ramsey and social planners. The remaining constraint (RP11) is satisfied by choosing p so that allocations in two problems are identical.

Next, I show that the allocations in the constrained social planner problem satisfy the equations in the Ramsey problem. The constrained-efficient allocations $\{e, k, b, B, D\}$ are set by the social planner, and C is determined by the resource constraint (SP1) and other implementability constraints. Variables $\{\lambda, \tau^k, \tau^b, m\}$ can be chosen to satisfy constraints (RP5), (RP6), and (RP7) given (RP12) after plugging constrained-efficient allocations into these constraints. Given $\{\tau^y, \tau^k, \tau^b\}$ and constrained-efficient allocations, (RP1) is satisfied by choosing a proper T. Given the stock market clearing condition (RP4) and the constrained efficient allocations including C, the government expenditure G can be chosen to satisfy (RP2). As constraints (SP1), (RP1), (RP2), and (RP4) are satisfied, combining these constraints gives the government bugdet contraint (RP3). The equation (RP11) is slack as p can be set freely given the constrained-efficient allocations. All remaining implementability constraints (RP8), (RP9), and (RP10) in the Ramsey problem are identical to those of the social planner problem.

The set of policies $\{\tau^b, T, \tau^k, B', D', G\}$ are functions of key state variables $X = \big\{z, k, b, B\big\}$, as they are solutions to the recursive equilibrium. policies are time-consistent since equilibrium policy functions are time-invariant. *Q.E.D.*

Appendix D of Chapter 1. Computational Details

To obtain the equilibria of the model, I adopt a discrete choice model with taste shocks following Dvorkin et al. (forthcoming). For the quantitative model, I add and modify the relevant ingredients of this model as described in section 1.5.1.

D1. Competitive Equilibrium

Consider the firm's maximization problem (1.11). I add taste shocks to the firm's value functions as follows:

$$\begin{aligned} V^f(z,k,b) =& \mathbb{E}_{\boldsymbol{\epsilon}} \max_{k',b'} \left[J^f(z,k,b,k',b') + \boldsymbol{\epsilon_{(k',b')}} \right] \qquad (18) \\ \text{where} \quad J^f(z,k,b,k',b') &= \phi(e) + \beta \int W^f(z',k',b') d\Pi(z'|z) \\ e &= (1-\tau^y)(1-\theta)F(z,k) + (1-\delta)k - k' - b + q(z,k',b')b' - \Psi(k,k') \\ \phi(e) &= e - \kappa(e-\bar{e})^2 \\ W^f(z',k',b') &= \mathbb{E}_{\boldsymbol{\epsilon'}} \max_{d'_i} \left\langle V^f(z',k',b') + \boldsymbol{\epsilon'_{i,repay}},\ \mu_{\nu^d} + \boldsymbol{\epsilon'_{i,default}} \right\rangle \end{aligned}$$

where taste shocks $\boldsymbol{\epsilon}$ are $i.i.d$ and distributed Gumbel (Extreme Value Type 1) with the variance of σ_ϵ. I use $\sigma_\epsilon = 0.001$.[20] Each taste shock is associated with the discrete choice of control variables. Average firms' defaulting value is given by μ_{ν^d} which corresponds to the mean parameter of firms' $i.i.d.$ enforcement shocks ν_i^d. These enforcement shocks are treated as $i.i.d.$ taste shocks $\boldsymbol{\epsilon_{i,default}} - \boldsymbol{\epsilon_{i,repay}}$ in actual computation for notational convenience. The number of grid points for the combination of firm capital and debt choices (k', b') is 275. Then, firms draw a vector of random variable $\boldsymbol{\epsilon_{(k',b')}}$ from the Gumbel distribution that assigns different values to each choice of (k', b'), and it will choose (k'^*, b'^*) which maximizes the *ex post* value. As is analogous to Chatterjee and Eyigungor (2012) who add small

[20] As σ_ϵ approaches zero, solutions become close to the original problem without taste shocks, but the algorithm becomes unstable.

shocks to output, taste shocks perturb value functions to improve the convergence property of the value function iteration method. To put it differently, taste shocks allow firms and the government to implement mixed strategies. With mixed strategies, it is easier for the algorithm to find a solution than pure strategies, since a mixed Nash Equilibrium always exists with a finite set of actions according to the Nash Theorem.

