Financing Corporate Growth*

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Abstract

Considerable research focuses on the aggregate impact of debt financing. We show that equity is empirically more important for firm growth than generally understood. An extra dollar of equity issuance is associated with an extra \$0.93 of real assets, whereas an extra dollar of debt issuance is associated with an extra \$0.14 of real assets. Firms issue equity first, then increase real assets, and finally issue debt while repurchasing equity. We explain this sequence using a model in which debt is tax preferred relative to equity but is subject to limited commitment. In the model, firms initially issue equity to finance investments. After they obtain assets that can be pledged to lenders, firms substitute debt for equity to benefit from interest tax deductions. We estimate the model and use it to evaluate the effect of several government policies on corporate growth through their impact on the sources of financing.

Key Words: corporate growth, investment, debt, equity financing, government policy.
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1 Introduction

As a result of the Great Recession economists have paid considerable attention to the aggregate implications of credit supply and debt financing constraints; see Gertler and Kiyotaki (2010), Mian, Rao, and Sufi (2013), Chodorow-Reich (2013), Giroud and Mueller (2017), Gertler and Gilchrist (2018), and Mian and Sufi (2018), among many others. Although Fama and French (2005) document that firms frequently issue equity, the role of external equity has not received comparable attention, and the general consensus is that equity does not play an important role in the aggregate (see, e.g., Eisfeldt and Shi, 2018). We show that external equity financing actually does play a key role in corporate asset growth, both in the aggregate and at the firm level. Equity issues tend to precede real asset accumulation, which in turn is followed by both debt accumulation and equity repurchases. We then show that this observed dynamic process emerges naturally from a model in which debt financing is tax preferred but requires collateral, but equity financing which is not as tax efficient does not require collateral.

This paper has three purposes. First, we provide novel evidence documenting the importance of equity in corporate growth, as well as the typical sequencing of financing actions. Second, we show that a simple model readily accounts for this characteristic dynamic process in an integrated way based on limited enforcement of debt contracts and taxation. Third, we use the model to study an actual policy change in 1996, as well as two commonly proposed policy changes, which affect different aspects of firms' debt and equity financing.

First we document the relation between firms' financing and asset growth in the data. The empirical analysis starts with a decomposition of the firm's flow budget constraint to show the contemporaneous connections. External financing, particularly equity issuance, shows up as a key factor for firm growth. In aggregate US data, the correlation between equity issuance and real asset growth is strongly positive at 0.39. The correlation between net debt issuance and real asset growth is 0.16. The correlation between operating income and real asset growth is just 0.10.

To study the contribution of the various components of firm financing to asset growth, we employ a modified Blinder-Oaxaca decomposition, following Mueller and Yannelis (2019).

Using aggregate US data, we find that an extra dollar of equity issuance is associated with an extra \$0.93 of real assets, but an extra dollar of net debt issuance is associated with an extra \$0.14 of real assets. Very similar results are found in several other countries for which we could get the necessary data, these are Australia, Canada, France, Germany, Korea, and the UK.

To document the empirical dynamics, we start with raw correlations between asset growth and leads and lags of the financing variables. These measures provide unconditional evidence of the time sequencing: first equity increases, then real assets grow, and finally debt rises as equity is repurchased. Up to this point, our tests are based on bivariate relations between the variables; however, these variables interact because they are jointly determined in equilibrium. We use the US aggregate data and estimate a vector autoregression (VAR) model that allows for interactions between asset growth and the three financing variables (i.e., equity issuance, debt issuance, and internal profits). Using the VAR model, the follow-up Granger causality tests, and impulse response functions, we show that the financing-growth sequence is statistically significant and robust to the inclusion of other factors.

Using aggregate data has the benefit of including all private and public firms. However, the aggregation process could be a source of concern. The aggregate tests cannot identify whether the specific firms that raise equity are the same firms that subsequently increase assets, then raise debt and repurchasing equity. To address this concern we study the publicly traded firms in Compustat. This permits us to track individual firms, but it does not include private firms. All of the main results hold when firm-level data is used in asset growth decompositions, lead and lag correlations, and a panel VAR model.

Second, we show that these novel facts are easy to interpret using reasonably standard theory. We use a modified version of the representative firm general equilibrium model of Jermann and Quadrini (2012). In the model, debt financing is desirable because of the interest tax advantage, but debt contracts have limited enforcement. This implies that in order to use debt financing, a firm must have a sufficient amount of pledgeable assets. Without enough of these assets, new debt may be hard to obtain. So, in response to investment opportunities, equity is used first despite its greater expense. The money obtained by issuing equity is used to buy physical assets. Once those assets have been obtained, the firm has

collateral. At that point, the firm issues the tax-preferred debt and increases payouts to equity investors.

We estimate the model using the simulated method of moments and show that it fits many aspects of the data very well. This includes several moments that are not targeted in the estimation, such as the correlations between asset growth and the sources of financing documented in the empirical analysis. In the estimated model, the initial effect of a positive productivity shock is to have negative equity payouts (i.e., issuing equity) in order to build up the stock of capital to take advantage of enhanced productivity. At this point, the firm cannot use enough debt financing because it does not yet have the assets in place. So it uses cash flow aggressively to increase inputs. From the second period after the shock onward, these actions reverse as the increased capital stock relaxes the collateral constraint. So, after the shock is realized and the new assets are in place, the firm substitutes between the sources of financing by issuing debt and repurchasing equity.

We also study a heterogeneous firm version of the model. We do this because the representative firm version of the model has a drawback. A positive shock to productivity in addition to making firm investment more attractive, also makes the investors wealthier. They want to consume more. That consumption must be paid for somehow. If there is only one firm in the model, that extra consumption is supported by reducing corporate debt. Adding another firm that does not have the same shocks, the investor can get the extra resources from the less productive firm. When calibrated, this extended version of the model still generates the key empirical dynamics, and it improves the corporate debt moments. Why not use the replace the representative firm model entirely? The heterogeneous firm version of the model is more complex, and heterogeneity is not the key driving force for the dynamic that is our primary focus. By having both representative firm and heterogenous firm versions, it is easier to see what really depends on firm heterogeneity per se. In both versions of the model the key force is getting resources to where they are productive, and doing so in a tax and collateral efficient manner.

Third, because the model matches the data reasonably, we use the model to consider the effects on a number of government policies. The first policy we consider is the 1996 National Securities Markets Improvement Act (NSMIA), which made it easier to issue private equity.

Ewens and Farre-Mensa (2018) show that this law played a role in the rise of private equity financing relative to more traditional public equity offerings. Consistent with the idea that the NSMIA facilitated equity financing, we find that the relation between equity financing and asset growth is stronger post-1996. After 1996 the same sequencing of firm actions takes place but the correlations among variables are almost twice as large compared with the earlier years.

We estimate the model using the pre- and post-1996 subsamples separately and find that the estimated cost of issuing equity is indeed lower in the post-1996 period. This finding implies that the NSMIA may have contributed to reducing institutional rigidities and equity financing frictions. According to the model, in the post-1996 period, firms issue more equity and increase capital and labor input more aggressively in response to positive productivity shocks.

The second policy we consider is a limit on the use of corporate debt. Corporate debt has long been a source of considerable concern among economic policy makers at both the national and international level; see Sutherland and Hoeller (2012), International Monetary Fund (2016), and Derby (2019). Countries are frequently advised by bodies such the International Monetary Fund (IMF) or the Bank for International Settlements (BIS) to adopt policies that induce firms to scale back their use of debt.

We examine the quantitative implications of a policy that imposes an exogenous upper bound limit on corporate debt. The debt limit is set at 50% of the equilibrium level of debt in an unconstrained economy. The qualitative results are robust to alternative levels of the debt limit. The firm is hit with a transitory productivity shock. Both the steady state and the impulse responses are studied. The model with the extra government policy constraint is compared to the baseline model without this extra constraint.

The main effect of the extra policy constraint is on the steady state. Under the policy limiting debt, the payout rate increases. Accordingly, there is less reinvestment of profits. The effect of this policy is to shrink the size of the economy by 16.6%, as measured by its impact on capital stock in the long run. Household consumption is reduced by 2.4%. Firms' responses to productivity shocks are in the same direction as in the benchmark case, but the policy serves to dampen the firms' response to a positive productivity shock.

The third policy we consider is a limit on share buybacks. Policy makers have periodically advocated policies of this type. In 2018, Commissioner Robert Jackson Jr. of the Securities and Exchange Commission (SEC) called for limits on stock buybacks, see Jackson Jr. (2018). In 2019, US Senators Chuck Schumer and Bernie Sanders advocated such limits, see Schumer and Sanders (2019). Senator Marco Rubio made a closely related proposal. The key idea is that a policy limiting equity buyback will prevent firms from transferring excess funds to shareholders. Accordingly they say, firms will use the now retained funds to increase capital investment and increase wages (Dharmapala, Foley, and Forbes, 2011) and perhaps reduce stock price manipulation (Lee, Mikkelson, and Partch, 1992; Babenko, Tserlukevich, and Vedrashko, 2012).

Motivated by these proposals, we use the model to consider a policy that imposes a modest limit on net payouts and we compare it to the benchmark model. The limit is set slightly above the steady state buybacks (105%) in the unconstrained benchmark economy. In the benchmark model, when a positive productivity shock arrives the firm initially issues equity. But under a policy that restricts equity buybacks, investors are reluctant to provide the extra equity. To some degree limited extra debt issues may take place, but they remain sharply limited by the need for extra collateral. So it takes an extended period of time for the firm to acquire enough resources internally to exploit the transitory opportunity.

Under this policy constraint the main effect is that the economy is much more sluggish in response to opportunities. If the economy commonly experiences transitory investment opportunities, many of them might be largely wasted. Overall, compare an economy with this policy restricting share buybacks, to the benchmark economy without the restriction. Consider the same shock applied to both economies. In the restricted economy consumption, labor input, wages, and capital stock have lower peaks, and therefore the cumulative increase in consumption, investment, and labor services is lower.

Related literature. We contribute to the literature documenting the positive effect of well-functioning financial markets on asset growth and productivity; see, e.g., King and Levine (1993a), King and Levine (1993b), Demirgüç-Kunt and Maksimovic (1998), and Rajan and Zingales (1998). Also, our highlighting of the role of equity financing has implications for the old debate over whether equity markets are unimportant for economic growth; see

Morck, Shleifer, and Vishny (1990). In our model, equity is certainly not a sideshow; it is key to real asset accumulation. But the benefit is in terms of financing investments, not in terms of information production, which is stressed by Bond, Edmans, and Goldstein (2012). Our findings are consistent with the results of Levine and Zervos (1998), who show that stock markets play an important role in capital accumulation and growth by providing services different from banks. Gonzalez-Uribe and Paravisini (2019) study the impact of a tax relief program that subsidized equity investment in young UK firms between 2009 and 2014. Broadly consistent with our findings, they show that young UK firms that raised subsidized external equity invested much more than firms that did not benefit from the program.

Our main finding about the financing-growth sequence—in which the firm starts with equity issuance, then adds assets, and finally ends up with adding debt and repurchasing equity—is consistent with Demirgüç-Kunt and Levine (1996), who find that in the long run, better equity financing tends to increase the quantity of debt in the economy. Also consistent with the financing-growth sequence, Frank and Shen (2019) find that at the firm level, major stock sales are typically followed by an increase in financial leverage in the next few years, whereas major stock repurchases occur concurrently with a rise in leverage. Fama and French (2005) find that unprofitable fast-growing firms typically issue equity, consistent with our findings. They focus on the implications of this fact for the relative merits of the pecking order theory and the tax-bankruptcy trade-off theory of capital structure, and conclude that neither theory is satisfactory. They do not consider the type of model we present.

We set up the model by adding financial frictions to a standard real business cycle model. The first friction is limited enforceability of debt contracts. In this regard, our model shares some similarities with the models of Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Albuquerque and Hopenhayn (2004), Rampini and Viswanathan (2013), and Li, Whited, and Wu (2016). An important difference between these models and the model studied here is that we allow firms to raise external equity. Our formulation of the borrowing constraint is more similar to Jermann and Quadrini (2012). The only difference is that we set the financial shock in their model to be constant and treat it as a parameter that determines the tightness of the borrowing constraint. This approach decreases the volatility of the debt-to-assets ratio in our model but does not affect the main economic mechanism

that explains our empirical findings. We confirm that our qualitative results are robust to the reintroduction of the financial shocks.

The second friction is the costly adjustment of net payouts that captures both dividend smoothing (Lintner, 1956; Brav, Graham, Harvey, and Michaely, 2005; DeAngelo, DeAngelo, and Skinner, 2009) and equity issuance costs (Altinkilic and Hansen, 2000; Hennessy and Whited, 2007). According to Dittmar (2000), firms repurchase shares for a number of reasons, the primary motive being to take advantage of undervalued shares. A careful review of a wide range of managerial motives for buybacks is provided by DeAngelo et al. (2009).

The external financing costs and financing frictions are shown to be important determinants of firms' financial and investment decisions (Gomes, 2001; Cooley and Quadrini, 2001; Leary and Roberts, 2005) and stock returns (Gomes, Yaron, and Zhang, 2006). Our model also shares this characteristic with DeAngelo, DeAngelo, and Whited (2011), who focus on debt financing and show that in the presence of high costs of external equity and high volatility of investment opportunities, firms preserve debt capacity and use it to finance rare investment spikes. However, consistent with our findings, their model predicts that in periods of normal investment—which covers about 96% of investments—the firm's average equity issuance is more than twice the size of its average debt issuance.

Businesses have used significant amounts of debt financing for centuries. The concern that their use of debt financing might be dangerous for both businesses and the economy is also very old; see Fisher (1933), Bernanke and Gertler (1989), and Bernanke, Campbell, and Whited (1990). As a result of the Great Recession, economists have shown renewed interest in debt and financial constraints; see, for example, Buera and Moll (2015), López-Salido, Stein, and Zakrajšek (2017), and Arellano, Bai, and Kehoe (2018). Mian and Sufi (2018) and Gertler and Gilchrist (2018) provide very helpful overviews of that large literature.

A key concern about corporate debt is the idea of "debt overhang" as in Myers (1977), Lamont (1995), and Diamond and He (2014), among others. The idea is that high debt levels reduce managers' incentives to invest. This is because equity holders bear the costs of investments, but in some states of the world, only debt holders will receive the benefits. So, high debt levels are associated with low investment. The evidence is broadly consistent with this perspective. For example, Lorenzoni (2008) shows that excessive borrowing can arise in

a rational equilibrium and is associated with an excessive contraction in investment and asset prices if a crisis occurs. Giroud and Mueller (2017) show that establishments belonging to highly levered firms reduced employment more than others during the Great Recession, and Giroud and Mueller (2018) find that buildups in regional firm leverage predict a subsequent drop in aggregate regional employment.

In our model, firms increase debt as they reduce investment. This result may seem similar to debt overhang, but the mechanism is quite different. Suppose we observe that investment is reduced relative to the immediate past. This might be because a positive productivity shock is returning to the long-run normal. As this happens, debt is increasing relative to the immediate past because the firm is using the newly acquired real assets to obtain lower-cost debt financing. Therefore, debt is not causing a reduction in investment. The empirical implications of this pattern in the model are consistent with the negative relation between capital expenditure and leverage, as studied by Purnanandam and Rajan (2016).

The idea that debt might be helpful for production is also intuitive if the debt proceeds are being used to support good projects; see Jayaratne and Strahan (1996) and Dinlersoz, Kalemli-Ozcan, Hyatt, and Penciakova (2018). The persistence of debt financing over the centuries suggests that it must have some benefits, at least under some conditions. The novelty in our empirical contribution is showing the distinctive sequential structure of the use of external debt and equity, as well as the interpretation in terms of collateral and taxes.

Outline. The rest of this paper is organized as follows. Section 2 describes the data. Section 3 documents our main empirical findings on the relation between sources of financing and corporate growth. Section 4 introduces a model of aggregate corporate growth and financing to help us understand and rationalize the empirical results. Section 5 provides the quantitative analysis of the model. Section 6 analyzes three policy experiments and their implications. Section 8 concludes.

2 Data

We compile two main data sets to conduct different parts of the main analysis: aggregate data on US businesses and firm-level data on US publicly traded firms. A complementary

analysis in Appendix B uses aggregate data on the business sector in OECD countries, details of which are provided in that appendix.

Our baseline analysis uses the Financial Accounts of the United States issued by the Federal Reserve Board. This data set includes the Flow of Funds, Balance Sheets, and Integrated Macroeconomic Accounts for all sectors of the US economy from 1946 to 2017. We focus on two sectors, Non-financial Corporate Businesses and Non-financial Non-corporate Businesses, and create our main variables for the combined non-financial business sector. We complement this data set with the time series for price indexes from the US Bureau of Economic Analysis and the risk-free (three-month Treasury bill) interest rates from the FRED database at the Federal Reserve Bank of St. Louis.

The main variables of interest are non-financial assets, net debt, equity, operating income, net debt and net equity issuance, dividends, net interest paid, depreciation, and taxes. We use the price indexes to deflate all of the variables to reflect the real values in 2009 US dollars. Table A.1 in Appendix A provides variable definitions and details on the construction of the US aggregate variables.

Note that in the baseline case, we treat financial assets as negative debt. Therefore, the baseline variables include non-financial assets and net debt, which is defined as total liabilities net of financial assets. We made this choice to create a direct connection between the data and the model and for a more straightforward model estimation. However, we confirm that all of our qualitative results remain the same if we alternatively use total assets—defined as financial plus non-financial assets—and debt—defined as total liabilities—as the main variables.

Problem w/ fof Rev

We replace a few missing observations by linear extrapolation. These include 2017 values for dividends paid, interest paid, and interest received for both non-financial corporate and non-corporate businesses; 1946 and 1947 values for compensation; and 1946 to 1958 values for gross value added, interest paid, interest received, and net of production taxes for only non-financial, non-corporate businesses.

The firm-level data come from the CRSP-Compustat merged data set that covers publicly traded US firms from 1950 to 2017. We require the firms to have the US dollar as their native currency code and drop observations if non-financial assets are below $1 million. We

also drop highly regulated financial (SIC 6000-6799), utilities (SIC 4000-4999), and public administration (SIC 9100-9999) sectors from the firm-level tests. All raw firm-level variables are winsorized at 1% on both tails to prevent potential biases from outliers and misrecorded data. Table A.2 in Appendix A provides definitions and details on the construction of US firm-level variables.

The literature studying the business cycle characteristics of financing decisions debates the potentially outsized impact of merger activity on the aggregate series in the United States; see Covas and Den Haan (2011). Three points alleviate this concern for us. First, using firm-level data, we find that merger and acquisitions account for only about 15% of the total investment of public firms. Second, firms finance mergers using a variety of financing methods, such as cash, equity, debt, and so on, and no particular method dominates (Andrade, Mitchell, and Stafford, 2001). Third, our key qualitative results remain the same when we use firm-level data, as discussed in section 3.4.

3 Financing corporate asset growth

We analyze a firm's budget constraint to relate corporate asset growth to sources of financing. Conventionally, sources of funds are divided into internally generated funds or external financing, which is equity and debt. Funds are typically used for investments, taxes, and servicing the external sources through dividend and interest payments. The firm's flow budget constraint at time t shows that cash coming in (the left-hand side) equals cash going out (the right-hand side):

$$\underbrace{Y_t}_{\substack{\text{operating}\\\text{income}}} + \underbrace{p_t(S_{t+1} - S_t)}_{\text{net equity issuance}} + \underbrace{B_{t+1} - B_t}_{\text{net debt issuance}} = \underbrace{A_{t+1} - (1-\delta)A_t}_{\text{investment}} + \underbrace{D_t}_{\text{dividends}} + \underbrace{r_t B_t}_{\text{interest}} + \underbrace{T_t}_{\text{taxes}}. \quad (1)$$

On the left-hand side, internally generated operating income Y_t is measured as total revenue minus input and operational costs. The firm starts the period with S_t number of shares, and the price of equity is p_t. After making equity issuance decisions, the firm ends period t with S_{t+1} shares. In practice, net equity issuance $p_t(S_{t+1} - S_t)$ can be positive (issuance) or negative (repurchase). Similarly, the firm starts period t with net debt liability

B_t and, after carrying out its debt policy, ends the period with B_{t+1}. Net debt issuance $B_{t+1} - B_t$ can also be positive (issuing bonds) or negative (repurchasing or maturing bonds). As mentioned earlier, throughout the paper we study net debt, which is defined as total liabilities net of financial assets. We confirm that all of our results are robust to using pure debt measures. For more details, see Section 2.

On the right-hand side, capital investment in period t is the difference between the firm's assets at the beginning of next period A_{t+1} and depreciated assets this period $(1-\delta)A_t$, where $0 < \delta < 1$ is the depreciation rate. Throughout the paper, we refer to non-financial assets simply as "assets" for brevity. The firm pays dividends D_t to shareholders, interest $r_t B_t$ to debt holders, where r_t is the interest rate, and taxes T_t to the government. Appendix A provides variable definitions for both the aggregate and the firm-level samples.

Define asset growth during period t as $\Delta A_{t+1} = A_{t+1} - A_t$, net debt issuance as $\Delta B_{t+1} = B_{t+1} - B_t$, and net equity issuance as $\Delta E_{t+1} = p_t(S_{t+1} - S_t)$. Then rearranging equation 1 and normalizing it by assets, we have the asset growth decomposition equation,

Holds in the data?

$$\frac{\Delta A_{t+1}}{A_t} = \frac{Y_t}{A_t} + \frac{\Delta E_{t+1}}{A_t} + \frac{\Delta B_{t+1}}{A_t} - \frac{D_t}{A_t} - \frac{r_t B_t}{A_t} - \delta - \frac{T_t}{A_t}. \tag{2}$$

Equation 2 shows how asset growth is related to the rest of the budget. Asset growth is positively related to internally generated funds, net equity issues, and net debt issues. It is negatively related to depreciation, taxes, interest payments, and dividend payments.

Table 1 shows the summary statistics of the elements of the budget constraint and the asset growth decomposition for the US aggregate sample. During our sample period, assets of the US non-financial business sector have been growing almost every year, except for a few recession years. Assets grow from about \$3.2 trillion in 1946 to about \$24.7 trillion in 2017, a 3% annual growth rate. All values are in 2009 US dollars.

Contradiction w/ what follows?

Regarding the sources of financing, aggregate operating income steadily grows from \$0.9 trillion in 1946 to \$5.5 trillion in 2017, and average profitability is 22.5%, as measured by the ratio of operating income to assets. The American non-financial businesses on average issue \$172.9 billion in net debt (1.5% of assets) and repurchase \$95 billion in equity (0.4% of assets) every year, although there is a lot of volatility from year to year.

[Table 1 around here]

Table 2 shows pairwise correlations among the elements of the asset growth decomposition. The asset growth rate is positively correlated with all three sources of finance, although its correlation with the ratio of equity issuance to assets (0.39) is much stronger than with the ratios of net debt issuance to assets (0.16) and operating income to assets (0.10). Among the sources of financing, the ratios of equity issuance and operating income to assets are positively correlated. However, both are negatively correlated with the net debt issuance ratio, as if there is a substitution between net debt and the other two sources of financing.

[Table 2 around here]

3.1 Correlations with leads and lags

We start our analysis by providing a more detailed description of the correlation structure among the key variables in the growth decomposition, that is, the asset growth rate and the ratios of equity issuance, debt issuance, and operating income to assets. Figure 1 presents cross-correlations between elements of the decomposition equations. These graphs are based on aggregate US data and are informative about the sequence of the flow of resources in the economy. Each graph shows correlations of a variable at $t = 0$ with up to five leads and lags of a second variable $t = -5, ..., +5$.

Figure 1(a) shows that asset growth has a significant positive correlation of about 50% with the first two *lags* of equity issuance. This means that US businesses typically raise equity prior to asset growth. In contrast, Figure 1(b) shows that asset growth has a high correlation with the first two *leads* of net debt issuance. This means that firms typically issue debt subsequent to asset growth. Figure 1(c) shows that debt issuance has a significantly negative correlation with subsequent equity issuance, resembling a substitution between debt and equity, in that firms issue debt to finance subsequent equity repurchases. Figure 1(d) suggests that asset growth is not strongly related to internally generated operating income, as opposed to the external sources of funds.

When we put the pieces together, the results show a clear time sequencing between asset growth and the sources of financing. A typical US firm first raises funds by issuing equity.

Then it uses the funds for investments in assets. After it has the assets in place, the firm issues debt, a process resembling a collateral effect. Finally, it uses the debt proceeds for payouts to the shareholders who financed the firm in the first place.

[Figure 1 around here]

what is this?

3.2 Decomposing financing in aggregate data

In this section, we study the contribution of various sources of financing to asset growth by employing the popular approach of Blinder (1973) and Oaxaca (1973), as modified by Mueller and Yannelis (2019). We estimate a univariate regression of the annual percentage asset growth, $\Delta \log(\text{Assets})$, on the percentage growth in equity, $\Delta \log(\text{Equity})$, percentage growth in debt, $\Delta \log(\text{Debt})$, or aggregate profitability log(1+operating income/assets). We complement these results by estimating multivariate versions of the regressions.

negative?

Table 3 shows the results. The estimated coefficients are the sensitivity of asset growth with respect to changes in the sources of financing. First, consider columns 1 to 3. The estimated coefficients suggest that only equity growth significantly contributes to asset growth. According to the estimates, a 1% increase in equity is associated with a statistically significant 0.81% increase in assets. A 1% increase in net debt and operating profits, however, are associated with 0.05% and 0.14% increase in assets, respectively, but the estimates are not statistically significant. In column 4, we regress percentage asset growth on the main sources of financing simultaneously. Column 5 includes all of the other variables that are related asset growth according to the asset growth decomposition (Equation 2). The multivariate versions of the decomposition in columns 4 and 5 confirm our main finding that asset growth is most significantly associated with equity growth, both economically and statistically.

These results can be used to estimate the magnitude of the relations in dollar terms. A 1% increase in equity equals an average increase of \$99.113 billion in equity, since the average aggregate equity in our sample is \$9,911.3 billion (see Table 1). Combine this with the estimation results in columns 1 to 3 of Table 3. A 0.81% growth in assets equals a \$91.681 billion increase in assets (i.e., $0.0081 \times 11{,}346.6$). Therefore, the Table 3 estimates suggest that an extra dollar of equity issuance is associated with an extra \$0.93 of real assets.

Following the same procedure for debt suggests that an extra dollar of net debt issuance is associated with an extra \$0.14 of real assets.

We repeat the decomposition exercise using a measure of debt growth (instead of net debt growth) and confirm that the main findings are not driven by the subtraction of financial assets from liabilities. Columns 6 to 8 of Table 3 show the results. We estimate that debt growth has a stronger association with the growth of assets than does net debt growth. However, asset growth is still close to three times more sensitive to equity growth than to debt growth. For instance, column 7 estimates suggest that a 1% increase in equity is associated with 0.78% growth in assets whereas a 1% increase in debt is associated with 0.27% growth in assets.

[Table 3 around here]

Robustness tests using aggregate data. We extend the study of the contribution of different sources of financing to asset growth along several dimension. We summarize the main findings below and provide the full results and discussions in Appendix B. A complementary set of robustness tests that use firm level data are discussed in Section 3.4.

We study the contribution of the sources of financing to asset growth in several other countries for which we could get the necessary data (Australia, Canada, France, Germany, Korea, and the UK) and find that equity financing plays a primary role for asset growth in those samples as well. In the international sample, a 1% increase in equity is associated with a 0.34% increase in assets, whereas a 1% increase in net debt is associated with only 0.04% more assets. However, for firms in these countries, internally generated operating profit plays a stronger role than it does for US firms. This finding is consistent with La Porta, Lopez-de Silanes, Shleifer, and Vishny (1997), Demirgüç-Kunt and Maksimovic (1998), and Rajan and Zingales (1998), who show that the differences in legal and financial systems affect firms' access to financing and the choice of external financing. Appendix B.1 provides more details.

Aggregate data often exhibit trends so they are usually detrended in macroeconomic studies. Our main variables are in the form of ratios or percentage growth and do not show significant trends over time. Nonetheless, to ensure that our main findings are not generated by time trends, we re-estimate the asset decomposition regressions using detrended data.

Appendix B.2 shows the details of detrending data and estimation results. The results are very similar to those of the baseline tests, showing a prominent role for equity financing in asset growth. Table B.5 results show that a 1% increase in equity is associated with 0.63% growth in assets whereas a 1% increase in net debt (pure debt) and profitability are associated with 0.02% (0.22%) and 0.08% growth in assets, respectively.

We also examine the effect of business cycles on the contribution of different sources of financing to corporate asset growth. This test is motivated by the literature on firm financing over the business cycle that documents procyclical debt issuance and countercyclical equity issuance at the aggregate level (e.g., Jermann and Quadrini, 2006). The cyclicality of equity issuance, however, varies with size: small firms have procyclical equity financing, whereas large firms have countercyclical equity issuance (Covas and Den Haan, 2011; Begenau and Salomao, 2018). We find that, during recessions, asset growth is much more strongly tied to equity growth, both compared with its tie to equity growth during normal times and with its tie to other sources of financing. These results are consistent with Jermann and Quadrini (2006). See more details in Appendix B.3.

3.3 Multivariate analysis

So far, our analysis has focused on the bivariate relations between corporate growth and the sources of financing. However, the sources of financing interact with each other as they are jointly determined in equilibrium. An example of these connections is Figure 1(c), which shows the relation between debt and equity issuances. To allow for the interactions among these features, we estimate a VAR model. The VAR model includes up to three lags of the main variables: the asset growth rate and the ratios of equity issuance, net debt issuance, and operating income to assets. We also estimate VAR models with two and four lags of the variables to confirm the robustness of the main results to the number of lags. We test and confirm the stability of the VAR estimations and provide the stability results in the Online Appendix.

Panel A of Table 4 shows the VAR estimations. The results are generally consistent with the financing-growth sequence: funds flow to the firm via equity, then assets grow, and finally debt issuance increases, which in turn is followed by equity repurchases. Each

column shows the estimation results for one equation of the VAR system, which is estimated simultaneously. Column 1 shows that asset growth is positively related to equity issuance in the past two years. Past operating income and debt issuance activity do not affect asset growth. Column 2 shows that asset growth in the past two years positively predicts debt issuance, resembling a collateral channel through which firms pledge available assets to borrow. Column 3 completes the cycle by showing that past asset growth (second lag) and debt issuance (first lag) negatively predict equity issuance. That is, following asset growth and debt issuance, firms repurchase equity, which transfers funds back to the shareholders.

We use the estimated VAR model to conduct Granger causality tests to formally investigate the "predictive causality" between these variables. It is well known that Granger causality may not be the same as true causality. It is, however, informative about the time series relationships among the variables when interactions are permitted. Panel B of Table 4 presents the results. This panel consists of four blocks that are derived from the four VAR equations, respectively. Each block shows p-values for the Wald tests of the hypothesis that 'the dependent variable is *not* Granger caused by each of the other variables.' Overall, the results are consistent with the VAR discussion above and are supportive of the financing-growth sequence.

[Table 4 around here]

Both cross-correlations functions and Granger causality tests make statements about temporal ordering without imposing prior restrictions on the sequence of impacts among variables. To go further, we have to assume a recursive order on the random shocks to the variables. However, this type of assumption is not innocuous. The interpretation of the relationships among the variables is affected significantly by the ordering chosen. As a result, this approach is most appropriate when there are sound theoretical reasons for choosing one ordering over another.

We impose the financing-growth sequence discussed above and generate impulse response functions (IRF) using the VAR estimations. At least two reasons justify the imposed ordering. First, the cross-correlations and the Granger causality tests suggest (but do not mandate) this ordering. Second, we show later that the model in Section 4 provides theo-

retical support for this ordering of variables. Under a set of estimated parameters based on the US data, the model confirms this ordering in a controlled environment. Moreover, when we impose alternative orderings, the generated IRFs are not consistent with this ordering of variables.

IRFs use the VAR estimates to forecast the way a shock to one variable affects the other variables in the model. Figure 2 shows the impact of a 1% increase in each source of financing on asset growth over a five-year horizon following the shock. The IRF plots confirm our previous findings. Figure 2(a) shows that a 1% equity issuance leads to about a 1.3% increase in assets after two years. On the other hand, Figures 2(b) and 2(c) show that debt issuance and increases in internal income do not lead to asset growth. In the Online Appendix we plot the rest of the IRFs.

Note that we limit the VAR analysis only to the aggregate US sample for the following reasons. For the non-US sample, as mentioned before, the length of the time series is too small. Depending on the number of lags in the model, we end up with about 20 observations to estimate the VAR system, which is less than ideal. Later in the paper we estimate a panel VAR using firm-level US data and show that our main findings hold in that setting too.

[Figure 2 around here]

3.4 Decomposing financing in firm data

Use aggregated Compustat data

The results based on aggregate data suggests a clear sequential ordering of financing and asset growth in the business sector. Although the aggregate data have the benefit of including private businesses, there is a caveat concerning the aggregation process. The aggregate tests cannot identify whether the firms that issue equity are the same firms that subsequently invest, raise debt, and repurchase equity. To address this issue, we test the financing-growth relations using firm level data.

We start by documenting the correlation structure at the firm level among the main elements of the asset growth decomposition (Equation 2). The cross-correlations are shown in Figure 3, in which each graph shows correlations of a variable at $t = 0$ with up to five leads and lags of a second variable $t = -5, ..., +5$. Given this setup, we require firms to

have at least 10 years of data in Compustat to be included in this particular exercise. To compute the correlation between Y_t and X_t, we estimate a firm-level regression of Y_t on X_t, then rescale the estimated coefficient by the ratio of their standard deviations $\frac{\sigma_X}{\sigma_Y}$. unbias

Overall, the correlation patterns are consistent with the aggregate patterns, supporting the existence of the financing-growth sequencing at the firm level. Figure 3(a) shows that asset growth is positively correlated with lagged equity growth, that is a typical firm raises equity in the periods leading to investment. Figure 3(b) shows that asset growth has almost no correlation with lagged debt issuance, but it has a positive correlation with lead values of debt issuance. This means that firms typically increase borrowing after they increase assets. Figure 3(c) documents that debt issuance has a negative correlation with contemporaneous and first lead of equity issuance, consistent with the idea that firms use debt proceeds to repurchase equity. Finally, Figure 3(d) shows that asset growth is positively correlated with the operating income ratio, which is reasonable since both variables are driven by firms' productivity shocks. The correlation coefficient is strongest between asset growth and one-period-ahead income, which is reasonable given that the firm's investments are expected to increase future income.

[Figure 3 around here]

Next, we apply the modified Blinder-Oaxaca decomposition to the firm-level data and compare the contribution of sources of financing to asset growth. The panel regression setting allows us to show the financing-growth relations within firms while controlling for firm characteristics and time trends. Also, another benefit of the firm-level data is that we can mitigate a potential bias from mergers and acquisitions (M&A). For example, if most of merger deals use a particular type of financing, they could bias upward the estimated contribution of that financing source to asset growth. To reduce this bias, in the baseline test we use an M&A-adjusted asset growth by deducting deal values from asset growth in the respective period. In the Online Appendix, we show that the main findings are very similar if we use gross asset growth that includes merger deals.

Table 5 shows the baseline estimations. The coefficients on the percentage growth in equity, debt, and profitability are the estimated sensitivity of asset growth with respect

to each source of financing. Firm and year fixed effects are included throughout, so the estimates could be interpreted as within firm effects. The first three columns of Table 5 suggest that asset growth is positively associated with all three sources of financing, but its relation with equity growth is at least three times larger than the others. In particular, a 1% increase in equity is associated with a 0.52% growth in assets, whereas a 1% increase in net debt and profitability are associated with 0.15% and 0.16% growth in assets, respectively.

We can use these estimates to calculate the dollar value equivalent of these relations. In our firm-level sample, an average firm has \$621.96 million in equity, \$495.26 million in net debt, and \$1,166.94 million in nonfinancial assets. Based on our estimates, an extra dollar of equity issuance is associated with an extra \$0.97 of real assets, while an extra dollar of net debt issuance is associated with \$0.35 in extra real assets.

Column 4 of Table 5 shows the estimates from a multivariate version of the regression. In column 5 we include firm characteristics known to affect financing and investment decisions, which are firm's tangibility, size, and Tobin's Q. These results similarly underscore the stronger association between asset growth and equity financing compared to the other sources of financing. We use pure debt (instead of net debt) in columns 6-8 of Table 5. Using this measure of debt diminishes the estimated contribution of debt financing to asset growth relative to equity financing but the results are broadly similar to the previous specification.

Overall, the estimated relations at the firm level are consistent with the documented relations in the aggregate data. Although the estimates are statistically more significant because of the increased sample size in the panel data. The differences in the magnitude of coefficients between the aggregate and firm-level estimations could be due to a few differences between the two samples. First, the aggregate sample includes all firms in the economy but our firm-level data only covers publicly traded firms. Second, firm-level variables are more volatile relative to the aggregate sample, where volatility is smoothed out. Next, the treatment of asset sales between firms are different across the two samples in that reallocation of assets between two firms does not change aggregate assets but shows up as a change in the firm level assets. Finally, the differences could be because of externalities from financing choices and cyclicality that affect the aggregate data but are mitigated in the firm-level tests.

[Table 5 around here]

Robustness tests using firm-level data. First, we investigate whether our main findings are concentrated in certain industries, or they are more general and observed across many different sectors. We conduct the decomposition exercise for each of the six major industrial sectors of the US economy (i.e., Agriculture & Mining, Construction, Manufacturing, Transportation & Utilities, Trade, and Services). The tests use panel regressions at the firm level while controlling for firm characteristics and the firm and year fixed effects. We find that our main findings hold consistently across all sectors of the US economy, that is equity financing exhibits a much stronger relation to asset growth that do debt financing and profitability. We note that debt financing plays a stronger role in the highly regulated "Transportation & Utilities" sector, yet still equity financing is the dominant channel. These results show that our main findings are general and not driven by certain industries. See more details in Appendix B.4.

Next, we note that the economic environment, such as the tax system and regulations, has changed over time since the beginning of our aggregate sample in 1945. We test whether the main results hold in different time periods. Using both aggregate and firm-level data we find that the baseline financing-growth relations consistently hold throughout the sample period. The details are provided in Appendix B.5.

Our baseline measure of equity issuance includes exercised equity-based compensation. The fact that firms use employee compensation contracts as a means of financing could alleviate this concern (Sun and Xiaolan, 2019). Nonetheless, we conduct an additional test to mitigate this issue. We assume that only large values of measured equity issuance reflect equity offerings, so equity issuance values that are less than 5% of firm's assets are set to zero. We re-estimate the decomposition regressions using the adjusted equity growth variable and find qualitatively similar results compared to the baseline test. Appendix B.6 provides the results.

Finally, we investigate the impact of firm characteristics on the relation between financing and growth. We focus on tangibility, size, and Tobin's Q, which are known to strongly affect firms' financing decisions (Rajan and Zingales, 1995; Frank and Goyal, 2009). We find that, as tangibility increases, equity issuance contributes less but debt and internal profits contribute more to asset growth. This result is consistent with a collateral effect in which, as

firms accumulate more tangible assets that can be used as collateral, they finance their asset purchases more with debt rather than equity. This could reduce the overall financing costs arising from the tax benefits of debt. With respect to the effect of firm size, we find that large firms use significantly more internal profits than do small firms to finance investments. Also, as firms grow in size, their external financing (both equity and debt) contribute slightly more to asset growth. Variation in Tobin's Q, however, does not affect the firms' use of external financing for growth. See more details in Appendix B.7.

3.5 Multivariate analysis in firm-level data

In the last empirical test, we estimate a panel VAR using the firm level sample. This exercise has two main goals. First, it provides the financing-growth relations at the firm level taking the interactions among these variables into account while controlling for firm characteristics. Second, given the joint estimation of the model and the inclusion of up to three lags of the variables, it provides a rigorous test of the sequential ordering of financing and investment actions at the firm level.

The main variables of the VAR include the asset growth rate and the ratios of equity issuance, net debt issuance, and operating income to assets. We control for firm size, tangibility, and Tobin's Q and include firm and year fixed effects in the model. Stability of the panel VAR is sensitive to the outliers, so we winsorize the VAR variables at 3% on both tails. Results of the stability test are available in the Online Appendix.

Table 6 shows the estimated panel VAR. Each column shows one of the VAR equations that are jointly estimated. Column 1 shows that asset growth is positively associated with the first two lags of equity issuance, but not related to debt issuance or profits. There is autocorrelation in asset growth, which is expected given persistence in firms' productivity. Column 2 shows that debt growth is predicted by lagged growth in assets and past equity issuance. Also, past profitability predicts negative debt growth. We find that this is mostly by construction in that to the extend that firms store part of the operating income in the form of financial assets it reduces their *net* debt. In an untabulated VAR model with pure debt instead of net debt, we find that the effect of lagged operating income on debt growth is close to zero, suggesting that a typical firm does not reduce debt after periods high

income. The main findings are similar in this alternative specification. Column 3 shows that the second lag of asset growth and the first lag of debt issuance negatively predict equity issuance. Also there is autocorrelation in equity issuance, which is consistent with the persistence in productivity if equity financing is used for investments. Lastly, column 4 shows autocorrelation in profitability and that past equity issuance and asset growth predict higher future income.

Overall, the panel VAR results in Table 6 are consistent with the aggregate VAR and provide clear evidence of a typical sequencing at the firm level: first equity increases, then assets grow, then debt is issued, followed by equity repurchases.

[Table 6 around here]

4 Model

To interpret the observed connections between corporate growth and financial variables, we use a relatively standard general equilibrium model. In the model, households own firms and provide labor services to them. Firms make dynamic investment, hiring, and financing decisions. They generate revenue by employing capital and labor as inputs and finance their operation with a combination of debt and equity, which are subject to financial frictions. Following Jermann and Quadrini (2012), in our model the financial frictions take the form of an equity payout adjustment cost and an enforcement constraint on debt contracts.

In what follows, we start with the firm's problem because this is where the model differs from a standard real business cycle model. We then describe the household sector and define the general equilibrium.

4.1 Firms

Technology. There is a continuum of firms in the [0,1] interval. A firm uses capital k_t and labor n_t to generate revenue with a gross revenue function

$$F(z_t, k_t, n_t) = z_t k_t^{\theta} n_t^{1-\theta}, \tag{3}$$

where $0 < \theta < 1$. The variable z_t is stochastic productivity, which is common to all firms and is the only source of uncertainty in the economy. Capital input k_t is chosen at time $t-1$ and predetermined at time t. Given investment i_t at time t, next-period capital is determined by $k_{t+1} = (1-\delta)k_t + i_t$, where δ is the depreciation rate. The input of labor n_t is flexibly chosen at time t.

Financing frictions. Firms can use internal funds and external financing in the form of debt and equity to finance their operation. Debt, denoted by b_t, is a one-period intertemporal contract and is preferred to equity because of its tax advantage, which is a typical feature in the capital structure models (e.g., Hennessy and Whited, 2005, 2007). Therefore, the effective gross interest rate on the firm's bonds is $R_t = 1 + (1-\tau)r_t$, where r_t is the interest rate and τ is the tax advantage of debt.

Firms are allowed to default on their debt obligations, so their ability to borrow is constrained by the limited enforceability of debt contracts. We follow Jermann and Quadrini (2012) to formulate the borrowing constraint. The default decision is made after the realization of revenue y_t and before the repayment of liabilities. In the case of bankruptcy the lender assumes the right to liquidate the firm's assets. However, the liquidation value of the assets is uncertain and unknown at the time of contracting. We assume that the lender recovers the full value of assets k_{t+1} with probability ξ, but the recovery value is zero with probability $1-\xi$.

The enforcement constraint arises from a bargaining game between the firm and the lender, as shown in Appendix C. The firm's choice of new debt is subject to

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$$\xi(k_{t+1} - \frac{b_{t+1}}{1+r_t}) \geq F(z_t, k_t, n_t). \tag{4}$$

Intuitively, a higher stock of capital relaxes the constraint. The enforcement parameter ξ is constant and common to all firms, and a higher value of ξ allows the firm to issue more debt, ceteris paribus. Of course, this borrowing constraint can be reorganized to indicate an upper bound limit for debt issuance $b_{t+1} \leq \frac{1+r_t}{\xi} \times \big(\xi k_{t+1} - F(z_t, k_t, n_t)\big)$.

The literature has taken different approaches to model the limited commitment problem. For instance, Kehoe and Levine (1993) assume that firms are excluded from the debt market

after default. Our assumption, however, is similar to Rampini and Viswanathan (2013) in this regard, in that firms are able to retain the period cash flow and issue new debt as they emerge from default. Our approach differs from the latter study in that we assume defaulted firms renege on all liabilities and the bankruptcy negotiations occur after the investment decision is made.

It is also worth noting that, in practice, borrowing constraints do not always depend on asset recovery rates. Lian and Ma (2019) show that borrowing constraints are commonly tied to operating cash flow rather than the liquidation value of assets, especially for large US firms. For our purposes, both versions of borrowing constraints generate essentially the same dynamic implications for the firm's use of equity and debt, which is our main interest. This is because, in our model, there is only one type of asset (i.e., physical capital), and it has a constant recovery rate (ξ) and primarily determines cash flow.

The firm can also issue equity or distribute funds to shareholders. We define payout d_t as the available net cash flow in the firm at time t. Positive values of d_t mean that the firm is distributing excess funds to shareholders, and negative values mean that it is raising equity from shareholders.

The second financial friction in the model represents rigidities in the adjustment of net payout d_t that affect the firm's flexibility in substituting debt and equity. Firms' tendency to smooth dividends (Lintner, 1956; Brav, Graham, Harvey, and Michaely, 2005; DeAngelo, DeAngelo, and Skinner, 2009) and the fact that external equity financing is costly (Altinkilic and Hansen, 2000; Hennessy and Whited, 2007) are well documented in the finance literature. To formulate these rigidities, we assume that the firm's net payout is subject to a quadratic adjustment cost, similar to Jermann and Quadrini (2012). Given the equity payout d_t, the actual cost for the firm is

$$\phi(d_t) = d_t + \kappa(d_t - \bar{d})^2, \tag{5}$$

where $\kappa \geq 0$ and $\bar{d}$ is the firm's long-run (steady-state) payout target. In Appendix I, we use an alternative form of the adjustment cost function that is asymmetric and include fixed costs. We show that our main results are robust to the functional form.

Firm's problem. The firm's objective is to maximize its equity market value $V(.)$,

which is equal to the discounted sum of future net payouts. The firm's individual state is determined by the stock of capital k and debt b. The aggregate states, specified below, are denoted by S. The next-period value of variables is indicated by a prime for easier reading.

Taking the stochastic discount factor m, the interest rate r, and the wage rate w as given, an individual firm chooses this period's labor input n and next period's capital k' and debt liability b' to maximize the current equity value. The firm's problem can be characterized recursively by the following Bellman's equation:

why does this not enter the enforcement constraint?

$$V(S;k,b) = \max_{n,k',b'} \Big\{ d + \mathbb{E}\big[m' V(S';k',b')\big] \Big\}, \tag{6}$$

$$\text{subject to} \quad \phi(d) + wn + k' + b = F(z,k,n) + (1-\delta)k + \frac{b'}{R}, \tag{7}$$

No idea where this comes from

$$\xi\left(k' - \frac{b'}{1+r}\right) \geq F(z,k,n). \tag{8}$$

The expectation on the right-hand side is over next-period aggregate state S', conditional on current S. Equation 7 is the firm's budget constraint, in which the left-hand side shows the uses for funds and the right-hand side shows the sources for funds. Let μ denote the Lagrangian multiplier for the enforcement constraint. The first order conditions (FOCs) are

$b' \leq k' - \frac{1}{\xi} F$

$$n \;:\; \frac{w}{1-\mu\phi_d(d)} = F_n(z,k,n), \tag{9}$$

$$k' \;:\; \frac{1}{\phi_d(d)} - \xi\mu = \mathbb{E}\Big[m' \frac{1-\delta+(1-\mu'\phi_d(d'))F_k(z',k',n')}{\phi_d(d')}\Big], \tag{10}$$

$$b' \;:\; \frac{1}{\phi_d(d)R} - \xi\mu\frac{1}{1+r} = \mathbb{E}\big[m' \frac{1}{\phi_d(d')}\big]. \tag{11}$$

Equation 9 shows the labor optimality condition. The right-hand side shows the marginal benefit of labor. The left-hand side is the marginal cost of labor, in which the denominator reflects the effects of the financial frictions on the firm's labor choice. All else equal, a tighter borrowing constraint increases the cost of labor because of a higher μ. Also, increasing equity payouts raises the cost of labor for the firm because of a higher $\phi_d(d)$. Therefore, the firm optimally increases equity payouts when it needs less labor input, and it issues equity at the same time as it increases labor input.