It can be shown that *ex ante* choice probabilities that firms will choose k'^* and b'^* conditional on state variables (z, k, b) are

$$P(k'^*, b'^*|z, k, b) = \frac{exp[J^f(z, k, b, k'^*, b'^*)/\sigma_\epsilon]}{\sum_{k',b'} exp[J^f(z, k, b, k', b')/\sigma_\epsilon]} \tag{19}$$

The firm value function is given by

$$V^f(z, k, b) = \sigma_\epsilon log\Big\langle \sum_{k',b'} exp[J^f(z, k, b, k', b')/\sigma_\epsilon]\Big\rangle \tag{20}$$

Other value functions and choice probabilities can be obtained in a similar fashion. Firms' default probability is given by

$$P(d = 1|z, k, b) = \frac{exp\big(\mu_{\nu^d}/\sigma_\epsilon\big)}{exp[V^f(z, k, b)/\sigma_\epsilon] + exp[\mu_{\nu^d}/\sigma_\epsilon]} \tag{21}$$

and the associated corporate bond price is

$$q(z, k', b') = \frac{1 - (1 - R^f)\int P(d' = 1|z', k', b')d\Pi(z'|z)}{1 + r} \tag{22}$$

Another firm value function is given by

$$W^f(z, k, b) = \sigma_\epsilon log\Big\langle exp[V^f(z, k, b)/\sigma_\epsilon] + exp[\mu_{\nu^d}/\sigma_\epsilon]\Big\rangle \tag{23}$$

Combined with relevant constraints (1.12), (1.13), (1.23), (1.24), and (1.25), the government problem (1.22) can be written compactly as

$$V^g(z,k,b,B) = \mathbb{E}_{\boldsymbol{\epsilon}} \max_{B'} \left[J^g(z,k,b,B,B') + \boldsymbol{\epsilon_{B'}} \right] \tag{24}$$

where $J^g(z,k,b,B,B') =$

$$\sum_{k',b'} P(k',b'|z,k,b)\big[u(C) + \beta_g \int \mathbb{E}_{\xi'} \max_{D'} \big\langle V^g(z',k',b',B'), V^g(z',k',b',0) - \xi' \big\rangle d\Pi(z'|z)\big]$$

$$C = (1-\mu(z,k,b))\big[(1-\theta)F(z,k) + (1-\delta)k - k' - b + q(z,k',b')b'$$
$$-\kappa(e-\bar{e})^2 - \Psi(k,k')\big] + Q(z,k',b',B')B' - B + \theta F(z,k)$$

Ex ante choice probabilities that the government will choose B'^* conditional on state variables (z,k,b,B) are

$$P(B'^*|z,k,b,B) = \frac{exp[J^g(z,k,b,B,B'^*)/\sigma_\epsilon]}{\sum_{B'} exp[J^g(z,k,b,B,B')/\sigma_\epsilon]} \tag{25}$$

The government value function is given by

$$V^g(z,k,b,B) = \sigma_\epsilon log \Big\langle \sum_{B'} exp[J^g(z,k,b,B,B')/\sigma_\epsilon] \Big\rangle \tag{26}$$

The cumulative distribution function (CDF) Ξ of government default costs ξ is a normal CDF with mean μ_ξ and standard deviation σ_ξ. Then, the government default probability is given by

$$P(D=1|z,k,b,B) = P\big(V^g(z,k,b,B) \leq V^g(z,k,b,0) - \xi\big) \tag{27}$$
$$= \Xi[V^g(z,k,b,0) - V^g(z,k,b,B)]$$

The government bond price can be expressed using the choice probability of the government default as below:

$$Q(z,k',b',B') = \int M(z',z)[1-(1-R^g)P(D=1|z',k',b',B')]d\Pi(z'|z) \tag{28}$$

I get value functions, choice probabilities, and bond price functions by implementing the standard value function iteration method on discrete grid points.[21]

1. Guess the firm value functions V^f and the firm bond price function q over the bounded grid points on z, k and b. I use the Tauchen method to discretize z with 5 grid points, and (11, 25) grid points are used for (k', b').

2. Given these guesses, update associated firm value functions using (18), (20) and (23), choice probabilities for firm capital k' and debt b' (19) and the probability of firm default d (20), and the firm bond price function (22).

3. Continue until distances between values in the previous iteration and those in the current iteration (using the maximum distance evaluated at each grid point) goes below 10^{-7} for V^f and q.

4. Guess the government value function V^g and the government bond price function Q over the bounded grid points on z, k, b and B. I use 25 grid points on B'.

5. Given the firm's choice probabilities (19) obtained in the firms' problem and new guesses, update associated government value functions using (24) and (26), choice probabilites for government borrowing B' (25) and the probability of government default (27), and the government bond price function (28).

6. Continue until distances between values in the previous iteration and those in the current iteration (using the maximum distance evaluated at each grid point) goes below 10^{-7} for V^g and Q.

[21] I solve the model using Julia version 1.4.0 with the QuantEcon package version 0.5.0 and 16 threads parallelization on the University of Maryland Economics cluster. Exponential terms are calculated using the Arbnumeric package that ensures accuracy and thread-safe parallelization without high memory usage.