The capital investment optimality condition is shown in Equation 10. The left-hand side

captures the marginal cost of investment today, and the right-hand side shows the expected marginal value of the investment next period. The ratio $\frac{1}{\phi_d(d)}$ is the shadow cost of available funds inside the firm, which increases when the firm is raising external equity. A tight borrowing constraint increases $\xi\mu$, which in turn decreases the marginal cost of investment and encourages the firm to buy more assets to relax the constraint.

The debt optimality condition in Equation 11 equates the marginal value of debt today, shown on the left-hand side, to the expected marginal cost of debt repayment next period, shown on the right-hand side. The ratio $\frac{1}{\phi_d(d)R}$ is the marginal value of debt proceeds. A tight borrowing constraint increases the term $\xi\mu\frac{1}{1+r}$, implying that a tighter borrowing constraint reduces the firm's incentive to issue more debt.

Sequence of events. Before continuing the model setup, we use the discussion about the firm's optimality conditions (Equations 9 to 11) to discuss the economic mechanism of the model in explaining the empirical findings. We study the mechanism quantitatively in Section 5.

Suppose the firm receives a positive productivity shock. All else equal, the shock increases the firm's revenue $F(z, k, n)$, so it tightens the borrowing enforcement constraint (Equation 4), which increases the Lagrangian multiplier μ. According to the optimality conditions, a tighter borrowing constraint creates an incentive for the firm to invest more and to reduce debt issuance. Therefore, the firm finds it optimal to finance asset purchases by issuing equity. The labor optimality condition shows that issuing equity reduces the shadow cost of labor and helps the firm to hire more labor to complement capital investments during high-productivity times.

In the periods following the shock, productivity reverts back to average levels and the firm has more assets in place, both of which relax the borrowing constraint. Given the tax benefits of debt and the borrowing capacity, the firm issues more debt and repurchases equity while slightly reducing the capital and labor input.

4.2 Households

There is a continuum of homogeneous households that make consumption, labor, and saving decisions to maximize their expected lifetime utility. They own the shares of the firm, sell

labor services to the firm, and invest in bonds issued by the firm. So, the households' problem can be characterized recursively by

$$U(S) = \max_{c,n^H,b^{H'},s^{H'}} \Big\{ u(c,n^H) + \beta \mathbb{E}\big[U(S')\big] \Big\}, \tag{12}$$

$$\text{subject to} \qquad c + s^{H'}p + \frac{b^{H'}}{1+r} + T = wn^H + s^H(p+d) + b^H, \tag{13}$$

where c is consumption and β is the discount factor. Equation 13 is the household's budget constraint, in which b^H is the face value of bonds and s^H is the number of shares owned by the household, p_t is the share price, and T is a lump-sum tax on the household. To close the model, we set this tax equal to the aggregate tax benefit of debt for the firms, that is, $T = \dfrac{B'}{1+(1-\tau)r} - \dfrac{B'}{1+r}$.

The FOCs with respect to n^H, $b^{H'}$, and $s^{H'}$, which determine the supply of labor, the interest rate, and the share price, respectively, are the following:

$$n^H \;:\; wu_c(c,n^H) + u_n(c,n^H) = 0, \tag{14}$$

$$b^{H'} \;:\; \frac{1}{1+r}u_c(c,n^H) - \beta\mathbb{E}\big[u_c(c',n^{H'})\big] = 0, \tag{15}$$

$$s^{H'} \;:\; pu_c(c,n^H) - \beta\mathbb{E}\big[u_c(c',n^{H'})(p'+d')\big] = 0. \tag{16}$$

Using forward substitution on the last equation, we get

$$p_t = \mathbb{E}_t \sum_{j=1}^{\infty} \frac{\beta^j u_c(c_{t+j}, n^H_{t+j})}{u_c(c_t, n^H_t)} d_{t+j}. \tag{17}$$

Firms' optimization is consistent with households' optimization, so the stochastic discount factor is $m_{t+j} = \beta^j \frac{u_c(c_{t+j}, n^H_{t+j})}{u_c(c_t, n^H_t)}$.

4.3 Equilibrium

The aggregate states are the productivity z, the aggregate stock of capital K, and the aggregate bonds B; $S = \{z, K, B\}$. A recursive competitive equilibrium is defined as a set of functions for:

(i) households' policies $c^H(S)$, $n^H(S)$, and $b^H(S)$ that satisfy the FOCs stated in Equations 14 to 16;

(ii) firms' value $V(S;k,b)$ that satisfies the Bellman's Equation 6, and policies $n(S;k,b)$, $k(S;k,b)$, and $b(S;k,b)$ that are optimal and satisfy the FOCs in Equations 9 to 11;

(iii) the aggregate wage rate $w(S)$ and interest rate $r(S)$ that clear the labor and bond markets, respectively, and the stochastic discount factor is $m(S,S') = \beta \frac{u_c(c',n^{H'})}{u_c(c,n^H)}$;

(iv) and the law of motion for aggregate states $S' = \Psi(S)$ that is consistent with individual decisions and the stochastic process for z.

5 Quantitative analysis of the model

The goal of this section is to examine the financing-growth sequence in the model. We first discuss the model parameterization and show that the model closely matches the financing and growth dynamics in the data. Next, we present the quantitative implications through simulations and responses of the model to productivity shocks. Definitions of the model variables and moments are provided in Table A.3 of Appendix A.

5.1 Parameters

Some parameters are directly estimated from the data. For the rest, we solve the model numerically and estimate those parameters using the simulated method of moments (SMM) by matching the model to the data.

5.1.1 Directly estimated parameters

The period in the model is a year. The annual risk-free interest rate is 4.06%, which is the average rate on three-month Treasury bills over the sample period from 1946 to 2017. The discount rate is then calculated as $\beta = \dfrac{1}{1+r_t}$. The tax benefit of debt is set to $\tau = 0.425$ to reflect the US average marginal corporate income tax rate of 42.5% over the sample period.

We construct the series for the productivity variable z_t following the standard Solow

residual approach. Using the revenue function in Equation 3, we estimate z_t in the data by

$$\log(\hat{z}_t) = \hat{F}_t - \theta\hat{k}_t - (1-\theta)\hat{n}_t, \tag{18}$$

where $\hat{F}_t$, $\hat{k}_t$, and $\hat{n}_t$ are log deviations from the deterministic trends of output, non-financial assets, and hours worked (see Table A.1 for variable definitions). Parameter θ is initially set to 0.374, estimated by setting $1-\theta$ equal to the average labor share in our sample. We calculate the labor share using non-financial corporate businesses following Karabarbounis and Neiman (2013). In our sample, non-financial non-corporate businesses have an unusually small labor share. This may be because the capital share and labor share sometimes overlap in small businesses that are formed as sole proprietorships or partnerships.

After constructing the series for the productivity variable $\hat{z}_t$, we estimate the following autoregressive process:

$$\log(\hat{z}_{t+1}) = \rho\log(\hat{z}_t) + \varepsilon_{t+1}, \tag{19}$$

where ε_{t+1} is an i.i.d. shock with volatility σ. Note that productivity parameters are estimated iteratively. We use the estimated values of persistence ρ and volatility σ to simulate the model and estimate θ to match the average labor share, as discussed below. Then we feed the estimated θ back into Equation 18 and repeat this process until convergence.

Finally, we assume that the utility function takes the form $u(c,n) = \log(c) + \alpha\log(1-n)$, where α directly affects the household's labor supply decision and is set to have steady-state hours equal to 0.3.

5.1.2 Model solution and simulated method of moments

Given a set of parameters, the model is solved numerically via value function iteration. We adopt a nonlinear global approximation method that accommodates occasionally binding constraints. We approximate the conditional expectations in the equilibrium conditions (i.e., Equations 10, 11, and 15) with functions that interpolate between the grid points of the three-dimensional state space (z, k, b). The interpolation is based on a cubic spline using not-a-knot end conditions. Starting with initial guesses for the conditional expectations at the grid points, we compute all variables of interest by solving the system of nonlinear

equations characterizing the equilibrium.

At each grid point, we first solve the system assuming that the borrowing enforcement constraint is binding. If the solution for the multiplier μ is negative, which shows that the assumption is violated, we set it equal to zero and solve the system ignoring the enforcement constraint. In doing so, we essentially check for the Kuhn-Tucker conditions at each grid point. Once the equilibrium is solved on all of the grid points, we update the guesses for the conditional expectations and keep iterating until convergence. Appendix D provides details of the numerical solution.

We use the model solution to estimate the remaining structural parameters $(\theta, \delta, \xi, \kappa)$ through SMM, developed by McFadden (1989), Lee and Ingram (1991), and Duffie and Singleton (1993). Let $\hat{\boldsymbol{M}}$ be a vector of moments estimated from the data and $\hat{\boldsymbol{m}}^n(\Theta)$ be the corresponding vector of moments estimated from the nth simulated sample using parameters $\Theta = \{\theta, \delta, \xi, \kappa\}$, where $n = 1, ..., N$. The SMM estimator $\hat{\Theta}$ is

$$\hat{\Theta} = \underset{\Theta}{\operatorname{argmin}} \left(\hat{\boldsymbol{M}} - \frac{1}{N} \sum_{n=1}^{N} \hat{\boldsymbol{m}}^n(\Theta) \right)' \hat{W} \left(\hat{\boldsymbol{M}} - \frac{1}{N} \sum_{n=1}^{N} \hat{\boldsymbol{m}}^n(\Theta) \right), \tag{20}$$

where $\hat{W}$ is a positive definite weighting matrix, which is equal to the inverse of a covariance matrix that is calculated using the influence function approach of Erickson and Whited (2002). We use the simulated annealing algorithm to find the global solution to the above optimization problem.

To compute the model-generated moments, we use policy functions to create N simulated time series of size T+100, where $T = 72$ is the length of the US aggregate time series described in Section 2. We use $N = 80$ simulated samples to be conservative. Michaelides and Ng (2000) show that a simulated sample 10 times as large as the empirical sample has acceptable finite sample properties. The first 100 periods of each simulation are discarded, allowing the final simulated sample to have a stationary distribution, after the economy works its way out of the initial point.

Choice of moments and identification. The reliability of the estimation results critically depends on choosing the moments that are sensitive to variations in the structural parameters. Although all of the parameters affect all of the moments in some way, some

moments have stronger monotonic ties to particular parameters because of the model structure. We choose the moments based on links that are well known in the literature; however, a formal test of parameter identification in Appendix E confirms these choices.

The production function parameter θ is strongly tied to the average labor share. The depreciation rate δ is strongly and monotonically related to the average investment rate. To choose the moments relevant for the financial friction parameters, we follow Jermann and Quadrini (2012). The enforcement parameter ξ affects the level of debt used by the firm, so we add the firm's average debt to assets ratio to the set of target moments. The equity cost parameter κ determines the rigidities in the firm's payout policy, so we also add the standard deviation of the payouts to assets ratio to the set of moments.

In Appendix E, we show the parameter identification more formally by computing the local elasticity of moments with respect to estimators, following Hennessy and Whited (2007). The intuition is that a particular parameter is precisely estimated if at least one moment is adequately sensitive to it, since moving away from the true parameter value makes the simulated moment deviate from the target data moment. We find support for the intuitive discussion of the selection of moments and also find some additional insights about the model. For instance, the productivity parameter θ affects the firms' debt and payout policies in addition to its impact on the labor share. Also, the depreciation rate δ, besides its one-to-one effect on the average investment rate, negatively affects the firms' average debt ratio, which is intuitive given the collateral effect of capital in the model.

5.1.3 Estimation results

Table 7 presents the results of our baseline estimation. Panel A contains estimates of the actual data moments, simulated moments from the model, and the t-statistics for the differences between the two. Panel B contains the parameter estimates.

Several results stand out in Panel A. First, the estimated model fits the data very well, as all of the actual and simulated target moments are economically and statistically indistinguishable. As an external validity test for the model, we show additional moments that are not targeted in the estimation but are informative about the main economic mechanism.

Among the non-targeted moments, the model generates a negative correlation between

the asset growth rate and the net payout ratio. Note that, in the model, a reduction in net payouts is equivalent to equity financing by the firm. So, this correlation represents the relation between equity financing and growth, which is at the core of this study, and it is reassuring that the simulations replicate the real data on this aspect without targeting it.

On the other hand, the model underestimates the correlation between asset growth and debt issuance, which is the only place where the simulations statistically significantly deviate from the real data. This result stems from simplicity of the baseline model. In the model, high productivity increases firms' investments as well as households' consumption. As firms raise equity to finance investments, they also slightly reduce debt, which transfers funds to bondholders (i.e., households). This transfer partly pays for the increase in households' consumption, with the rest being financed by the increase in the wage bills. We elaborate on this point in the next section where we analyze responses to productivity shocks. In a model extension in Section 7, we show that the correlation between asset growth and debt issuance is higher in a model with heterogeneous firms, in which consumption need not be financed by the firms that are investing at a high rate.

The model fits the average payout ratio and the standard deviation of investments reasonably well, both economically and statistically. The model generates a lower standard deviation of debt ratio compared with the data, but the difference is not statistically significant. This result stems from having a constant borrowing constraint parameter ξ. In an extension of the model, we confirm that treating ξ as a time-varying financial shock, instead of a constant, increases the volatility of the debt ratio but does not affect our main findings. So we stick with the simpler version of the model, which is sufficient to show the main economic mechanism.

Next we turn to parameter estimates in Panel B of Table 7. The t-statistics confirm that the estimations are statistically significant. Our baseline estimation sets the production function parameter θ at 0.349 and the annual depreciation rate at 0.079, in line with the prior literature. We estimate the borrowing enforcement parameter ξ at 0.431, which is the probability that lenders will successfully find a buyer for the seized assets of a bankrupt firm (i.e., the recovery rate). Finally, we estimate the payout adjustment cost parameter at 0.018. This estimate implies that an equity issuance equal to half of the steady-state stock

of capital costs 1.68% of the raised funds, a cost that is in line with those estimated by Altinkilic and Hansen (2000) and Hennessy and Whited (2007) for an issuance of this size.

[Table 7 around here]

5.2 Productivity shock effects

Annual model

To evaluate the relation between financing and growth in the model, consider the responses of the variables to productivity shocks. We simulate the baseline model in the steady state and give the economy an unexpected one-standard-deviation positive productivity shock.

Figure 4 shows the response of the model variables for the first 20 periods after the shock. The economy is at the steady state at year 0, and the shock arrives at year 1. In response to the positive productivity shock, the household increases consumption because it is wealthier. To exploit the high productivity, firms respond by accumulating capital (asset growth) and increasing labor input (employment growth).

The way in which firms finance their growth is the heart of the economic mechanism of this paper. First, consider the initial responses of the financing variables to the shock. Figure 4(e) shows that the firm decreases net payouts which means increased equity financing. At the same time, Figure 4(f) shows that the firm reduces the amount of debt at year 1. This means that, upon the arrival of a positive productivity shock the firm finances its growth primarily with equity. This initial response is consistent with the evidence provided in section 3.

In this version of the model, firms initially repay debt in response to the positive shock for at least three reasons. First, it supports the households' increased consumption at the same time as the firm is increasing investment to take advantage of the productivity shock. The firm is getting money from the household by issuing equity. How can the household pay for the extra consumption? It does so by reducing corporate debt holdings (Figure 4(f)). The increased wages and labor supply also help to support the greater consumption, as shown by Figures 4(d) and 4(h). Second, the lower level of debt relaxes the enforcement constraint (Equation 4). This gives the firm the flexibility to increase labor input, as explained in the discussion of the FOCs (Equation 14). This "labor wedge" channel is similar to the one in

Jermann and Quadrini (2012). Third, the firm's demand for debt drops given the increase in the interest rate as shown in Figure 4(g).

It should be noted, that for the firm to repurchase debt at a time that it wants to increase investment, is costly. But the household wants to increase consumption, and with only one type of firm, that firm must provide for the greater consumption. In Section 7 we study an economy with two types of firms. In this case a firm-specific shock does not cause the firm to reduce debt. Instead, the greater household consumption is supported by pulling resources from other less productive firms.

Next consider the dynamics of growth and financing in later periods. Moving past the initial response, the firm starts to issue more debt and increase payouts. This pattern is similar to what we observed in the real data. In the model, the initial investment by the firm means that the firm is accumulating capital. This capital serves as collateral and so the firm is able to raise debt without tightening the enforcement constraint. The firm is motivated to increase debt because of its tax benefits and distributes excess funds to shareholders by increasing payouts.

Overall, the results show that the response to an investment opportunity in the model are essentially the same as in the data.

[Figure 4 around here]

5.3 Cross-Correlations in the model

The previous exercise show that the optimal firm policies in response to productivity shocks can generate similar dynamics to those documented in the data. In this section, we evaluate the dynamics of financing-growth relations in the model by generating cross-correlations between the main variables in the simulated data. We show that these dynamic patterns in the simulated data are also similar to those in the actual data.

Figure 5 shows the cross-correlations generated by simulations of the estimated model. As before, each graph shows correlations of a variable at $t = 0$ with up to five leads and lags of a second variable $t = -5, ..., +5$. Figure 5(a) show a strong positive correlation between asset growth and contemporaneous and lagged values of equity issuance. This shows that in

the simulated economy, firms increase equity in the periods leading up to investments, which is consistent with the equity financing channel in the actual data. Figure 5(b) shows that asset growth is correlated with future debt issuance, consistent with the collateral channel. Figure 5(c) displays a strong negative contemporaneous correlation between debt and equity issuance, showing that firms use debt proceeds to increase payouts. Finally, Figure 5(d) shows a positive correlation between asset growth and operating income ratio, especially with its lagged values. This relation is generated because both asset growth and income are solely driven by the productivity shocks, which is the single source of uncertainty in our baseline model.

Overall, Figure 5 shows that key dynamics of financing-growth relations in the model do match the dynamics observe both in the aggregate data (Figure 1) and firm-level data (Figure 3).

[Figure 5 around here]

6 Policy experiments

Because the model does generate major patterns observed in the data, we are interested in what the model has to say about policies that affect capital structure. We consider three policy experiments: an observed policy change and two policies with high level advocates.

The first experiment is a policy change that took place in the United States in 1996. The policy made it easier for firms to raise private equity from qualified investors. We first investigate the effect of this policy in the data and then test it in the context of the model. The second experiment is a government policy to limit corporate use of debt finance. This experiment is carried out within the model. Economic policy makers at a number of institutions including the BIS, the IMF, and the OECD, often express concern about the amount of corporate debt in some countries. As mentioned in the introduction, concerns about corporate debt also have deep roots in macroeconomics, going back at least to Fisher (1933). The third policy experiment is a limitation on share buybacks. This type of policy has recently been advocated by several high-profile US politicians and some financial regulators. For completeness we also consider what happens if both debt and buybacks are limited so

that the two policy restrictions are combined.

It should be kept in mind that our policy experiments in Section 6 use the baseline representative economy. They are intended to be illustrative. Any particular policy is likely to involve parameters that may differ from our policy parameter assumptions. Some policies also frequently include exemptions for specific types of firms. To quantitatively evaluate such a policy would require more detailed information about the policy specifics and suitable attention to any cross-sectional differences among firms that might prove important.

6.1 The National Securities Markets Improvement Act

The market for issuing equity in the United States experienced a major change following the National Securities Markets Improvement Act of 1996. Fewer firms went public, but private equity raising increased. The founders of firms were better able to raise several forms of private equity and retain greater control of their firms. The laws were harmonized across the states, thereby making the process of selling equity to "qualified purchasers" simpler and more effective. Ewens and Farre-Mensa (2018) show that this process facilitated raising large amounts of equity. Of course, many other things happened during this time period which may have also facilitated equity financing, so they put considerable effort into establishing a causal link to the NSMIA. From our perspective, their evidence implies that equity raising probably differed significantly after 1996. In this section, we examine whether a significant change took place at that time and, if it did, its potential implications for corporate growth.

The evidence provided by Ewens and Farre-Mensa (2018) suggests that the equity market impact starts in 1997, but the main effects may take two or three years to take full effect. If so, one might choose to define the break point as late as perhaps 1999. The exact timing of the break point is then a judgment call. Rather than doing any such fine tuning, we stick with the before and after 1996 definition, which is sufficient for our purposes.

The first step is to examine the cross-correlations as we did in Figure 1, but distinguishing the pre-1996 and post-1996 time periods. Figure 6 shows stark results. The essential financing-growth patterns are present in the pre-1996 period (the figures on the left), but they are muted when compared to the post-1996 period (the figures on the right). Panel A shows that before 1996, equity issuance is elevated in advance of asset growth, but it is not

sharply defined in time. In the post-1996 period, a sharp increase occurs in the correlation between the first two lags of equity issuance with asset growth, which reaches 0.75. Panel (b) shows that the correlation between asset growth and subsequent debt issuance in the next two years is almost double in magnitude after 1996 when compared to earlier. Finally, Panel (c) shows that, in the pre-1996 period, equity repurchasing after debt issuance is extended over several years. In the post-1996 period, debt growth is more strongly correlated with equity repurchasing, but the correlation is more sharply limited in time to the subsequent two years.

This evidence indicates that the central dynamic process is true both before and after the NSMIA. The effects appear to be much stronger in the more recent years. This evidence is consistent with the perspective of Ewens and Farre-Mensa (2018). Of course, other macroeconomic changes may also have been at work. So we remain cautious and would not claim that the full effect is due to the NSMIA. Nonetheless, the fact that the effects are much stronger in more recent years is of note.

[Figure 6 around here]

Having established that the key empirical patterns are stronger post-1996, we re-estimate the model around 1996 in order to analyze the effects through the lens of the model. Table 8 shows the moments and the parameters from the estimations using the "before 1996" and "after 1996" subsamples. Similar to the baseline case, the model simulations fit the actual data very well in both subsamples. None of the reported simulated moments are statistically distinguishable from the real-data moments.

Panel A of Table 8 shows the moments. First, consider the target moments. The labor share falls from the pre-1996 value of 0.635 to 0.605 in the more recent subsample, consistent with the findings of Karabarbounis and Neiman (2013). There is a small increase in post-1996 investment rates. The average debt ratio, however, more than doubles from 0.234 to 0.481. This sharp increase in debt is broadly consistent with the sharp increase in policy makers' and academics' attention to the role of corporate debt in recent years.

Next, consider the other reported moments in Panel A of Table 8. The correlation between asset growth and the net payout ratio has become more strongly negative after

1996. The model produces this strong change but has a weaker correlation in both time periods than in the data. The average payout ratio in the data increased from 0.013 to 0.034. The model captures this change by increasing from 0.011 to 0.036. The standard deviation of the investment rate does not change much across the two time periods in either the data or the model. The standard deviation of the debt ratio falls sharply after 1996 in the data. It also falls in the model, although the model underestimates the magnitudes.

Panel B of Table 8 shows the parameter estimates. Among the parameters that are directly estimated, the tax advantage τ is 45.5% for the period from 1946 to 1996 and 35% for the period from 1997 to 2017. These rates are the average marginal corporate tax rates obtained from the IRS (2002). The discount rate β is 0.954 in the earlier subsample, which is lower than 0.980 in the second part of the sample, reflecting the lower average risk-free rates in recent years. Productivity is less persistent after 1996, but the volatility of productivity shocks remains fairly constant over time.

The equity payout cost parameter κ is important for our purposes. We estimate that the post-1996 equity cost parameter κ is 0.002, which is substantially lower than the pre-1996 estimate of 0.124. This estimate is consistent with reduced institutional rigidities and reduced costs of equity financing, as shown by Ewens and Farre-Mensa (2018). The estimations also suggest that the debt enforcement parameter ξ has increased over time, from 0.425 before 1996 to 0.478 after 1996. This increase implies reductions in credit markets' frictions over time. The post-1996 production technology θ is estimated at 0.386, which is higher compared with 0.331 in the earlier subsample, reflecting the decline in labor share in recent decades (Karabarbounis and Neiman, 2013).

Our estimations imply that the NSMIA reduced the cost of raising equity for US firms. But the differences between the before and after subsamples cannot be solely attributed to the cost of equity, since much else has changed in the economy, as is shown by the other parameters.

[Table 8 around here]

We isolate the impact of the estimated change in the equity issuance cost by comparing model simulations when we change *only* the cost parameter κ from the pre-1996 to the post-

1996 estimated value. Figure 7 shows two sets of model responses to a one-standard-deviation positive productivity shock. The dashed lines use "before 1996" parameter estimates (see Table 8). The solid lines use the same set of parameters except for the payout adjustment cost κ, which is changed from the pre-1996 value of 0.124 to its post-1996 value of 0.002.

Figure 7 shows that, in response to the same investment opportunity, the lower equity adjustment cost induces larger increases in households' consumption (7b), capital expenditure (7c), labor hiring (7d), and wages (7h). The economic magnitude of the change in the equity adjustment cost caused by NSMIA is large. For instance, one period after the shock ($t = 2$), the "After" simulations have stronger responses in consumption by 23.8%, capital stock by 25.2%, labor input by 50.1%, and wages by 29.38%, as compared with the responses of "Before" simulations. These results underscore our empirical findings that equity financing plays a key role in corporate growth.

Next, consider the impact on firms' financing policies. As a result of the reduced equity adjustment cost after the NSMIA, Figure 7(e) shows that the first-period response in equity issuance (i.e., the negative payout) increases by 72.3% compared to before. This is followed by more payouts as the firm accumulates capital and raises debt. Figure 7(f) shows that the initial debt reduction is stronger. More importantly, firms in the "After" simulations accumulate more debt from the second period on, backed by additional assets in place, to the extent that at $t = 5$, the "After" simulations have a 0.7% larger debt liability than the "Before" simulations. This implication is consistent with the observed increases in leverage of the US corporate sector in recent years. It is also consistent with the findings of Demirgüç-Kunt and Levine (1996) showing that, in the long run, better equity financing tends to increase aggregate corporate debt.

[Figure 7 around here]

6.2 Policy to limit corporate debt

Corporate debt has been a source of considerable concern among economic policy makers at both the national and international level (Sutherland and Hoeller, 2012; International Monetary Fund, 2016; Derby, 2019). Countries are frequently advised by bodies such as

the IMF and the BIS to adopt new policies to induce firms to scale back their use of debt. Therefore, we examine the quantitative impact of a policy that exogenously restricts the corporate use of debt in our model.

One might hope that a policy limiting corporate debt would not be too damaging in our model because it is equity that leads corporate investment. However, the equity is issued anticipating subsequent debt issues and equity repurchases. If the subsequent debt issues are restricted, the initial equity issuance might be less attractive, resulting in reduced real asset accumulation and output. How large these effects are is a quantitative question that we investigate here.

In this section we study an exogenous policy that puts an upper bound limit on firms' borrowing. We impose $b_{t+1} \leq \bar{B}$ as an additional constraint on the firm's problem, where the debt limit $\bar{B}$ is exogenously set by policy makers. The reported results are for a debt limit is set at 50% of the baseline steady-state debt level. Quite similar qualitative results are found when we set the debt limit at other levels as long as the constraint is often binding; that is, $\bar{B}$ is below the level imposed by the borrowing constraint. In Appendix F we discuss how this new constraint affects the equilibrium and show that the debt limit effectively replaces the borrowing enforcement constraint for the firm.

Table 9 compares the constrained model simulations with the actual data and the baseline simulations. Of course the debt ratio is reduced. Beyond that, the policy causes significant reductions in the standard deviations of the payout and debt ratios. This means that firms' financing actions become less volatile under the debt policy limit. The way in which firms finance their asset growth is also changed. Now firms pay for asset growth almost exclusively with equity financing. There is a near-perfect (negative) correlation between asset growth and net payout and a near-zero correlation between asset growth and debt issuance.

[Table 9 around here]

Figure 8 shows the impulse responses under the debt limit policy. Solid lines show responses from the policy-constrained model to a positive productivity shock. Dashed lines show the responses from the baseline model. Note that these graphs show real quantities and prices instead of the percentage deviations from the steady state. This allows for evaluating

the impact of the borrowing limit on the long-run levels of quantities and prices by comparing the steady states of the two models.

The effect of the debt limit policy on the steady state as shown in 8 is stark. The size of the economy shrinks, the households work more hours at lower wage rates, they get more in dividends but less in interest, and they consume less. The corporate borrowing limit shrinks the size of the economy by 16.6%, as measured by the change in capital stock from 1.87 in the baseline economy to 1.56 under the debt limit. Consumption decreases by 2.4%, the wage rate decreases by 2.3%, and labor input increases by 0.1%. On the financing side, net payout to shareholders increases by 8.5% because the firm is financed with more equity due to the 50% drop in debt.

The post-shock dynamics are shown in Figure 8. The debt limit serves to dampen the initial response to an economic shock. Figure 8(c) shows that the policy reduces the investment response by 7.9%, as measured by comparing the increase in the capital stock from time 0 to its peak at $t = 7$ between the two sets of simulations. Firms understand that this policy limits future debt issuance. This makes the net debt unresponsive to the shock, as shown in Figure 8(f). It also affects the payout policy in Figure 8(e) because firms cannot rely on debt issuance to finance future payouts, as was the case in the baseline economy. As a result, even though equity issuance in the first period increases by 18.1% under the policy, firms never pay out more than the steady-state level of payouts in later periods, in contrast to the payout policy in the baseline economy (dashed line).

[Figure 8 around here]

6.3 Policy to restrict share buybacks

Corporate equity buybacks are politically controversial, and they are often described as a waste of corporate resources that ought to be reinvested in the firm instead. Democratic Senators Schumer and Sanders recently proposed limiting corporate stock buybacks; see Schumer and Sanders (2019). They argue that large-scale share buybacks may boost the stock value but restrain the firm's "capacity to reinvest profits more meaningfully in the company. ... The goal is to curtail the overreliance on buybacks while also incentivizing

the productive investment of corporate capital." Republican Senator Rubio made a closely related proposal about the same time.[1] SEC Commissioner Jackson has called for stricter regulation on buybacks in order to remove potential stock price manipulation motives.[2] The fact that these proposals are coming from senior policy makers of both major US political parties motivates our interest in the likely effects.

We assume that the firm cannot recharacterize income to do tax arbitrage. The policy makers are sensitive to this issue, and they discuss the fact that dividends may also be restricted in their proposals. Our model does not distinguish between buybacks and dividends, so we assume that a buyback restriction policy places a limit on the net payout.

We implement the buyback policy by putting an upper bound limit on the net payout, $d_t \leq \bar{D}$. Appendix G discusses the implementation of the buyback restrictions and equilibrium conditions of this model extension. The limit $\bar{D}$ is exogenously set by policy makers. We assume that $\bar{D}$ is set at 105% of the steady-state net payout derived in the baseline model. This is a fairly mild restriction because it does not bind on net payouts in the baseline steady state. This is also consistent with the fact that the policy makers are calling for restricting "excessive" buybacks — not a ban on all payouts. We find qualitative similar results if the limit is set exactly at the steady-state payout.

Table 9 reports the simulated moments under limited buybacks. We show two sets of moments for different levels of the limit in the last two columns. We focus on the case in which $\bar{D}$ is set to 105% of the steady-state baseline payout. Simulations suggest that the qualitative effects of the policy limit are similar in the other case.

Comparing the constrained simulations with the baseline, several results stand out. First, the limit significantly reduces the volatility of net equity payouts, from 0.012 in the baseline case to 0.001 in the constrained model. This implies that the policy discourages equity financing, which is the main source of volatility in net payouts in the baseline case. The volatilities of the debt ratio and investments are also reduced, but not by nearly as much.

[1] "Rubio's Smart Push to Change the Tax on Buybacks," editorial, Bloomberg, February 19, 2019, https://www.bloomberg.com/opinion/articles/2019-02-19/marco-rubio-s-sensible-stock-buyback-tax-plan

[2] US SEC, Commissioner Robert Jackson Jr.: "Stock Buybacks and Corporate Cashouts" (speech at the Center for American Progress, June 11, 2018), https://www.sec.gov/news/speech/speech-jackson-061118. Jackson cited the findings of Lee, Mikkelson, and Partch (1992) and Babenko, Tserlukevich, and Vedrashko (2012).

The impact on firms' financing choices also shows up in the financing-growth correlations. The correlation between asset growth and debt issuance increases from -0.198 in the baseline case to 0.424 under the buyback policy limit. There is more intensive use of debt issuance to pay for asset growth. On the other hand, the correlation between asset growth and net payouts goes from -0.433 to 0.086, suggesting the lack of equity financing (negative payouts) under the buyback limit.

Overall, the results in Table 9 show that the buyback policy curbs equity financing. This finding is intuitive given that a buyback limit severely restricts the firm's ability to return funds to shareholders in subsequent years after equity issuance. This discourages equity investors from financing the projects in the first place. The reluctance to invest in equity is potentially consequential due to the role of equity financing in asset growth we have documented.

We confirm this hypothesis by examining the constrained firms' responses to a positive productivity shock and compare them with the baseline firms. Figure 9 shows the results. First, consider the responses in financing decisions. Figure 9(e) suggests that firms do not use much equity financing when buybacks are limited (solid line). This is a significant change from the baseline model (dashed line). The firm uses more debt, but only to the extent that is possible. Figure 9(f) shows that the debt level under the buyback limit (solid line) is above the benchmark debt level (dashed line). However, immediately after the shock, assets are inadequate to secure needed debt issuance. So the firm's access to needed finance is constrained in the short run. In other words, the firm needs more funds for investments, but it takes time to acquire the necessary collateral. This leads to a *delayed response* to the shock. The responses in consumption, capital, labor, and prices follow trends similar to those in the baseline model but with a two- to three-period delay.

These results suggest that the main impact of this type of regulatory restriction is on the ability of firms to respond in a timely manner to a transitory opportunity. If positive productivity shocks occur, the firm is less able to respond promptly, and as a result there are losses. This effect is evident in the graphs: the peaks in the solid lines happen a few periods after the peaks in the dashed lines.

This policy also affects the economy in the long run. Comparing the steady-state values

at time 0, we find that the buyback limit shrinks the economy's size (capital stock) by 1.0%, employment by 0.7%, and consumption by 0.8%. The wage rate is also lower by 1.1%.

[Figure 9 around here]

Proposals to restrict the corporate use of debt and proposals to restrict share repurchases have been advanced independently, which is why we have considered them independently. In Appendix H, we consider what happens if both proposals are adopted together. The two policy limits effectively shut down external financing. This leaves the firm with inadequate resources during expansions as it is forced to rely on internal financing. Firms' investment response to productivity shocks become weaker and significantly delayed compared with an unconstrained economy. We find that the joint effect of these policies is more than the sum of the effects of the two policies if implemented separately. Appendix H provides a detailed discussion.

7 Heterogeneous firms model

In the baseline model, we assume that the stochastic productivity is common to all firms. This assumption allows the aggregation of the firm sector into a representative firm, which makes the model solution and estimation more efficient. However, a representative firm economy cannot match some aspects of the flow of resources between firms and households in the data.

The key problem is the following. In response to a positive productivity shock, the representative firm issues equity and increases investment. The household is also wealthier and wants to consume more. Because there is only one firm and one household in the economy, the increased consumption is supported by a decrease in corporate debt. This creates a slightly negative contemporaneous correlation between asset growth and debt issuance. For more detailed discussion of the correlation between asset growth and debt issuance see Section 5.1.3, and the baseline impulse responses see Section 5.2.

In this section, we directly address this issue and show that the main financing-growth dynamics results still hold in a model with more than one type of firm. We model an

economy with heterogeneous firms and a household sector that lends to and owns all firms. The correlation between asset growth and debt issuance is higher than it was in the baseline model and much closer to that in the data. The main intuition is that a firm that gets a positive shock still raises equity. But now it can also raise some debt instead of decreasing debt in the baseline case. This is possible because the household can support consumption by pulling resources from less productive firms.

The economy has two firm sectors and both produce the single consumption good. Capital and labor are used as inputs to generate revenue. The shock process is now more elaborate in order to permit idiosyncratic shocks.

$$F(z_i, k_i, n_i) = z_i k_i^{\theta} n_i^{\nu}, \tag{21}$$

where $i = 1, 2$, indexes the firm sector and $0 < \theta + \nu \leq 1$. The variable z_i is the stochastic productivity in sector i in the current period and determined by $z_i = z^a \times z_i^f$, where z^a is the aggregate productivity common to all firms and z_i^f is the idiosyncratic productivity of sector i. Both z^a and z_i^f follow AR(1) processes in logs, where persistence and volatility of the shocks are indicated by (ρ_a, σ_a) and (ρ_f, σ_f), respectively. As in the baseline model, the main frictions are the limited enforcement of debt contracts, and the net payout adjustment costs. Factors of production are liquid and move freely between the two sectors. The aggregate states are denoted by S and the firm's individual state is determined by its sector productivity z_i^f, capital stock k, and debt b.

The firm's problem is given by the following Bellman's equation:

$$V(S, z_i, k_i, b_i) = \max_{n_i, k_i', b_i'} \Big\{ d_i + \mathbb{E}\big[m_i' V(S', z_i', k_i', b_i')\big] \Big\}, \tag{22}$$

$$\text{subject to} \quad \phi(d_i) + w_i n_i + k_i' + b_i = F(z_i, k_i, n_i) + (1-\delta)k_i + \frac{b_i'}{1 + (1-\tau) r_i}, \tag{23}$$

$$\xi(k_i' - \frac{b_i'}{1 + r_i}) \geq F(z_i, k_i, n_i), \tag{24}$$

where $i = 1, 2$, indexes the firm sector. Each firm's problem is the same as that of the baseline representative firm (Equations 6-8), so the discussion of the optimality conditions and the economic mechanism applies to this case too.

A continuum of homogeneous households maximize their expected lifetime utility by making decisions about consumption, providing labor to both firm sectors, and investing in equity and bonds of both sectors. Since both firm sectors produce the same consumption good, the households' problem can be given by

$$U(S) = \max_{c,\{n_i^H, b_i^{H\prime}, s_i^{H\prime}\}_{i=1,2}} \Big\{ u(c, \{n_i^H\}_{i=1,2}) + \beta \mathbb{E}\big[U(S')\big] \Big\}, \tag{25}$$

$$\text{subject to} \quad c + \sum_{i=1}^{2} \big(s_i^{H\prime} p_i + \frac{b_i^{H\prime}}{1+r_i} \big) + T = \sum_{i=1}^{2} \big(w_i n_i^H + s_i^H (p_i + d_i) + b_i^H \big), \tag{26}$$

where T is a lump-sum tax on the household, which is set equal to the aggregate tax benefit of debt for the firms, $T = \sum_{i=1}^{2} \left(\frac{B_i'}{1+(1-\tau)r_i} - \frac{B_i'}{1+r_i} \right)$.

We parameterize the model and simulate it to study the effects of the new setup on the model-generated moments and, more broadly, on the dynamics of financing-growth relations in the model economy. Our main focus is still on the aggregate financing flows between the households and firms, not on moments related to the distribution of firms. So we do not add to the baseline set of target moments. The parameters are the result of calibrating the model to the same set of target moments. Nonetheless, all of our main qualitative results in this section proved to be quite robust to a wide range of parameter choices.

Table 10 presents the simulated moments and parameters. The table also shows moments from the actual data and baseline simulations as benchmarks. The model with heterogeneous firms matches the target moments as well as the baseline model did. Among the non-target moments, the correlation coefficients stand out as they are greatly improved compared to the baseline model's match along these dimensions. In the heterogeneous firms' model, the correlation between asset growth and net payouts (i.e., negative equity issuance) is -0.36, which matches well the -0.35 correlation in the data. More importantly, the correlation between asset growth and debt issuance is 0.17 in the heterogeneous firms model, which is close to the estimated 0.16 in the data. This is a big improvement over the -0.20 in the baseline model. This confirms the intuition that the negative sign on this correlation in the representative firm model is due to the representative firm simplifying assumption.

[Table 10 around here]

Next, we evaluate model responses to productivity shocks to shed light on the model mechanism that improves the financing-growth correlation structure. We simulate the economy in the steady state and give an unexpected positive productivity shock *only* to firm sector $i = 1$. For easier comparison, the shock size is the same as those in the baseline case. Figure 10 shows the responses. As Figure 10(a) shows, firm 1's productivity increases while firm 2's productivity remains at the steady state level. As a result households increase consumption because of the wealth effect, see Figure 10(b). There is a reallocation of resources shown in Figures 10(c) and 10(d) as firm 1 exploits high productivity by increasing capital (asset growth) and labor while firm 2 reduces factor inputs.

The main difference between this model and the baseline model is in the responses of the financing variables. Figure 10(e) shows that firm 1 decreases net payouts (i.e., issues equity) to finance its asset growth. In contrast to the baseline model, Figure 10(f) shows that firm 1 also raises debt. In the representative firm model the firm reduced debt initially. This is the basis for the positive correlation between asset growth and debt issuance in Table 10. Firm 1 is able to raise equity and debt at the same time because firm 2 exists in the economy. Firm 2 does not have high productivity at this time, so households can pull resources from firm 2 to support their increased consumption and investments in firm 1. This is evident in Figures 10(e) and 10(f) as firm 2 increases payouts and pays back debt in response to the shock. In later periods, as firm 1 accumulates more capital to use as collateral, it raises more debt while increasing payouts to shareholders, that is, substituting debt for equity.

[Figure 10 around here]

Finally, we directly evaluate the dynamics of financing-growth relations in this model by generating cross-correlations between the main variables in the simulated data. Figure 11 presents the graphs. As before, each graph shows correlations of a variable at $t = 0$ with up to five leads and lags of a second variable $t = -5, ..., +5$. Figure 11(a) shows that asset growth is positively correlated to contemporaneous and lagged values of equity issuance, suggesting that typically equity increases prior to asset growth. Figure 11(b) shows that asset growth predicts future debt issuance, which is consistent with the collateral channel as a driver of debt decisions. Figure 11(c) shows that debt issuance has a significant

negative correlation with contemporaneous equity issuance, suggesting that firms typically raise debt to substitute for equity by increasing payouts. Lastly, Figure 11(d) depicts a positive correlation between firms' asset growth and revenue, which is not surprising given that in the model both variables are driven by productivity shocks.

[Figure 11 around here]

Overall, the results show that the heterogeneous firm model continues to generate financing-growth dynamics that are very similar to the sequencing of firm actions in the data, as shown in Figures 1 and 3 for aggregate and firm-level data. Having firm heterogeneity improves the ability of the model to reflect the flow of debt between the household and firm sectors as discussed above in Table 10 and Figure 10.

8 Conclusion

Equity financing plays an important role in corporate asset accumulation. This shows up in both aggregate US data and firm level data. There is a distinctive dynamic sequence that starts with equity financing, then real asset accumulation, and finally ends with both debt financing and equity repurchasing.

This empirical sequence of events emerges from a fairly conventional model that we study. In the model, there is a tax advantage to debt, but issuing debt requires collateral. Equity does not have the tax advantage, but it does not require collateral. As a result, when a good investment opportunity arrives, the firm issues equity and uses the money to buy physical capital for production. It then uses the physical capital as collateral, along with the newly generated revenue, to issue debt and repurchase equity. This model does a good job of matching a number of key moments in the data.

Because the model matches the data well, we evaluate several government policies through the lens of the model. The first policy is the 1996 NSMIA, which made it easier to issue private equity. Parameter estimations before and after the change capture this very well. The second policy is a restriction on the use of debt financing. We consider this policy because economic policy makers often express concern about high corporate debt. We find

that the main effect of the policy is on the steady state rather than on the responses to a shock. In the model, the debt limit causes an increase in the payout ratio of the firm, so it maintains a lower capital stock and hence produces less output in the steady state. This policy also reduces long-run wages and consumption.

The third policy is a restriction on stock buybacks. This kind of policy has recently been proposed by a number of well-known US senators. Limiting buybacks and dividends makes equity financing unappealing, which is a problem particularly when the firm is attempting to take advantage of transitory opportunities. Since equity is hard to obtain, the firm ought to use debt. But debt requires collateral, and the firm requires an extended period of time to build up that collateral if external equity is not available. As a result, the firm is unable to take full advantage of the transitory opportunities, and so output and consumption are lost in the process.

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Table 1: Summary statistics for the US business sector

This table shows summary statistics for the US aggregate time series. We construct the variables using the Financial Accounts of the United States issued by the Federal Reserve Board. Our sample aggregates the US non-financial businesses and covers the period from 1946 to 2017. Real values are in billions of 2009 US dollars. Appendix A provides variable definitions.

Variable	Symbol	Obs.	Mean	SD	Min	Max
Real quantities (in billions of 2009 USD):						
Total assets	–	72	18230.4	12993.0	4001.3	48957.9
Non-financial assets	A	72	11346.6	6294.8	3201.2	24706.2
Assets (non-fin.) growth	ΔA	71	302.9	396.1	-1171.1	1246.1
Operating income	Y	72	2539.5	1474.3	930.2	5546.1
Net debt	B	72	4430.1	3805.0	77.6	12355.4
Net debt issuance	ΔB	71	172.9	310.0	-840.0	1039.6
Equity	E	72	9911.3	6106.1	3144.1	24536.5
Net equity issuance	ΔE	72	-95.0	173.4	-777.3	91.4
Dividends	D	72	189.7	165.6	41.2	623.6
Interest paid	rB	72	239.5	169.4	8.0	535.3
Depreciation	δA	72	676.5	457.7	100.4	1598.1
Taxes paid	T	72	432.1	241.3	92.1	897.9
Real quantities as a fraction of non-financial assets:						
Asset growth rate	$\Delta A/A$	71	0.030	0.025	-0.058	0.082
Operating income to assets ratio	Y/A	72	0.225	0.023	0.181	0.293
Net debt issuance to assets ratio	$\Delta B/A$	71	0.015	0.020	-0.042	0.087
Equity issuance to assets ratio	$\Delta E/A$	72	-0.004	0.010	-0.036	0.013
Interest to assets ratio	rB/A	72	0.018	0.009	0.003	0.036
Dividends to assets ratio	D/A	72	0.015	0.005	0.009	0.026
Depreciation rate	$\delta A/A$	72	0.055	0.010	0.031	0.072
Taxes to assets ratio	T/A	72	0.038	0.003	0.029	0.043

Table 2: Correlations among variables of the asset growth decomposition (Equation 2)

The sample is the same as in Table 1. Appendix A provides variable definitions.