D2. Constrained Efficient Equilibrium

The constrained social planner problem (1.36) can be written as

$$V^g(z,k,b,B) = \mathbb{E}_{\boldsymbol{\epsilon}} \max_{k',b',B'} \quad J^g(z,k,b,B,k',b',B') + \boldsymbol{\epsilon_{B'}} \tag{29}$$

where $\quad J^g(z,k,b,B,k',b',B') =$

$$u(C) + \beta_g \mathbb{E}_{z'|z,\xi'} \max_{D'} \left\langle V^g(z',k',b',B'), V^g(z',k',b',0) - \xi' \right\rangle$$

$$C = (1-\mu(z,k,b))\big[(1-\theta)F(z,k) + (1-\delta)k - k' - b + q(z,k',b')b'$$

$$-\kappa(e-\bar{e})^2 - \Psi(k,k')\big] + Q(z,k',b',B')B' - B + \theta F(z,k)$$

subject to

corporate default decision from (18), corporate and government bond prices (22) and (28)

It can be shown that *ex ante* choice probabilities that the planner will choose B'^* conditional on state variables (z,k,b) and choices of k' and b' are

$$P(B'^*|z,k,b,k',b') = \frac{exp[J^g(z,k,b,k',b',B'^*)/\sigma_\epsilon]}{\sum_{B'} exp[J^g(z,k,b,k',b',B')/\sigma_\epsilon]} \tag{30}$$

The government value function is given by

$$V^g(z,k,b,B) = \sigma_\epsilon log \Big\langle \sum_{B'} exp[J^g(z,k,b,k'^*,b'^*,B')/\sigma_\epsilon] \Big\rangle \tag{31}$$

where k'^* and b'^* are maximizers of the expected value function $\mathbb{E}_{\boldsymbol{\epsilon}}[J^g(z,k,b,B,k',b',B') + \boldsymbol{\epsilon_{B'}}]$. Solutions to this problem are obtained as in the competitive equilibrium.

Data Construction for Chapter 2

This section describes the construction of aggregate time-series data. We use dataset constructed by Avdjiev et al. (2018) (henceforth, AHKS) to obtain external assets and liabilities and external debt inflows, in which all measures break down into sectors (banks, corporates, and public sector), and the public sector consists of the government and the central bank. The counterparty sector and the currency type do not break down in AHKS. AHKS mainly follow the 6th Edition Balance of Payments Manual (BPM6) in constructing data. According to the BPM6, all liabilities and assets are measured at market values when it is possible. However, if it is not possible, nominal values are used. We use the sample period of 1996–2014 mainly due to data availability of the AHKS dataset. We collect all available data across countries and follow the AHKS country classification for choosing advanced and emerging market economies.

In **Figure 2.4, 2.5, 2.7, 2.8**, and **2.9**, we plot sectoral inflows, external assets and liabilities, and associated leverage (assets to liabilities ratio) measures, using AHKS database. To obtain aggregate debt inflows into each sector, first, we deflate debt inflows (billions USD) using the US consumer price index in 1996. Second, we calculate aggregate debt inflows into each sector in a given year as the sum of deflated debt inflows (billions 1996 USD) over the country group in a given year. To obtain aggregate external leverage by sector, we use external assets and liabilities. External positions are converted into US dollars by AHKS. We calculate external leverage of each sector in a given year as the sum of each sector's external liabilities over the country group in a given year divided by the sum of each sector's external assets over the country group in a given year.

In **Figure 2.5**, we use the average of bank credit to the private non-financial sector to GDP ratios over the country group in a given year as the measure of the private non-financial sector's leverage. Bank credit to GDP ratios are obtained from BIS credit statistics. Bank credit includes credit extended by domestic banks to the private non-financial sector.

The financial instruments covered comprise currency and deposits (which are mostly zero in the case of credit to the private non-financial sector), loans, and debt securities. The statistics follow the framework of the System of National Accounts 2008, which mandates that outstanding credit instruments be valued at market values when market prices are observable.

In **Figure 2.6**, we measure the foreign currency share of domestic banks' external liabilities and assets, using BIS locational banking statistics (LBS). We calculate the share of foreign currency liabilities as the sum of the liabilities in foreign currency across countries divided by the sum of total liabilities across countries. The share of foreign currency assets is calculated in the same fashion.

We illustrate how to download banks' stock measures of assets and liabilities from BIS LBS. Liabilities and assets include all balance sheet positions. Liabilities include interbank loans received, deposits from banks or nonbanks, and holdings of securities. Assets also include interbank deposits, loans, and advances to banks or nonbanks, and holdings of securities. We download data in the item called "A5, Location of reporting banks," which provides positions of reporting banks located in each country. **Table 2.2** shows the list of downloaded data. By the reporting conventions, claims are market values, while liabilities are nominal values in most cases.

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