		$\frac{\Delta A}{A}$	$\frac{Y}{A}$	$\frac{\Delta B}{A}$	$\frac{\Delta E}{A}$	$\frac{rB}{A}$	$\frac{D}{A}$	$\frac{\delta A}{A}$	$\frac{T}{A}$
Asset growth rate	$\Delta A/A$	1.00							
Operating income to assets	Y/A	0.10	1.00						
Net debt issuance to assets	$\Delta B/A$	0.16	-0.17	1.00					
Equity issuance to assets	$\Delta E/A$	0.39	0.23	-0.25	1.00				
Interest to assets ratio	rB/A	-0.29	-0.56	0.05	-0.57	1.00			
Dividends to assets ratio	D/A	-0.10	0.38	-0.07	-0.43	0.15	1.00		
Depreciation rate	$\delta A/A$	-0.15	-0.27	0.00	-0.62	0.79	0.62	1.00	
Taxes to assets ratio	T/A	0.22	-0.07	-0.06	0.20	-0.12	0.24	0.12	1.00

Table 3: Contribution of different sources of financing to growth in the aggregate data

This table presents a modified Blinder-Oaxaca decomposition to explain the contribution of each form of financing to asset growth using aggregate data on US businesses. Each column shows a regression of the annual percentage asset growth on the percentage growth in sources of financing according to Eq. 2. The % growth in each variable X is computed as $\Delta \log(\mathrm{X})$ and, for profitability, it is computed as log(1+operating income/assets). Estimations are based on the aggregate sample of US corporate and non-corporate businesses that spans from 1946 to 2017. Heteroscedasticity robust standard errors are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Equity growth	0.808**			0.775**	0.621*		0.778***	0.732***
	(0.327)			(0.336)	(0.321)		(0.278)	(0.271)
% Net debt growth		0.055		0.043	0.016			
		(0.042)		(0.042)	(0.046)			
% Debt growth						0.277**	0.273**	0.264**
						(0.127)	(0.115)	(0.122)
% Profitability			0.138	-0.037	-0.113		0.031	0.004
			(0.132)	(0.178)	(0.195)		(0.133)	(0.160)
% Dividends growth					0.012			0.008
					(0.021)			(0.017)
% Interest growth					-0.010			-0.017
					(0.049)			(0.056)
% Deprec. growth					0.170			0.025
					(0.180)			(0.194)
% Taxes growth					0.128			0.070
					(0.115)			(0.102)
Const.	0.033***	0.025***	0.001	0.037	0.043	0.016**	0.014	0.017
	(0.003)	(0.004)	(0.027)	(0.035)	(0.037)	(0.006)	(0.025)	(0.028)
N	71	71	71	71	71	71	71	71
R^2	0.155	0.044	0.011	0.180	0.220	0.202	0.351	0.366

Table 4: Asset growth decomposition using a VAR model

Panel A: VAR model estimations

The VAR model studies the interconnections between the asset growth rate $\frac{\Delta A}{A}$ and the three main sources of financing for firms. These sources are debt financing, proxied by the net debt issuance to assets ratio $\frac{\Delta B}{A}$, equity financing, proxied by the equity issuance to assets ratio $\frac{\Delta E}{A}$, and internally generated funds, proxied by the operating income to assets ratio $\frac{Y}{A}$. Each column shows one equation of the VAR system. Up to three lags of each variable are included in the model. We estimate the VAR using our aggregate sample of US businesses over the period 1946 to 2017. Variable definitions are provided in Appendix A. Standard errors are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

		Dependent variables at time t			
		$\Delta A/A$	$\Delta B/A$	$\Delta E/A$	Y/A
		(1)	(2)	(3)	(4)
Asset growth $\Delta A/A$	$t-1$	0.609***	0.231**	-0.006	0.019
		(0.124)	(0.108)	(0.035)	(0.032)
	$t-2$	-0.319**	0.248**	-0.082**	-0.135***
		(0.144)	(0.125)	(0.040)	(0.037)
	$t-3$	-0.012	-0.107	0.031	-0.032
		(0.154)	(0.134)	(0.043)	(-0.040)
Debt issuance $\Delta B/A$	$t-1$	-0.073	0.120	-0.152***	0.069*
		(0.153)	(0.133)	(0.043)	(0.039)
	$t-2$	0.151	0.070	0.061	-0.098**
		(0.161)	(0.140)	(0.045)	(0.042)
	$t-3$	0.160	-0.230*	0.109**	-0.030
		(0.143)	(0.124)	(0.048)	(0.037)
Equity issuance $\Delta E/A$	$t-1$	0.271*	0.412	0.618***	-0.160
		(0.158)	(0.415)	(0.133)	(0.124)
	$t-2$	1.097**	-0.955**	0.397***	0.068
		(0.542)	(0.470)	(0.396)	(0.141)
	$t-3$	-0.553	0.408	-0.132	0.009
		0.429	(0.372)	(0.120)	(0.111)
Operating income Y/A	$t-1$	0.412	-0.153	-0.105	0.819***
		(0.466)	(0.404)	(0.130)	(0.121)
	$t-2$	-0.301	-0.234	0.260	0.066
		(0.561)	(0.486)	(0.156)	(0.145)
	$t-3$	-0.034	0.215	-0.132	-0.003
		(0.399)	(0.346)	(0.112)	(0.103)
Constant		0.005	0.042*	-0.004	0.030***
		(0.027)	(0.023)	(0.008)	(0.007)
N		68	68	68	68
R^2		0.471	0.337	0.743	0.942

Table 4: Asset growth decomposition using a VAR model (continued)

Panel B: Granger causality Wald tests

This panel shows the Granger causality test results based on the VAR estimations in Panel A. The four blocks correspond to the VAR equations in columns 1 to 4 of Panel A, respectively. Each block shows the p-values for the Wald tests of the hypothesis that 'the dependent variable is *not* Granger caused by each of the other variables.'

Eq.	Dependent variable	H_0: The dependent variable is ***not*** Granger caused by:	χ^2	df	p-value	H_0 rejected at 5%?
(1)	Asset growth	Net debt issuance	2.40	3	0.493	No
(1)	Asset growth	Equity issuance	8.89	3	0.031	Yes
(1)	Asset growth	Operating income	0.92	3	0.819	No
(1)	Asset growth	All	11.10	9	0.269	No
(2)	Net debt issuance	Asset growth	16.28	3	0.001	Yes
(2)	Net debt issuance	Equity issuance	4.14	3	0.247	No
(2)	Net debt issuance	Operating income	3.30	3	0.348	No
(2)	Net debt issuance	All	25.42	9	0.003	Yes
(3)	Equity issuance	Asset growth	5.92	3	0.116	No
(3)	Equity issuance	Net debt issuance	20.51	3	0.000	Yes
(3)	Equity issuance	Operating income	3.32	3	0.344	No
(3)	Equity issuance	All	37.24	9	0.000	Yes
(4)	Operating income	Asset growth	22.25	3	0.000	Yes
(4)	Operating income	Net debt issuance	9.80	3	0.020	Yes
(4)	Operating income	Equity issuance	1.83	3	0.607	No
(4)	Operating income	All	45.02	9	0.000	Yes

Table 5: Contribution of different sources of financing to growth at the firm level

This table presents a modified Blinder-Oaxaca decomposition to explain the contribution of each form of financing to asset growth using firm-level data on US public firms. Each column shows a regression of the annual percentage asset growth on the percentage growth in sources of financing according to Eq. 2. The % growth in each variable X is computed as $\Delta \log(\mathrm{X})$ and, for profitability, it is computed as log(1+operating income/assets). Firm-level data are from CRSP-Compustat covering the period from 1950 to 2017. Table A.2 provides variable definitions. Standard errors are clustered at the firm level and are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Equity growth	0.515***			0.410***	0.390***		0.412***	0.381***
	(0.006)			(0.005)	(0.005)		(0.006)	(0.006)
% Net debt growth		0.150***		0.157***	0.149***			
		(0.003)		(0.003)	(0.003)			
% Debt growth						0.138***	0.126***	0.116***
						(0.002)	(0.002)	(0.002)
% Profitability			0.159***	0.069***	0.076***		0.075***	0.077***
			(0.008)	(0.009)	(0.010)		(0.009)	(0.009)
Tangibility$_{t-1}$					-0.004			-0.097***
					(0.010)			(0.011)
Tobin's Q$_{t-1}$					0.004			0.003
					(0.002)			(0.002)
Size$_{t-1}$					-0.037***			-0.051***
					(0.002)			(0.002)
Firm & Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	156,504	101,960	163,733	91,838	83,426	135,126	120,733	108,640
R^2	0.195	0.220	0.048	0.516	0.515	0.130	0.325	0.334

Table 6: Asset growth decomposition using a panel VAR model at the firm level

The panel VAR model at the firm level shows the relations between the asset growth rate $\frac{\Delta A}{A}$ and the three main sources of financing for firms. These sources are debt financing, proxied by the net debt issuance to assets ratio $\frac{\Delta B}{A}$, equity financing, proxied by the equity issuance to assets ratio $\frac{\Delta E}{A}$, and internally generated funds, proxied by the operating income to assets ratio $\frac{Y}{A}$. Each column shows one equation of the VAR system with up to three lags of the variables. We use the US public firms data from CRSP-Compustat over 1950-2017. Variable definitions are provided in Appendix A. Standard errors are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

		Dependent variables at time t			
		$\Delta A/A$	$\Delta B/A$	$\Delta E/A$	Y/A
		(1)	(2)	(3)	(4)
Asset growth $\Delta A/A$	$t-1$	0.053***	0.048***	-0.010	0.111***
		(0.013)	(0.017)	(0.018)	(0.011)
	$t-2$	-0.17	0.022	-0.034**	-0.002
		(0.012)	(0.015)	(0.015)	(0.008)
	$t-3$	0.017	0.010	0.011	0.006
		(0.011)	(0.013)	(0.014)	(0.008)
Debt issuance $\Delta B/A$	$t-1$	-0.055	-0.026	-0.045***	-0.172***
		(0.034)	(0.016)	(0.016)	(0.010)
	$t-2$	0.013	-0.012	0.015	0.002
		(0.1.18)	(0.015)	(0.014)	(0.008)
	$t-3$	-0.012	-0.010	-0.012	-0.006
		(0.009)	(0.012)	(0.013)	(0.007)
Equity issuance $\Delta E/A$	$t-1$	0.111***	0.022	0.099***	0.087***
		(0.012)	(0.016)	(0.016)	(0.010)
	$t-2$	0.061***	0.030**	0.029**	-0.029
		(0.011)	(0.014)	(0.014)	(0.027)
	$t-3$	0.005	0.013	-0.006	-0.026
		(0.010)	(0.012)	(0.013)	(0.027)
Operating income Y/A	$t-1$	0.008	-0.093**	0.023	0.503***
		(0.009)	(0.043)	(0.014)	(0.010)
	$t-2$	-0.015	-0.025	0.001	0.052***
		(0.010)	(0.016)	(0.014)	(0.009)
	$t-3$	0.006	0.008	-0.007	0.047***
		(0.008)	(0.010)	(0.010)	(0.007)
Tangibility	$t-1$	-0.245***	-0.226***	-0.023	0.013
		(0.019)	(0.019)	(0.017)	(0.010)
Tobin's Q	$t-1$	0.009***	0.001	0.009***	-0.007***
		(0.002)	(0.002)	(0.002)	(0.001)
Size	$t-1$	-0.047***	0.010***	-0.058***	0.001
		(0.003)	(0.003)	(0.003)	(0.001)
Firm & Year FE		Yes	Yes	Yes	Yes
N		108,461	108,461	108,461	108,461

Table 7: Baseline simulated method of moments estimation

This table contains the results of our baseline estimations. Actual data moments are based on the US aggregate time series from 1946 to 2017. Panel A reports the actual moments, model-simulated moments, and the t-statistics for their differences. Panel B shows the parameter estimates and the t-statistics. Parameters $\{\tau, \beta, \rho, \sigma, \alpha\}$ are directly estimated from the data, and parameters $\{\theta, \delta, \xi, \kappa\}$ are estimated with SMM. Appendix A provides variable definitions in the actual data and the model. Appendix D explains the computation of the t-statistics.

Panel A: Moments

	Actual	Model	t-stat. of difference
Target moments:			
Mean labor share	0.626	0.626	(0.00)
Mean investment rate	0.079	0.079	(0.00)
Mean debt ratio	0.306	0.306	(0.00)
SD net payout ratio	0.013	0.012	(0.00)
Other moments:			
Corr(asset growth, net payout ratio)	-0.347	-0.433	(0.72)
Corr(asset growth, debt issue ratio)	0.164	-0.198	(4.60)
Mean net payout ratio	0.019	0.028	(-0.01)
SD investment rate	0.009	0.007	(0.00)
SD debt ratio	0.169	0.016	(0.05)

Panel B: Parameter estimates

		Estimate	t-stat.
Directly estimated parameters:			
Tax advantage	τ	0.425	(50.19)
Discount rate	β	0.961	(11.21)
Persistence of TFP	ρ	0.919	(57.24)
Volatility of TFP shock	σ	0.018	(11.63)
Utility parameter	α	1.963	N/A
SMM estimated parameters:			
Production technology	θ	0.349	(28.59)
Depreciation rate	δ	0.079	(27.83)
Debt enforcement parameter	ξ	0.431	(15.43)
Payout adjustment cost	κ	0.018	(10.03)

Table 8: Model estimation around the NSMIA 1996

This table shows the results from two estimations for the periods before and after the passage of the NSMIA. The full sample is based on the US aggregate time series from 1946 to 2017. Panel A reports the actual moments, the model-simulated moments, and the t-statistics for their differences. Panel B shows the parameter estimates and the t-statistics. Parameters $\{\tau, \beta, \rho, \sigma, \alpha\}$ are directly estimated from data, and parameters $\{\theta, \delta, \xi, \kappa\}$ are estimated with SMM. Appendix A provides variable definitions in the actual data and the model. Appendix D explains the computation of the t-statistics.

Panel A: Moments

	Before 1996			After 1996		
	Actual	Model	Difference t-stat.	Actual	Model	Difference t-stat.
Target moments:						
Mean labor share	0.635	0.635	(0.00)	0.605	0.605	(0.00)
Mean investment rate	0.078	0.078	(0.00)	0.083	0.083	(0.00)
Mean debt ratio	0.234	0.234	(0.00)	0.481	0.481	(0.00)
SD net payout ratio	0.008	0.008	(0.00)	0.012	0.011	(0.00)
Other moments:						
Corr(asset growth, net payout ratio)	-0.225	-0.310	(0.41)	-0.707	-0.478	(-0.41)
Corr(asset growth, debt issue ratio)	0.031	-0.129	(1.79)	0.297	-0.144	(1.44)
Mean net payout ratio	0.013	0.011	(-0.00)	0.034	0.036	(0.00)
SD investment rate	0.009	0.007	(0.00)	0.008	0.007	(0.00)
SD debt ratio	0.149	0.014	(0.04)	0.033	0.012	(0.01)

Panel B: Parameter estimates

		Before 1996		After 1996	
		Estimate	t-stat.	Estimate	t-stat.
Directly estimated parameters:					
Tax advantage	τ	0.455	(60.89)	0.350	N/A
Discount rate	β	0.954	(11.44)	0.980	(4.52)
Persistence of TFP	ρ	0.922	(17.64)	0.794	(3.54)
Volatility of TFP shock	σ	0.018	(10.77)	0.018	(7.79)
Utility parameter	α	1.941	N/A	2.101	N/A
SMM estimated parameters:					
Production technology	θ	0.331	(39.24)	0.386	(63.16)
Depreciation rate	δ	0.078	(5.54)	0.083	(22.13)
Debt enforcement parameter	ξ	0.425	(14.62)	0.478	(59.11)
Payout adjustment cost	κ	0.124	(100.69)	0.002	(0.27)

Table 9: Effects of the debt and buyback policy limits on the data moments

This table shows simulated moments generated from constrained models under debt and buyback policy limits. The baseline estimated parameters are used in simulations. The table also contains the moments from actual data and baseline simulations as a benchmark. Appendix A provides variable definitions in the actual data and the model.

Moments	Actual	Model simulations			
		Baseline	Debt limit	Buyback limit	
			$50\%*b_{ss}^{\text{baseline}}$	$105\%*d_{ss}^{\text{baseline}}$	$110\%*d_{ss}^{\text{baseline}}$
Mean labor share	0.626	0.626	0.651	0.620	0.614
Mean investment rate	0.079	0.079	0.079	0.079	0.079
Mean debt ratio	0.306	0.306	0.183	0.305	0.298
SD net payout ratio	0.012	0.012	0.004	0.001	0.008
Corr(asset growth, net payout)	-0.347	-0.433	-0.989	0.086	-0.165
Corr(asset growth, debt issue)	0.164	-0.198	-0.010	0.424	0.158
Mean net payout ratio	0.019	0.028	0.036	0.030	0.032
SD investment rate	0.009	0.007	0.007	0.006	0.005
SD debt ratio	0.169	0.015	0.006	0.012	0.009

Table 10: Simulated moments and parameters of the model with heterogeneous firms

Panel A shows the model-simulated moments. For comparison, this panel also reports simulated moments from the baseline model and actual data moments that are based on US aggregate time series over 1946-2017. Appendix A provides variable definitions. Panel B show the set of parameters used in simulations. This set includes the tax advantage of debt τ, discount rate β, utility parameter α, production technology θ and ν, depreciation rate δ, debt enforcement parameter ξ, payout adjustment cost κ, and persistence and volatility of TFP shocks for the aggregate ρ_a, σ_a and idiosyncratic ρ_f, σ_f shocks.

Panel A: Moments

	Actual	Model simulation	
		Baseline	Heterogeneous firms
Target moments:			
Mean labor share	0.626	0.626	0.626
Mean investment rate	0.079	0.079	0.079
Mean debt ratio	0.306	0.306	0.306
SD net payout ratio	0.013	0.012	0.014
Other moments:			
Corr(asset growth, net payout ratio)	-0.347	-0.433	-0.363
Corr(asset growth, debt issue ratio)	0.164	-0.198	0.172
Mean net payout ratio	0.019	0.028	0.048
SD investment rate	0.009	0.007	0.015
SD debt ratio	0.169	0.016	0.027

Panel B: Parameters

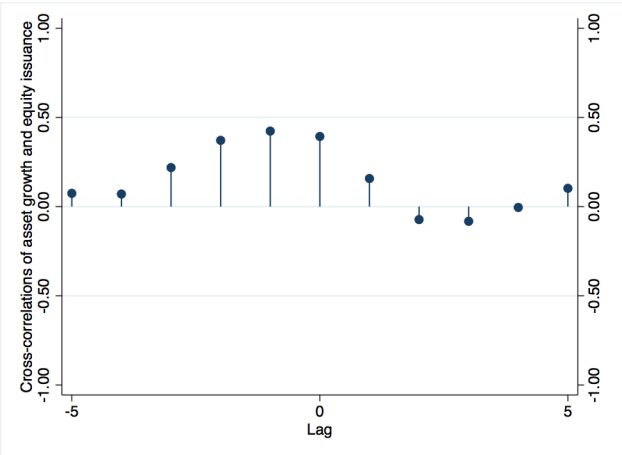
τ	β	α	θ	ν	δ	ξ	κ	ρ_a	σ_a	ρ_f	σ_f
0.35	0.961	1.665	0.290	0.643	0.079	0.524	0.179	0.980	0.028	0.930	0.023

Figure 1: Cross-correlations between elements of the asset growth decomposition

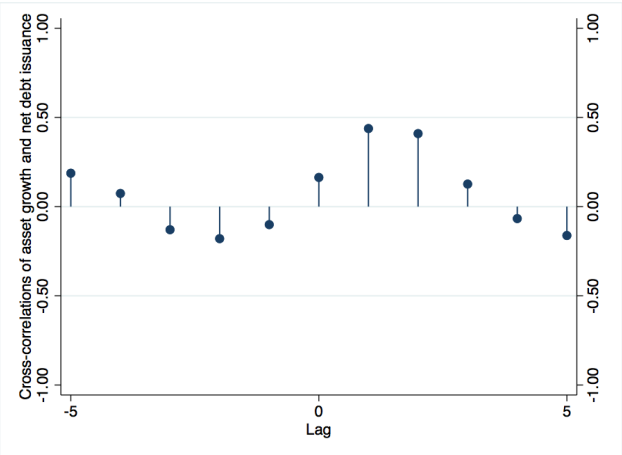
$$\frac{\Delta A_{t+1}}{A_t} = \frac{Y_t}{A_t} + \frac{\Delta E_{t+1}}{A_t} + \frac{\Delta B_{t+1}}{A_t} - \frac{D_t}{A_t} - \frac{r_t B_t}{A_t} - \delta - \frac{T_t}{A_t}.$$

These figures show the cross-correlations between elements of the asset growth decomposition equation. Each figure covers a pair of variables. For instance, Panel (a) shows correlations between the asset growth rate $\frac{\Delta A_{t+1}}{A_t}$ and up to five leads and lags of equity issuance to assets $\frac{\Delta E_{t+1}}{A_t}$. Here we cover the correlations between the growth rate of the non-financial assets ratio ($\frac{\Delta A_{t+1}}{A_t}$), the equity issuance to assets ratio ($\frac{\Delta E_{t+1}}{A_t}$), the net debt issuance to assets ratio ($\frac{\Delta B_{t+1}}{A_t}$), and the operating income to assets ratio ($\frac{Y_t}{A_t}$). Estimations are based on aggregate data on US businesses from 1946 to 2017. Variable definitions are provided in Appendix A.

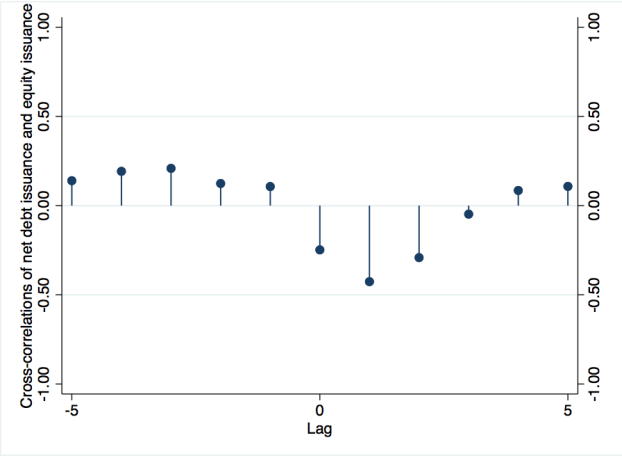
(a) Corr. btw $\frac{\Delta A_{t+1}}{A_t}$ (t=0) and $\frac{\Delta E_{t+1}}{A_t}$ (t=-5,...,+5)



(b) Corr. btw $\frac{\Delta A_{t+1}}{A_t}$ (t=0) and $\frac{\Delta B_{t+1}}{A_t}$ (t=-5,...,+5)



(c) Corr. btw $\frac{\Delta B_{t+1}}{A_t}$ (t=0) and $\frac{\Delta E_{t+1}}{A_t}$ (t=-5,...,+5)



(d) Corr. btw $\frac{\Delta A_{t+1}}{A_t}$ (t=0) and $\frac{Y_t}{A_t}$ (t=-5,...,+5)

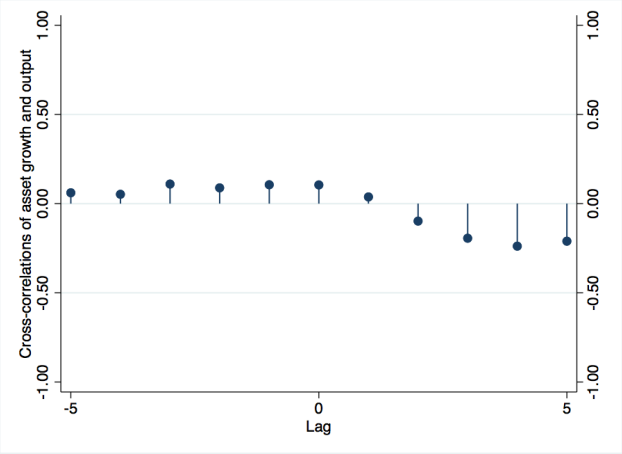
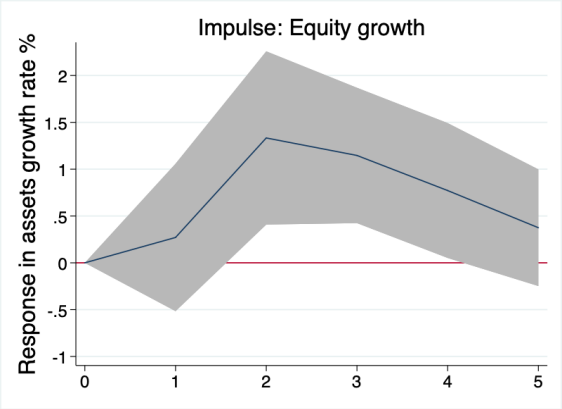


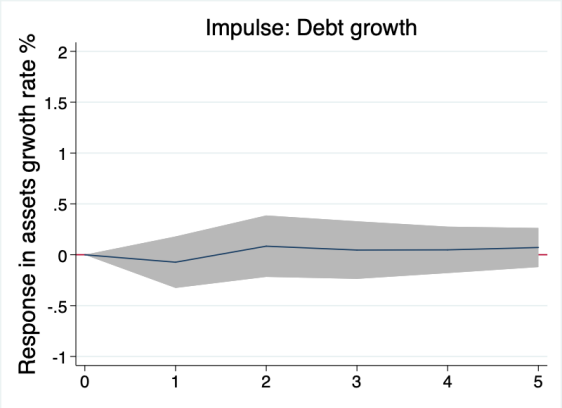
Figure 2: Impulse response functions estimated by the VAR

This figure uses the estimated VAR model in Table 4 to quantify the impact of a shock to each method of financing on asset growth. Each graph shows the response in the asset growth rate to a 1% temporary increase in equity issuance to assets ($\frac{\Delta E}{A}$), net debt issuance to assets ($\frac{\Delta B}{A}$), or operating income to assets ($\frac{Y}{A}$) at time 0. Shaded areas show the 90% confidence interval.

(a) Response in asset growth rate to a 1% increase in equity issuance at time 0



(b) Response in asset growth rate to a 1% increase in net debt issuance at time 0



(c) Response in asset growth rate to a 1% increase in operating income at time 0

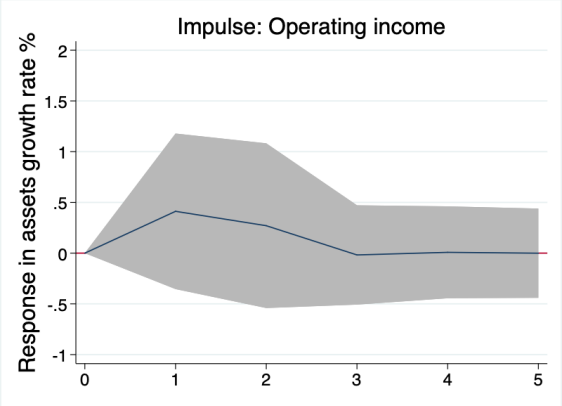
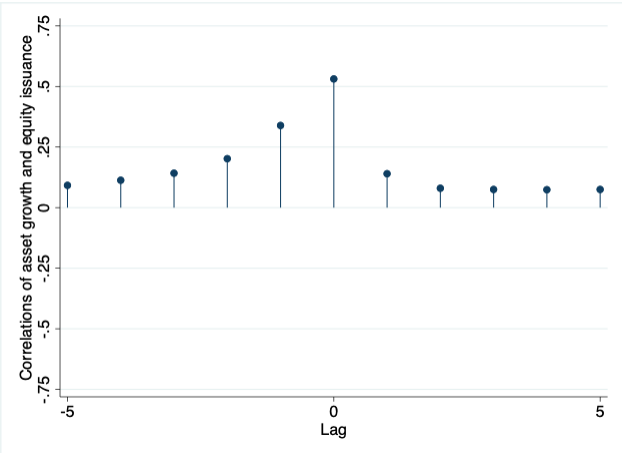


Figure 3: Firm-level cross-correlations between elements of the asset growth decomposition

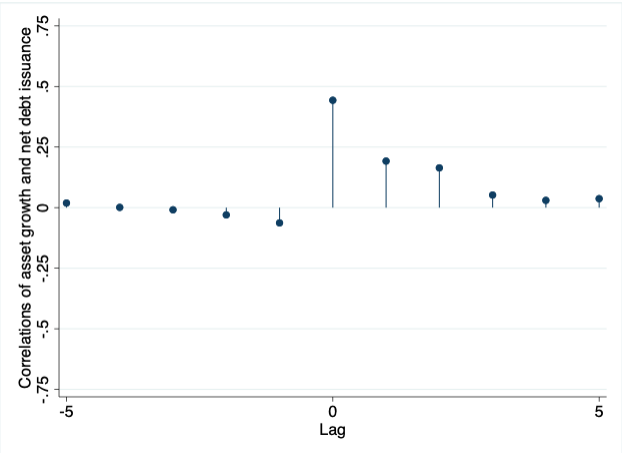
$$\frac{\Delta A_{t+1}}{A_t} = \frac{Y_t}{A_t} + \frac{\Delta E_{t+1}}{A_t} + \frac{\Delta B_{t+1}}{A_t} - \frac{D_t}{A_t} - \frac{r_t B_t}{A_t} - \delta - \frac{T_t}{A_t}.$$

These figures show the firm-level cross-correlations between elements of the asset growth decomposition equation. Each figure covers a pair of variables. For instance, Panel (a) shows firm-level correlations between the asset growth rate $\frac{\Delta A_{t+1}}{A_t}$ and up to five leads and lags of equity issuance to assets $\frac{\Delta E_{t+1}}{A_t}$. Here we cover the relations between the growth rate of the non-financial assets ratio ($\frac{\Delta A_{t+1}}{A_t}$), equity issuance to assets ratio ($\frac{\Delta E_{t+1}}{A_t}$), net debt issuance to assets ratio ($\frac{\Delta B_{t+1}}{A_t}$), and operating income to assets ratio ($\frac{Y_t}{A_t}$). Estimations are based on US firm level data from CRSP-Compustat covering 1950-2017. Variable definitions are provided in Appendix A.2.

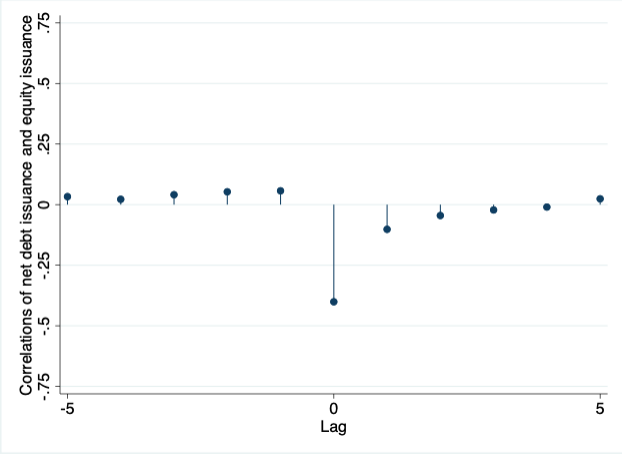
(a) Corr. btw $\frac{\Delta A_{t+1}}{A_t}$ (t=0) and $\frac{\Delta E_{t+1}}{A_t}$ (t=-5,...,+5)



(b) Corr. btw $\frac{\Delta A_{t+1}}{A_t}$ (t=0) and $\frac{\Delta B_{t+1}}{A_t}$ (t=-5,...,+5)



(c) Corr. btw $\frac{\Delta B_{t+1}}{A_t}$ (t=0) and $\frac{\Delta E_{t+1}}{A_t}$ (t=-5,...,+5)



(d) Corr. btw $\frac{\Delta A_{t+1}}{A_t}$ (t=0) and $\frac{Y_t}{A_t}$ (t=-5,...,+5)

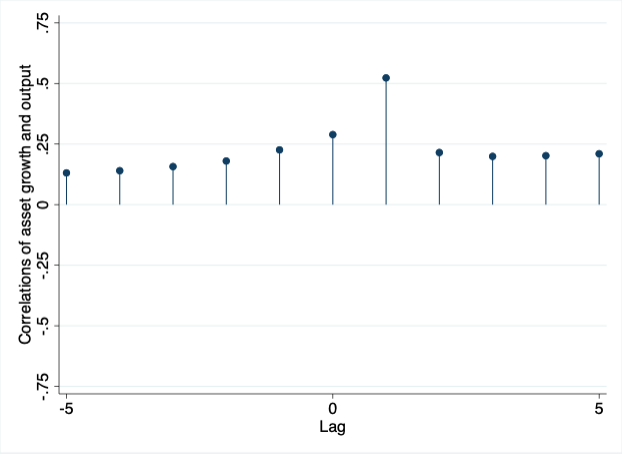


Figure 4: How does the economy respond to a positive productivity shock?

We use the baseline model estimation to show the dynamics of model variables in response to a one-standard-deviation shock to the firm's productivity at time 1. The firm is at the steady state at time 0. Vertical axes show percentage deviations from the steady state.

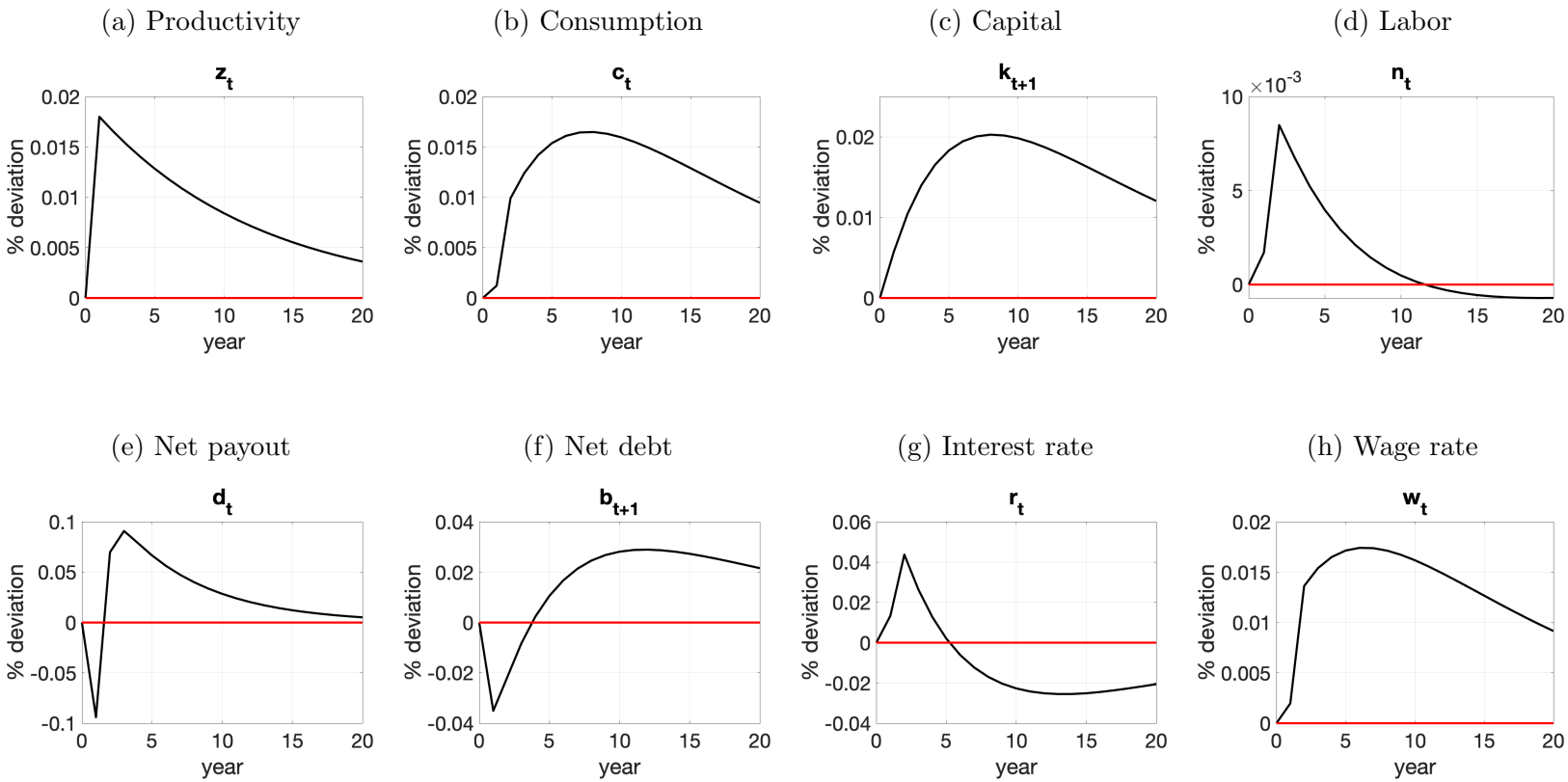


Figure 5: Cross-correlations in the simulated data

This figure uses simulated data from the model to replicate the cross-correlations between elements of the asset growth decomposition equation. Each figure covers a pair of variables. For instance, Panel (a) shows correlations between the asset growth rate and up to five leads and lags of equity issuance to assets. We cover the correlations between the asset growth rate, equity issuance to assets ratio, net debt issuance to assets ratio, and operating income to assets ratio. Equity issuance is defined as negative payouts. Variable definitions are provided in Table A.3 in Appendix A.

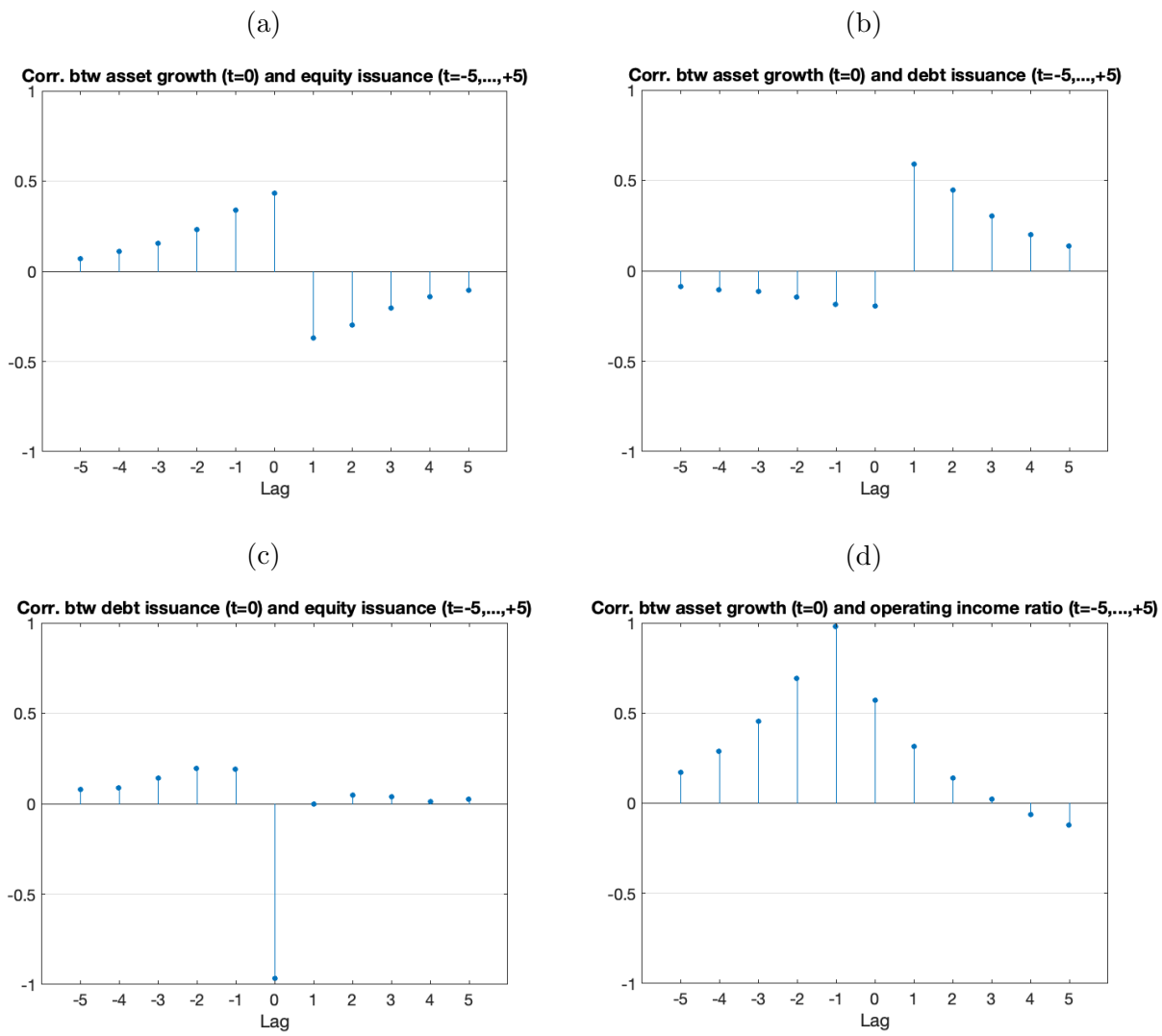
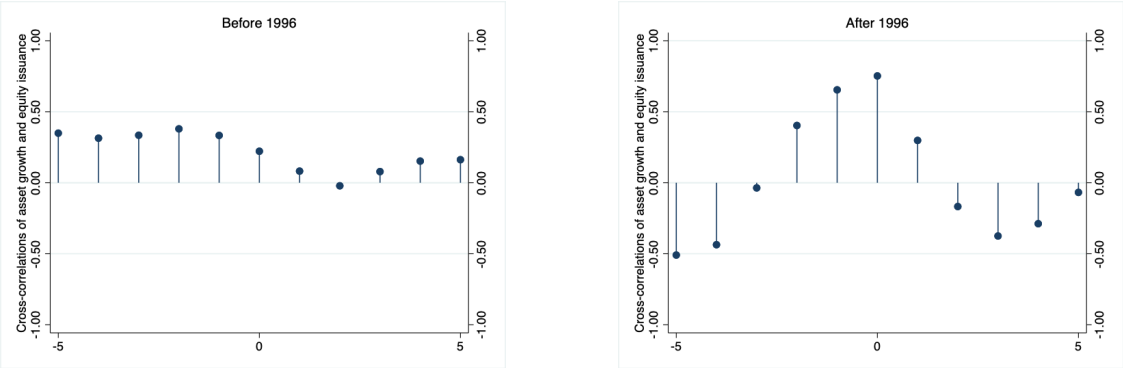


Figure 6: Cross-correlations between asset growth and financing around the NSMIA 1996

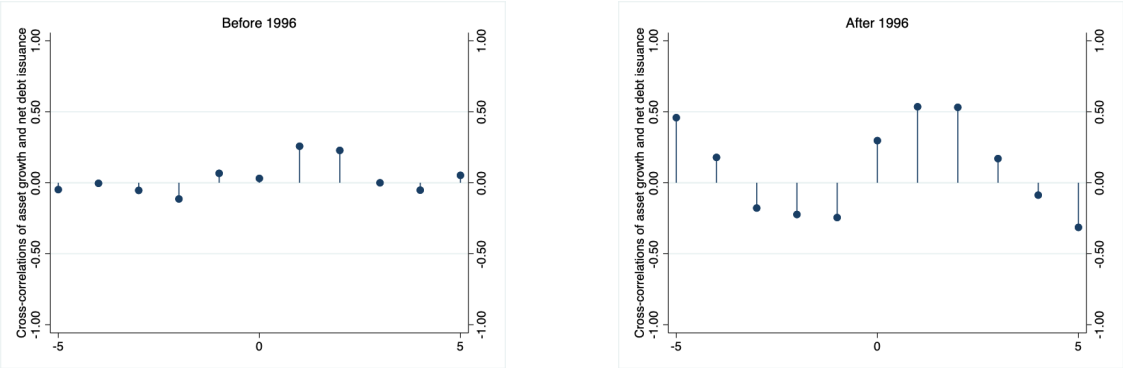
These figures show the cross-correlations between the asset growth rate ($\frac{\Delta A_{t+1}}{A_t}$), equity issuance to assets ($\frac{\Delta E_{t+1}}{A_t}$), and net debt issuance to assets ($\frac{\Delta B_{t+1}}{A_t}$), similar to Figure 1. Estimations are based on aggregate data on US businesses from 1946 to 2017. We split the sample in the year 1996, when the NSMIA is passed. Variable definitions are available in Appendix A.

Before 1996 **After 1996**

(a) Correlations between $\frac{\Delta A_{t+1}}{A_t}$ (t=0) and $\frac{\Delta E_{t+1}}{A_t}$ (t=-5,...,+5)



(b) Correlations between $\frac{\Delta A_{t+1}}{A_t}$ (t=0) and $\frac{\Delta B_{t+1}}{A_t}$ (t=-5,...,+5)



(c) Correlations between $\frac{\Delta B_{t+1}}{A_t}$ (t=0) and $\frac{\Delta E_{t+1}}{A_t}$ (t=-5,...,+5)

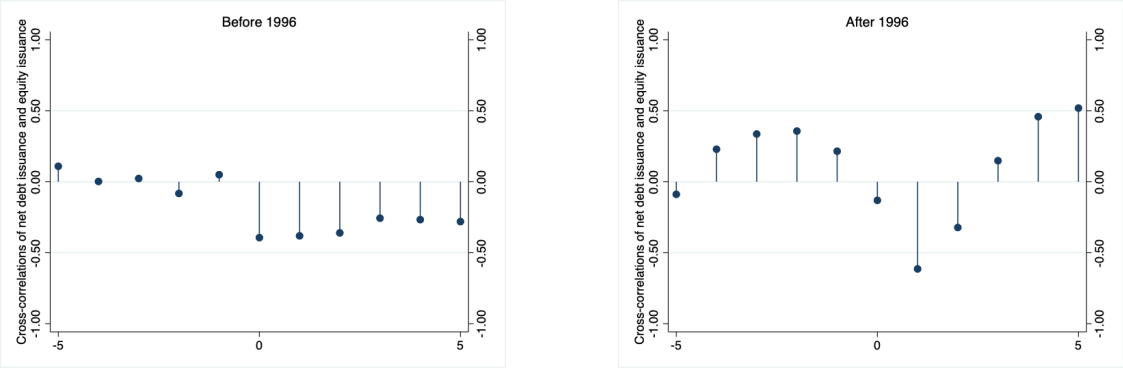


Figure 7: Isolating the effects of a reduction in the equity adjustment cost (κ)

These figures show the effect of a change in the equity adjustment cost (κ) on the dynamics of model variables in response to a one-standard-deviation shock to productivity at time 1. Dashed lines show responses when model parameters are set to "Before 1996" estimates in Table 8, capturing the high-issuance cost period. Solid lines use the same set of parameters except for κ, which is reduced to its "After 1996" value of 0.002. The firm is at the steady state at time 0. Vertical axes show percentage deviations from the steady state.

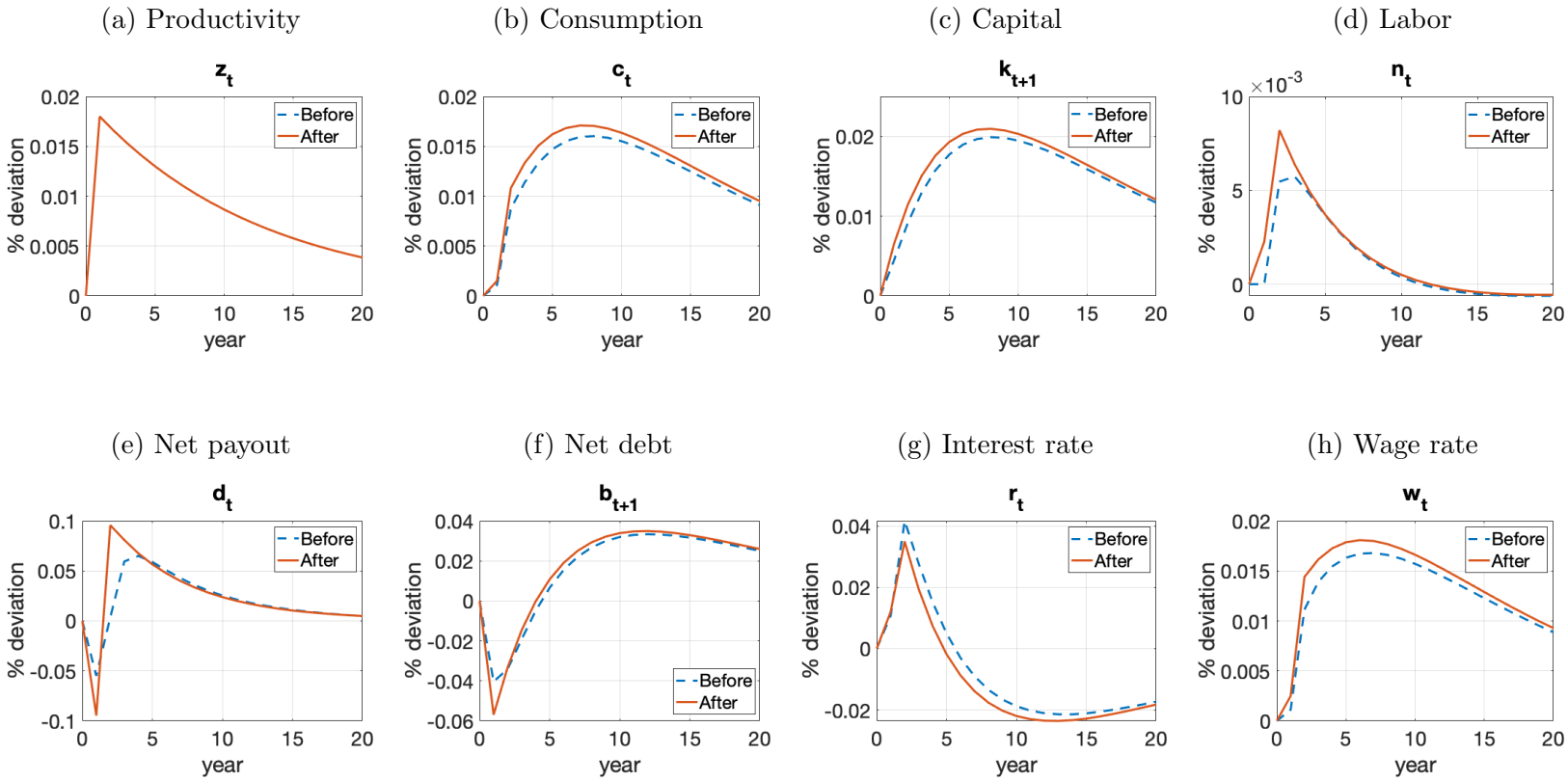


Figure 8: Effects of an exogenous debt limit on responses to productivity shocks

These figures show the dynamics of model variables in response to a one-standard-deviation shock to the firm's productivity at time 1. The firm is at the steady state at time 0. Dashed lines are from the baseline model. Solid lines are generated by a version of the model with an exogenous debt limit set to 50% of the average debt in the baseline model.

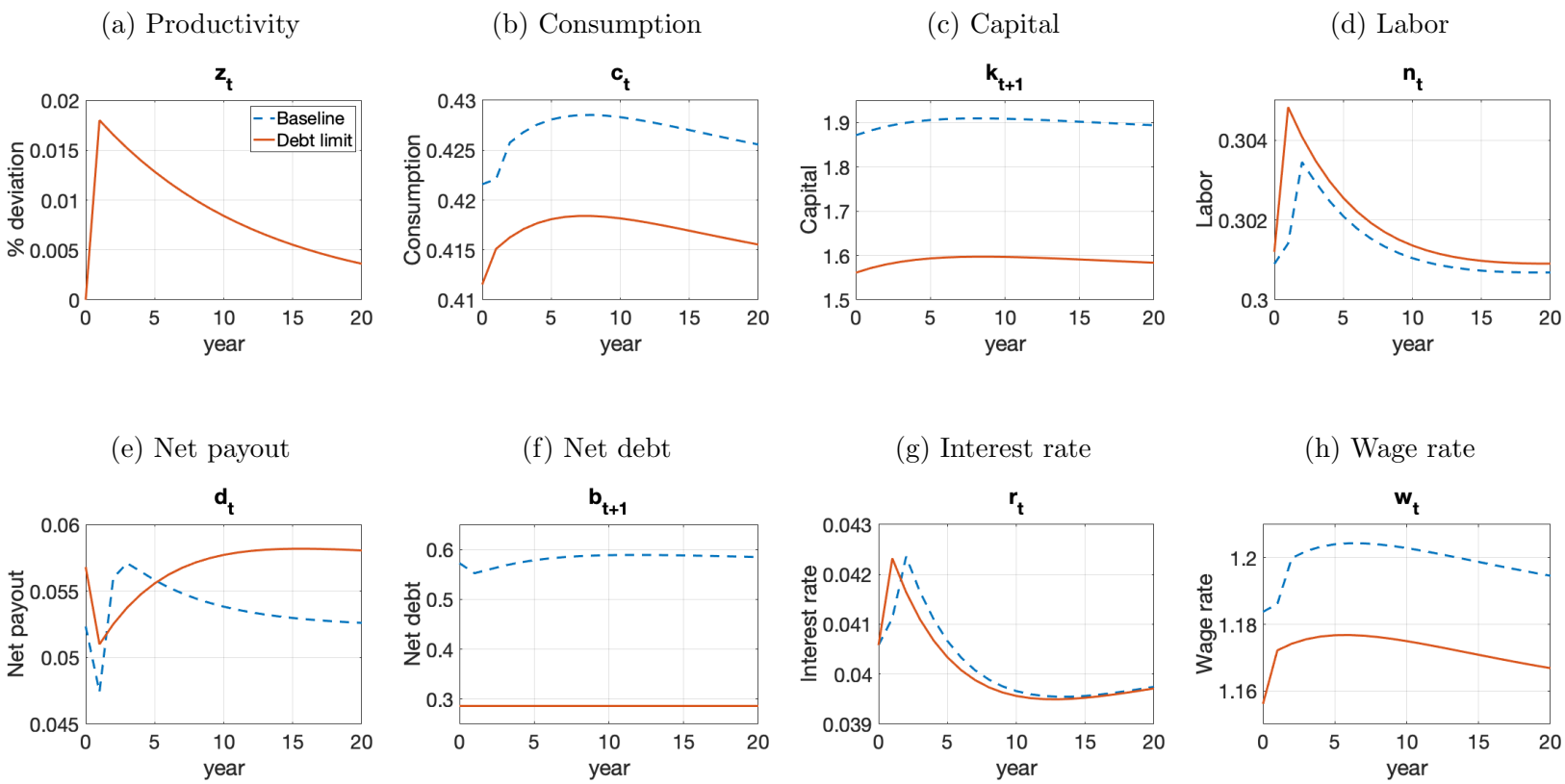
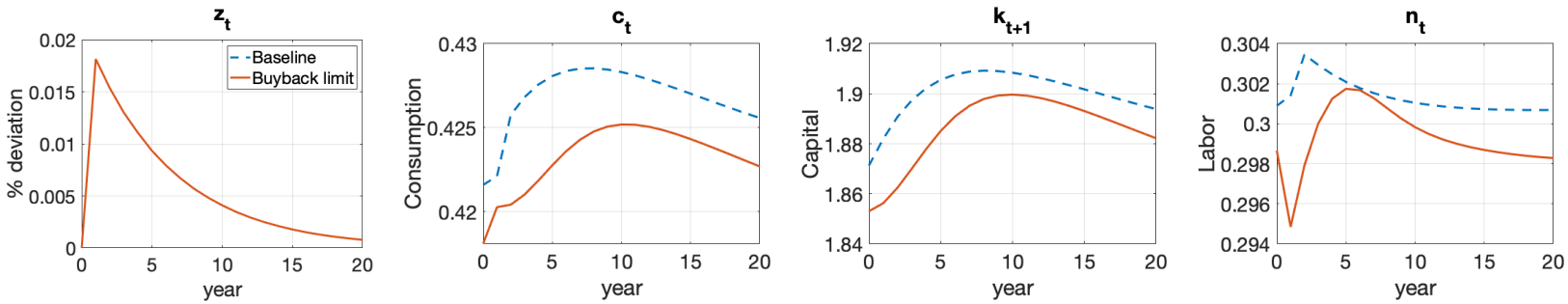


Figure 9: Effects of an exogenous buyback limit on responses to productivity shocks

These figures show the dynamics of model variables in response to a one-standard-deviation shock to the firm's productivity at time 1. The firm is at the steady state at time 0. Dashed lines are from the baseline model. Solid lines are generated by a version of the model with an exogenous buyback limit that limits the firm's net payout to 105% of baseline steady-state payouts.

(a) Productivity (b) Consumption (c) Capital (d) Labor



(e) Net payout (f) Net debt (g) Interest rate (h) Wage rate

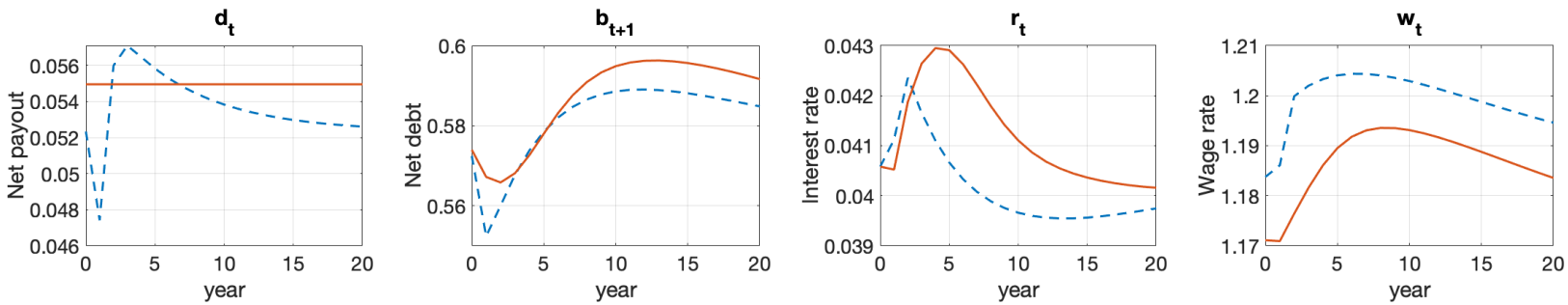


Figure 10: How does the economy with heterogeneous firms respond to a positive productivity shock to *one firm*?

We use the model with heterogeneous firms to show the dynamics of variables in response to an unexpected positive shock to idiosyncratic productivity of *only firm 1* at time 1. The economy is at the steady state at time 0. Vertical axes show percentage deviations from the steady state.

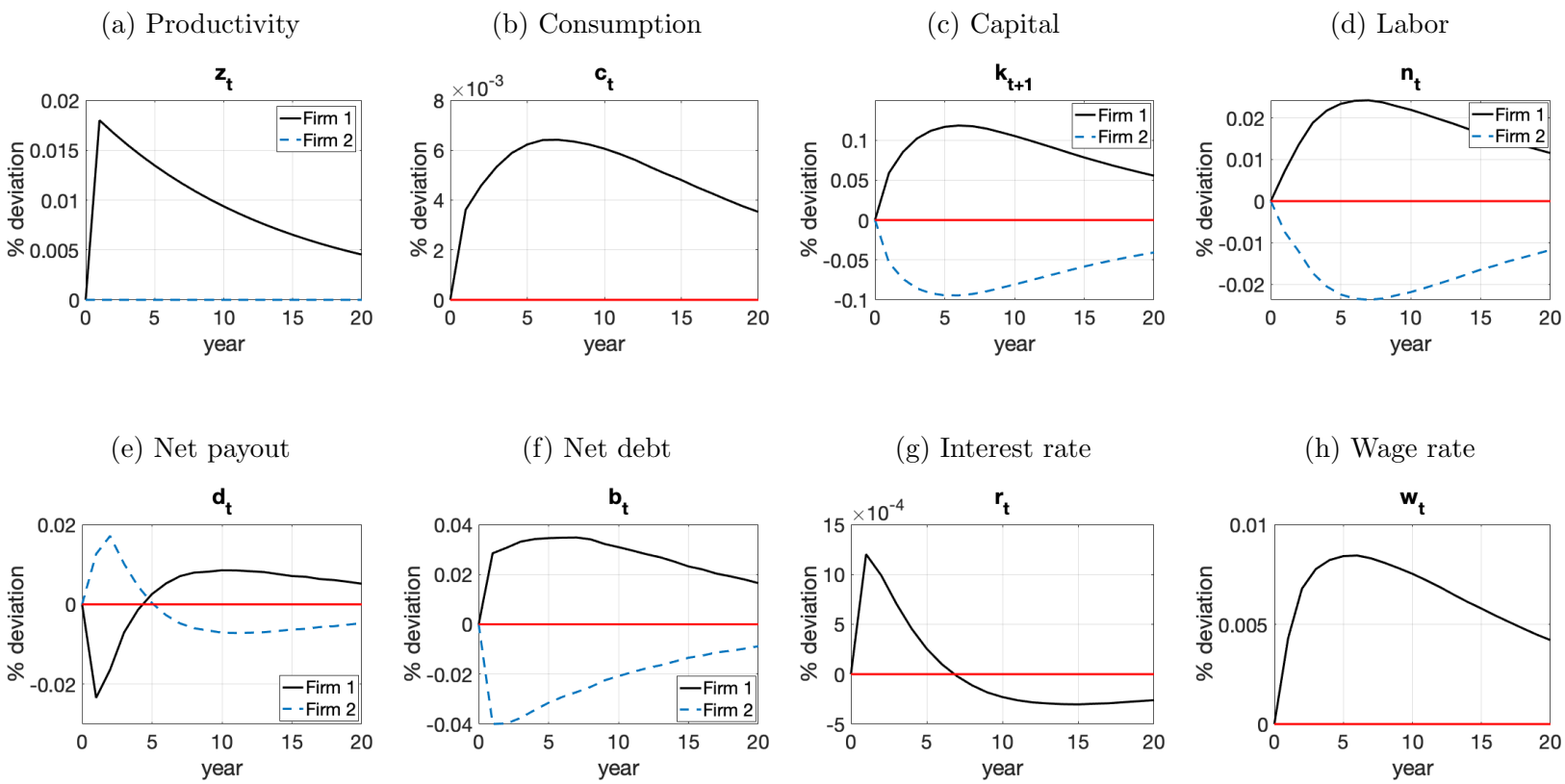
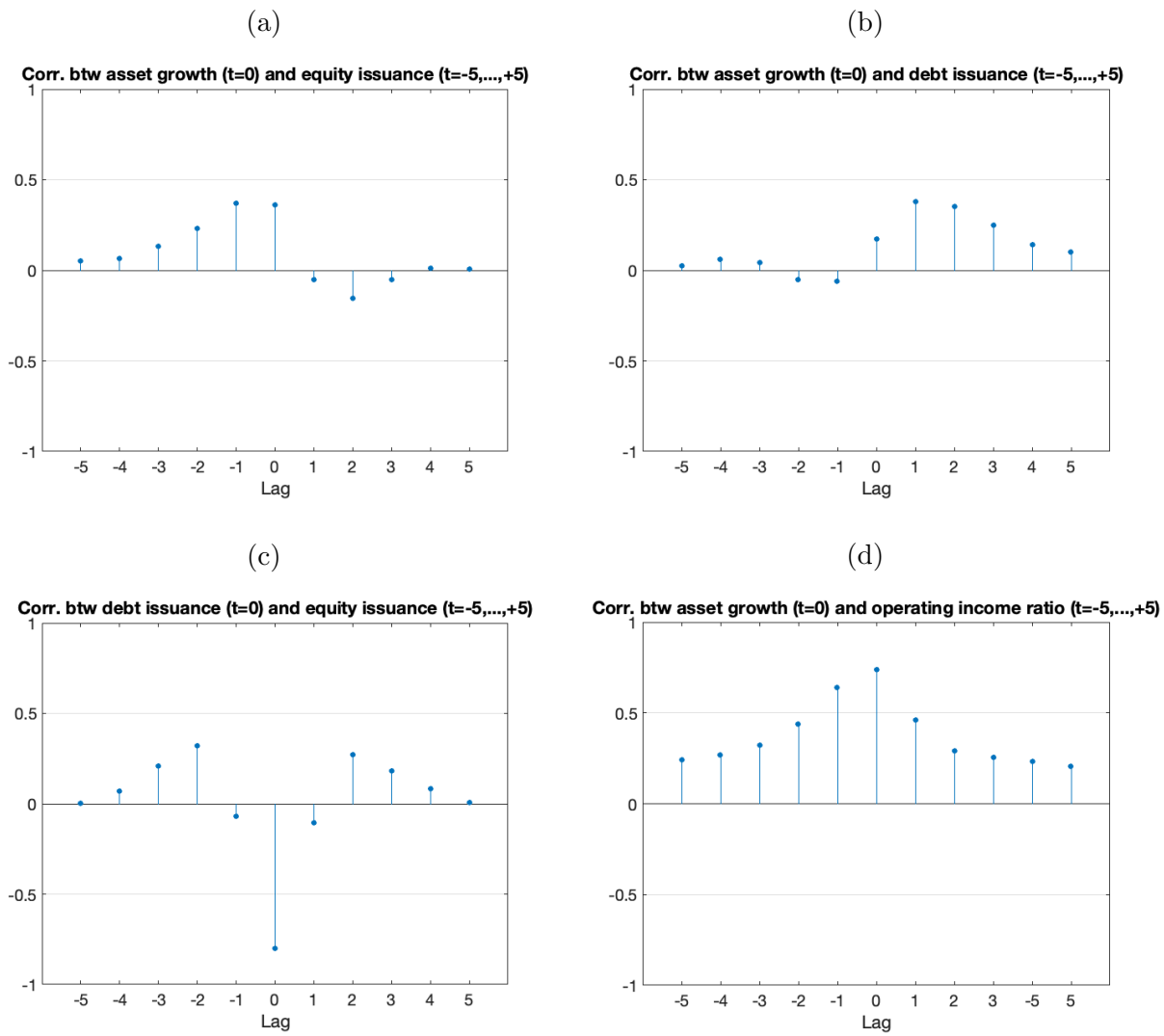


Figure 11: Cross-correlations in the simulated data with heterogeneous firms

This figure uses simulated data from the model with heterogeneous firms to replicate the cross-correlations between elements of the asset growth decomposition equation. Each figure covers a pair of variables. For instance, Panel (a) shows correlations between the asset growth rate and up to five leads and lags of equity issuance to assets. The correlations between the asset growth rate, equity issuance to assets ratio, net debt issuance to assets ratio, and operating income to assets ratio are shown. Equity issuance is defined as negative payouts. Variable definitions are provided in Table A.3 in Appendix A.



A Variable definitions

Table A.1: Variable definitions for the US aggregate data

This table shows how we construct each of the aggregate variables using Financial Accounts of the United States issued by the Federal Reserve Board. Each variable is computed as the sum of relevant elements for non-financial corporate businesses and non-corporate businesses.

Variable	**Symbol**	**Definition**	**Financial Accounts' item**	**Form (Line)**
Non-financial assets	A	Book value of non-financial assets	FL102010115 + FL112010005	B.103 (45) + B.104 (2)
Operating Income	Y	= Output − Wages		
Output		Gross value added	FA116902505 + FA106902501	S.4.a (1) + S.5.a (1)
Wages		Compensation of employees (paid)	FA116025001 + FA106025005	S.4.a (4) + S.5.a (4)
Net debt	B	= Liabilities − Financial assets		
Liabilities		Total liabilities	FL104190005 + FL114190005	B.103 (25) + B.104 (26)
Financial assets		Total assets−(non-financial + misc. assets)	FL104090005 + FL114090005	B.103 (7) + B.104 (11)
Equity	E	Book value net worth	FL102090115 + FL112090205	B.103 (51) + B.104 (35)
Net equity issuance	ΔE	Net increase in corporate equities	FA103164103	F.103 (47)
		+ Proprietor's net investment in business	+ FA112090205	+ F.104 (32)
Dividends	D	Net dividends	FA106121075	F.103 (3)
Interest paid (net)	rB	Interest paid − Interest received	(FA106130001 - FA106130101)	(S.5.a (16) - S.5.a (12))
			+ (FA116130001 - FA116130101)	+ (S.4.a (13) + S.4.a(11))
Depreciation	δA	Consumption of fixed capital	FA106300003 + FA116300001	S.5.a (36) + S.4.a (28)
Taxes paid	T	Taxes on production and imports less subsidies	FA116240101 + FA106240101	S.4.a (7) + S.5.a (7)

Table A.2: Variable definitions for the US firm-level data

This table shows how firm-level variables are constructed. Item names refer to CRSP-Compustat data items.

Variable	**Definition**	**CRSP-Compustat**
Non-financial assets	Total assets−financial assets	$at - (act - invt)$
Operating income	Operating income before depreciation	$oibdp$
Net debt	Total liabilities−financial assets	$lt - (act - invt)$
Pure debt	Total of short- and long-term debt	$dlc + dltt$
Equity	Book value of common equity	ceq
Size	log of total assets	$\log(at)$
Tangibility	Property, plant, and equipment/total assets	$ppent/at$
Tobin's Q	(Mkt value of equity+ total liabilities)/total assets	$\big((prcc_f \times csho) + (at - ceq)\big)/at$

Table A.3: Variable definitions in the model

Variable	**Definition in the model**
Labor share	$w_t n_t / z_t k_t^{\theta} n_t^{1-\theta}$
Assets	k_t
Assets growth rate	$\big(k_{t+1} - k_t\big)/k_t$
Investment rate	$\big(k_{t+1} - (1-\delta)k_t\big)/k_t$
Payout ratio	d_t/k_t
Debt ratio	b_{t+1}/k_t
Debt issue ratio	$\big(b_{t+1} - b_t\big)/k_t$
Operating income ratio	$(z_t k_t^{\theta} n_t^{1-\theta} - w_t n_t)/k_t$

B Extensions of "decomposing financing"

We extend the study of the contribution of different sources of financing to asset growth along several dimension:

B.1 Growth-financing elasticities in non-US countries

We compile an aggregate non-U.S. data set for the members of the Organization for Economic Co-operation and Development (OECD) with the same set of variables as in the aggregate U.S. data set described in the paper. The non-U.S. sample is also compiled with a focus on non-financial corporate sector in each country. The Canadian Financial Flow Accounts and National Balance Sheet Accounts are available from Canada Statistics–the country's national statistical office. The OECD provides National Accounts of the other OECD member countries, from which we use

standard tables 1, 3, 4, 5, 6A, 9B, 14A, and 710. Variable definitions are the same as in Appendix A of the paper.

For most of the OECD countries the balance sheet accounts are available only since the mid-1990s. Because robustness of our analysis depends on the length of the time series, we require a country to have at least 25 years of data, which leaves Australia (1989-2015), Canada (1988-2017), France (1987-2015), and South Korea (1987-2016) in the sample. We add Germany (1995-2014) and the U.K. (1995-2015) because of their economic significance even though they do not meet the 25-year requirement.

Similar to the baseline tests, we run univariate panel regressions of percentage assets growth on the percentage growth equity, net debt, and internal profitability, one at a time. We also include country and year fixed effects to take out country-specific effects and global economic trends.

Table B.4 presents the results. The estimated contribution of external sources of financing on asset growth is very similar to the financing-growth relations in the United States. The contribution of equity issuance to assets growth is about nine times stronger than the contribution of debt issuance. On average, a 1% increase in equity is associated with a 0.34% increase in assets, while a 1% increase in net debt is associated with only 0.04% more assets. Regarding dollar value of the relations, an extra dollar of equity issuance is associated with an extra $1.27 of real assets, while an extra dollar of net debt issuance is associated with $0.37 in extra real assets.

The relation between internal funds and asset growth is, however, very different from what we observe in the aggregate U.S. sample. Column 3 of Table B.4 suggests that, in the non-U.S. sample, asset growth is much more strongly related to the increase in internal profits than to the increase in external financing. Also, the internal financing-growth relation is much stronger in the non-U.S. sample than it is in the U.S. sample. This could be due to the institutional differences between the U.S. and non-U.S. countries (Demirgüç-Kunt and Maksimovic, 1998; La Porta, Lopez-de Silanes, Shleifer, and Vishny, 1997, 1998; Qian and Strahan, 2007) and suggests that American businesses use more external financing to finance their growth.

B.2 Decomposition using detrended data

We detrend the aggregate data using the Hodrick-Prescott high-pass filter to separate the time series into trend and cyclical components. The smoothing parameter for the filter is set to 1600 for our annual data according to Ravn-Uhlig rule. Table B.5 shows the asset growth decomposition

Table B.4: Contribution of different sources of financing to growth in Non-U.S. countries

This table uses aggregate data on business sectors in six non-U.S. countries, including Australia, Canada, France, Germany, Korea, and the U.K. We conduct a modified Blinder-Oaxaca decomposition to explain the contribution of each form of financing to asset growth in non-U.S. countries. Columns show regressions of the annual percentage asset growth on the percentage growth in equity, net debt, or aggregate profitability. The % growth in each variable X is computed as $\Delta \log(X)$ and, for profitability, it is computed as log(1+operating income/assets). Standard errors are clustered at the country level and are shown in parentheses. The *, **, and *** symbols denote statistical significance at 10%, 5%, and 1% levels, respectively.

	% Asset growth			
	(1)	(2)	(3)	(4)
% Equity growth	0.337***			0.261**
	(0.071)			(0.083)
% Net debt growth		0.039		0.047*
		(0.023)		(0.022)
% Profitability			1.235**	1.087**
			(0.349)	(0.244)
Country and year FE	Yes	Yes	Yes	Yes
N	154	114	154	114
R^2	0.602	0.518	0.550	0.682

results using the detrended aggregate data. Columns 1 to 4 of the table show the Blinder-Oaxaca decomposition tests using the growth in equity, net debt, and profitability. Columns 5 and 6 show the results when pure debt is used (instead of net debt).

B.3 Business cycle effects

Eisfeldt and Rampini (2006) document that the benefits to capital reallocation across firms are countercyclical, whereas capital reallocation itself is clearly procyclical. The literature on firm financing over the business cycle documents procyclical debt issuance and countercyclical equity issuance at the aggregate level (e.g., Jermann and Quadrini, 2006). However, the cyclicality of equity issuance varies with size: small firms have procyclical equity financing, whereas large firms have countercyclical equity issuance (Covas and Den Haan, 2011; Begenau and Salomao, 2018). Motivated by these studies, Table B.6 examines the effect of business cycles on the contribution of different sources of financing to corporate asset growth. We add a recession dummy variable and its interactions with the sources of financing to the previous specification.

As expected, asset growth is lower in downturns, as indicated by the negative coefficient on

Table B.5: Using detrended aggregate data to test the financing-growth relations

This table the BO decompositions using detrended aggregate data. Columns show regressions of the annual percentage asset growth on the percentage growth in equity, net debt, or aggregate profitability. The % growth in each variable X is computed as $\Delta \log(\mathrm{X})$ and, for profitability, it is computed as log(1+operating income/assets). Estimations are based on the aggregate US from 1946 to 2017 that is detrended using the HP filter. Heteroscedasticity robust standard errors are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth					
	(1)	(2)	(3)	(4)	(5)	(6)
% Equity growth	0.633***			0.634***		0.633***
	(0.228)			(0.231)		(0.200)
% Net debt growth		0.016		0.029		
		(0.114)		(0.076)		
% Debt growth					0.222	0.225**
					(0.148)	(0.104)
% Profitability			0.083	0.122		0.117
			(0.080)	(0.144)		(0.140)
Const.	0.035***	0.029***	-0.017	0.010	0.029***	0.011
	(0.003)	(0.003)	(0.017)	(0.030)	(0.003)	(0.029)
N	71	71	71	71	71	71
R^2	0.203	0.001	0.006	0.215	0.071	0.285

the recession dummy. Column 1 of Table B.6 suggests that, during recessions, equity growth is much more strongly tied to asset growth, both compared to equity growth during normal times and compared to other sources of financing. In fact, the coefficient on the interaction between equity growth and the recession dummy exceeds one, indicating that the proceeds from equity issuance in downturns are typically combined with resources obtained in other ways. There is weaker but still significant evidence that firm profitability during a recession contributes more to asset growth than during ordinary times. Even in a recession, however, internal profitability does not have as strong an effect as does raising equity.

Table B.6: The effect of business cycles on the financing growth relations

We test the effect of business cycles on the contribution of each form of financing to asset growth using aggregate data on US businesses. Each column shows a regression of the annual percentage asset growth, $\Delta \log(\text{Assets})$, on a recession dummy and its interactions with the percentage growth in equity, $\Delta \log(\text{Equity})$ (column 1), the percentage growth in net debt, $\Delta \log(\text{Net debt})$ (column 2), or aggregate profitability log(1+operating income/assets) (column 3). The recession dummy is defined using the NBER business cycle dates. Estimations are based on the aggregate sample of US corporate and non-corporate businesses that spans from 1946 to 2017. Heteroscedasticity robust standard errors are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth			
	(1)	(2)	(3)	(4)
Recession	-0.018***	-0.024***	-0.132**	-0.114**
	(0.006)	(0.008)	(0.056)	(0.053)
% Equity growth	0.386*			0.471*
	(0.227)			(0.243)
% Equity growth × Recession	1.426***			1.248***
	(0.335)			(0.329)
% Net debt growth		0.019		0.038
		(0.032)		(0.036)
% Net debt growth × Recession		0.057		0.024
		(0.081)		(0.056)
% Profitability			-0.161	-0.327*
			(0.114)	(0.174)
% Profitability × Recession			0.550*	0.464*
			(0.283)	(0.261)
Const.	0.038***	0.034***	0.068***	0.102***
	(0.003)	(0.003)	(0.024)	(0.034)
N	71	71	71	71
R^2	0.474	0.206	0.208	0.532

B.4 Distribution of growth-financing elasticities across US sectors and industries

We investigate whether our main findings are concentrated in certain industries or observed across many different sectors. This test is motivated by the fact that industry effects could explain a great deal of variation in firms' financial and real decisions (Frank and Goyal, 2009). We start by conducting the decomposition exercise within each sector of the US economy. We use the firm-level sample of US public firms and run panel regressions at the firm level controlling for firm characteristics and the firm and year fixed effects.

We define six sectors using the SIC codes: The SIC codes in the range of 1000 to 1400 indicate firms in the "Agriculture & Mining" sector. Similarly, the range 1500 to 1700 indicates "Construction," 2000 to 3900 indicates "Manufacturing," 4000 to 4900 indicates "Transportation & Utilities," 5000 to 5900 indicates "Trade," and 7000 to 8900 indicates "Services." As usual, we drop "Finance, Insurance, and Real Estate" firms with SIC codes 6000 to 6700 and the "Public Administration" sector with SIC codes 9100 to 9900.

Table B.7 presents the results. We find that in all of the main sectors of the US economy, equity issuance contributes more to asset growth than does debt issuance or internal profits—since the elasticity of asset growth with respect to equity is significantly higher than its elasticity with respect to the other two sources of financing. This result is a little weaker in the highly regulated "Transportation and Utilities" sector, in which asset growth is associated more strongly with debt issuance compared to other sectors, but still dominated by equity issuance.

We also repeat this exercise separately for two-digit SIC industries. In the Online Appendix, we plot the histograms for estimated elasticities of asset growth with respect to equity issuance, net debt issuance, and internal profits. The distribution of the estimated coefficients shows that, overall and across majority of the industries, equity growth is more strongly associated with asset growth as compared to growth in the other two sources of finance. Overall, these results rule out the possibility that our baseline findings using the aggregate data are dominated by a few outlier industries.

B.5 Sample splits

We use both aggregate and firm-level data to test whether the main results hold in different time periods throughout the sample. Table B.8 shows the asset growth decomposition when the aggre-

Table B.7: Contribution of different sources of financing to growth across sectors

This table presents a modified Blinder-Oaxaca decomposition to explain the contribution of each form of financing to asset growth within each sector of the US economy. Each column shows a regression of the annual percentage change in asset growth, $\Delta \log(\text{Assets})$, on the percentage change in equity growth, $\Delta \log(\text{Equity})$, the percentage change in net debt growth, $\Delta \log(\text{Net debt})$, or aggregate profitability log(1+operating income/assets). We use firm-level data from CRSP-Compustat covering the period from 1950 to 2017. The "Agriculture & Mining" sector includes firms with a SIC code 1000-1400, "Construction" includes SIC codes 1500-1700, "Manufacturing" includes SIC codes 2000-3900, "Transportation & Utilities" includes SIC codes 4000-4900, "Trade" includes SIC codes 5000-5900, and "Services" includes SIC codes 7000-8900. Table A.2 provides variable definitions. Standard errors are clustered at the firm level and are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth					
	Agriculture & Mining	Construction	Manufacturing	Transportation & Utilities	Trade	Services
	(1)	(2)	(3)	(4)	(5)	(6)
% Equity growth	0.450***	0.401***	0.378***	0.369***	0.373***	0.395***
	(0.015)	(0.036)	(0.007)	(0.013)	(0.013)	(0.014)
% Net debt growth	0.178***	0.196***	0.136***	0.274***	0.164***	0.158***
	(0.010)	(0.030)	(0.003)	(0.015)	(0.017)	(0.007)
% Profitability	0.043*	0.147***	0.087***	0.016	0.118***	0.047**
	(0.023)	(0.046)	(0.013)	(0.031)	(0.033)	(0.021)
Tangibility_{t-1}	0.081***	-0.025	-0.001	-0.002	0.005	-0.059**
	(0.029)	(0.049)	(0.014)	(0.018)	(0.023)	(0.027)
Tobin's Q_{t-1}	0.004	0.006	0.007***	0.003	0.011***	-0.010**
	(0.003)	(0.014)	(0.002)	(0.002)	(0.003)	(0.005)
Size_{t-1}	-0.043***	-0.029**	-0.034***	-0.027***	-0.037***	-0.043***
	(0.006)	(0.014)	(0.002)	(0.004)	(0.004)	(0.005)
Firm and Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	7593	1704	47730	16031	15168	11231
R^2	0.564	0.593	0.520	0.594	0.546	0.475

Table B.8: Sample split: Financing-growth relations over time in the aggregate data

This table conducts the baseline BO decomposition when we (time) split the sample in half to compare the relations over time. Columns show regressions of the annual percentage asset growth on the percentage growth in equity, net debt, or aggregate profitability. The % growth in each variable X is computed as $\Delta \log(\mathrm{X})$ and, for profitability, it is computed as log(1+operating income/assets). Estimations are based on the aggregate sample of US corporate and non-corporate businesses that spans from 1946 to 2017. The columns labeled "Old" cover the years 1946-1981 of the sample and the "New" columns cover data over the period 1982-2017. Heteroscedasticity robust standard errors are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth							
	Old	New	Old	New	Old	New	Old	New
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Equity growth	0.722	0.962*					1.680*	1.167**
	(0.786)	(0.525)					(0.873)	(0.484)
% Net debt growth			0.016	0.168			0.053	0.247***
			(0.041)	(0.118)			(0.044)	(0.081)
% Profitability					0.020	0.482**	-0.299	0.475**
					(0.170)	(0.233)	(0.195)	(0.223)
Const.	0.032***	0.036***	0.032***	0.018**	0.030	-0.074	0.085**	-0.065
	(0.004)	(0.007)	(0.004)	(0.007)	(0.036)	(0.046)	(0.038)	(0.048)
N	36	35	36	35	36	35	36	35
R^2	0.036	0.180	0.007	0.094	0.001	0.050	0.100	0.405

gate time series is split in two halves. The results show that, during both halves of the sample, asset growth is more strongly associated with equity growth than with debt growth and profitability. Although there is a caveat in interpreting the magnitude and statistical significance of the coefficients due to the sample size (35 and 36 annual observations in each part of the sample).

To mitigate the sample size issue, we also estimate decade-by-decade asset growth decomposition regressions using firm-level data. Table B.9 presents the results. We only show the multivariate regressions with firm level controls to save space. Columns 1-5 use net debt and columns 6-10 use pure debt as the main measure of debt financing. The estimations suggest that our core results hold in every decade during the sample period. The asset growth's association with equity growth is consistently more than twice as large as its relation to debt growth and more than four times as large as its relation with profitability. The only exception is that the estimated coefficient on profitability in 1970s is larger than its values in the following decades.

Table B.9: A decade-by-decade look at the financing-growth relations at the firm level

This table presents a modified Blinder-Oaxaca decomposition to explain the contribution of each form of financing to asset growth using firm-level data on US public firms. Each column shows a regression of the annual percentage asset growth on the percentage growth in sources of financing according to Eq. 2. The % growth in each variable X is computed as $\Delta \log(\mathrm{X})$ and, for profitability, it is computed as log(1+operating income/assets). Firm-level data are from CRSP-Compustat covering the period from 1970 to 2017. Table A.2 provides variable definitions. Standard errors are clustered at the firm level and are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth									
	'70s	'80s	'90s	'00s	'10s	'70s	'80s	'90s	'00s	'10s
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
% Equity growth	0.368***	0.399***	0.420***	0.429***	0.426***	0.326***	0.308***	0.391***	0.426***	0.415***
	(0.014)	(0.011)	(0.010)	(0.011)	(0.016)	(0.016)	(0.011)	(0.011)	(0.014)	(0.019)
% Net debt growth	0.154***	0.186***	0.194***	0.183***	0.199***					
	(0.005)	(0.012)	(0.005)	(0.006)	(0.011)					
% Debt growth						0.130***	0.170***	0.159***	0.127***	0.157***
						(0.004)	(0.005)	(0.004)	(0.005)	(0.006)
% Profitability	0.284***	0.098***	0.094***	0.049*	0.068*	0.408***	0.135***	0.091***	0.068***	0.096***
	(0.023)	(0.021)	(0.020)	(0.027)	(0.040)	(0.029)	(0.022)	(0.021)	(0.022)	(0.036)
Tangibility$_{t-1}$	-0.073***	-0.071***	-0.012	-0.033	-0.015	-0.154***	-0.234***	-0.198***	-0.241***	-0.239***
	(0.025)	(0.026)	(0.025)	(0.035)	(0.050)	(0.033)	(0.030)	(0.032)	(0.039)	(0.059)
Tobin's Q$_{t-1}$	0.004	0.001	0.001	-0.010	0.012*	0.004	0.002	0.012***	-0.009***	0.015***
	(0.003)	(0.002)	(0.003)	(0.006)	(0.007)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)
Size$_{t-1}$	-0.072***	-0.086***	-0.091***	-0.088***	-0.123***	-0.084***	-0.112***	-0.120***	-0.134***	-0.139***
	(0.006)	(0.007)	(0.005)	(0.007)	(0.017)	(0.008)	(0.007)	(0.007)	(0.008)	(0.017)
Firm & Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	16981	19020	20227	14921	9032	20640	25470	27372	20281	10958
R^2	0.586	0.554	0.578	0.594	0.564	0.367	0.349	0.368	0.352	0.403

B.6 Accounting for equity-based compensation

Table B.10: Accounting for equity-based compensation in asset growth decomposition

This table repeats the firm level BO decomposition when we account for equity-based compensation by filtering out equity growth values that are less than 5% of firm's assets. Each column shows a regression of the annual percentage asset growth on the percentage growth in sources of financing according to Eq. 2. The % growth in each variable X is computed as $\Delta \log(\mathrm{X})$ and, for profitability, it is computed as log(1+operating income/assets). Firm-level data are from CRSP-Compustat covering the period from 1950 to 2017. Table A.2 provides variable definitions. Standard errors are clustered at the firm level and are shown in parentheses. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Equity growth	0.525***			0.471***	0.449***		0.459***	0.422***
	(0.006)			(0.005)	(0.005)		(0.006)	(0.006)
% Net debt growth		0.183***		0.192***	0.186***			
		(0.003)		(0.003)	(0.004)			
% Debt growth						0.178***	0.169***	0.158***
						(0.002)	(0.002)	(0.002)
% Profitability			0.189***	0.087***	0.095***		0.100***	0.105***
			(0.008)	(0.010)	(0.010)		(0.009)	(0.010)
Tangibility$_{t-1}$					-0.015			-0.122***
					(0.010)			(0.011)
Tobin's Q$_{t-1}$					0.003			0.003
					(0.002)			(0.002)
Size$_{t-1}$					-0.040***			-0.055***
					(0.002)			(0.002)
Firm & Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	157070	101969	163797	92387	83918	135168	121283	109125
R^2	0.199	0.266	0.048	0.584	0.584	0.166	0.370	0.381

B.7 Relation to firm characteristics

We also investigate the impact of firm characteristics on the relation between financing and growth. We focus on tangibility, Tobin's Q, and size, which are known to strongly affect the firms' financing decisions (Rajan and Zingales, 1995; Frank and Goyal, 2009). Table A.2 shows the definitions for these firm characteristics. We run panel regressions of the asset growth percentage on the growth percentage in the sources of financing and their interactions with the firm characteristics. We include firm and year fixed effects, so the results capture the within-firm effects.

Table B.11 presents the results. Columns 1 to 3 study the impact of tangibility, defined as the ratio of tangible to total assets, on how corporate asset growth is related to the sources of financing. Tangibility is negatively related to asset growth, showing that firms with more tangible assets invest at lower rates. The estimated coefficients on the interaction terms suggest that as tangibility increases, equity issuance contributes less (column 1) but debt and internal profits contribute more (columns 2 and 3, respectively) to asset growth. This trade-off between debt and equity is consistent with a collateral effect. As firms accumulate more tangible assets that can be used as collateral, they finance their asset purchases more with debt rather than equity, which could reduce the overall financing costs arising from the tax benefits of debt.

Columns 4 to 6 of Table B.11 show the impact of Tobin's Q, measured as the ratio of the market to book value of total assets. Overall, asset growth is positively related to Tobin's Q, which is expected since Tobin's Q is typically interpreted as a proxy for growth opportunities. However, variation in Tobin's Q does not seem to affect the firms' use of external financing for growth. Columns 7 to 9 show the impact of the size of the firm, measured as the log of assets. As firms get larger, their asset growth rate decreases. The interaction terms suggest that as firms grow in size, their asset growth is more strongly associated with all three sources of financing.

Table B.11: The effect of firm characteristics on the relation between financing and growth

This table uses a modified Blinder-Oaxaca decomposition to assess the impact of firms' tangibility, growth, and size on the contribution of each form of financing to asset growth. Each column shows a regression of the annual percentage change in asset growth, $\Delta \log(\text{Assets})$, on a firm's characteristic and its interactions with the percentage change in equity growth, $\Delta \log(\text{Equity})$, the percentage change in net debt growth, $\Delta \log(\text{Net debt})$, or aggregate profitability log(1+operating income/assets). We use firm-level data from CRSP-Compustat covering the period from 1950 to 2017. Table A.2 provides variable definitions. Standard errors are not shown in order to save space. The *, **, and *** symbols denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	% Asset growth								
	Impact of tangibility			Impact of Tobin's Q			Impact of size		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tangibility	-0.462***	-0.105***	-0.417***						
Tobin's Q				0.018***	0.056***	0.032***			
Size							-0.078***	-0.091***	-0.127***
% Equity growth	0.377***			0.308***			0.243***		
% Net debt growth		0.164***			0.199***			0.137***	
% Profitability			0.160***			0.144***			-0.042***
% Equity growth*Tangibility	-0.202***								
% Net debt growth*Tangibility		0.093***							
% Profitability*Tangibility			0.091**						
% Equity growth*Tobin's Q				0.001					
% Net debt growth*Tobin's Q					-0.003				
% Profitability*Tobin's Q						0.006***			
% Equity growth*Size							0.015***		
% Net debt growth*Size								0.012***	
% Profitability*Size									0.072***
Firm and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	176,359	120,902	185,019	173,571	115,305	174,470	176,560	121,081	185,155
R^2	0.197	0.278	0.055	0.200	0.308	0.076	0.197	0.310	0.090

C Derivation of the Enforcement Constraint

Our debt enforcement constraint arises from the bargaining between firms and creditors, following Jermann and Quadrini (2012). We assume that the firm has all the bargaining power in negotiations with the lender. The decision to default is made after the realization of revenue $F(z_t, k_t, n_t)$ but before the repayment of liabilities, so the firm has total liquidity of $F(z_t, k_t, n_t)$ at the time of default.

If the firm enters bankruptcy, the lender has the right to liquidate the firm's assets. The liquidation value, however, is uncertain at the time of contracting and is unknown to both parties. With probability ξ the lender will be able to fully recover the assets' value, but with probability $1 - \xi$ the recovery value is zero. The parameter ξ reflects the probability that the lender finds a buyer for the seized assets. Because the firm has all the bargaining power, in each case the firm has to make a payment that leaves the lender indifferent between liquidating the assets and letting the firm continue operation.

Case I. Full recovery: In this case, the lender recovers full asset value k_{t+1} in default. So, in order to make the lender indifferent, the firm must pay $k_{t+1} - \frac{b_{t+1}}{1+r_t}$ in the default period and promise to pay b_{t+1} next period, when the intertemporal debt is due. Hence, the ex post default value of the firm is

$$F(z_t, k_t, n_t) + \mathbb{E}_t[m_{t+1}V_{t+1}] - (k_{t+1} - \frac{b_{t+1}}{1 + r_t}). \tag{27}$$

Case II. Zero recovery: In this case, the liquidation value of the firm's assets is zero, so the lender gains nothing from liquidating the firm. The firm does not need to pay anything to the lender to make her indifferent; thus the ex post default value of the firm is

$$F(z_t, k_t, n_t) + \mathbb{E}_t[m_{t+1}V_{t+1}]. \tag{28}$$

Given the above scenarios, the expected default value of the firm when the debt contract is written is

$$F(z_t, k_t, n_t) + \mathbb{E}_t[m_{t+1}V_{t+1}] - \xi(k_{t+1} - \frac{b_{t+1}}{1 + r_t}). \tag{29}$$

Enforcement requires that the solvency value of the firm is not smaller than its default value, that is,

$$\mathbb{E}_t[m_{t+1}V_{t+1}] \geq F(z_t, k_t, n_t) + \mathbb{E}_t[m_{t+1}V_{t+1}] - \xi(k_{t+1} - \frac{b_{t+1}}{1 + r_t}), \tag{30}$$

which could be rearranged in the form of the following enforcement constraint:

$$\xi(k_{t+1} - \frac{b_{t+1}}{1+r_t}) \geq F(z_t, k_t, n_t). \tag{31}$$

D Details of the numerical solution and estimation

Numerical solution. To perform value function iteration, we discretize the state space. The AR(1) process for the idiosyncratic productivity in Equation 19 is discretized on a grid with $N_z = 5$ points, and the transition matrix is computed using the algorithm by Tauchen and Hussey (1991). The quantitative implications of the model do not change when we use finer productivity grids, for example, $N_z = 11$, 15, or 19.[3] The capital and labor grids are equally spaced, with $N_k = N_n = 75$ grid points that are set around the steady state. We set the bounds at $[0.65k_{ss}, 1.30k_{ss}]$ and $[0.75n_{ss}, 1.25n_{ss}]$ so that they are never binding. The grid for net debt is also equally spaced with $N_b = 55$ grid points. The upper bound (b^{UB}) is set at the highest possible value in the enforcement constraint (Equation 4) given the capital and labor grids, and the lower bound is set as $b^{LB} = -0.30 \times b^{UB}$. Note that b is net corporate debt, with positive values interpreted as borrowing and negative values interpreted as firms having a net saving position. Finally, we use the steady-state values as the initial guess to start the value iteration and use the policy function iteration algorithm (Howard's improvement) to improve efficiency.

SMM standard errors. We compute the t-statistics for the parameter estimates and differences in moments in the following way. Under mild regularity conditions, the limiting distribution for the vector of SMM-estimated parameters $\hat{\Theta}$ is given by

$$\sqrt{T}(\hat{\Theta} - \Theta) \to \mathcal{N}(0, V),$$

where T is the size of the time series used in the estimation (e.g., $T = 72$ in the baseline case), $V = (D\hat{W}D')^{-1}$, and $\hat{W}$ is the weighting matrix, which is the inverse of the actual moments covariance matrix $\hat{\Sigma}$. Also, D' is the gradient matrix defined as $D' = \frac{\partial \hat{m}(\Theta)}{\partial \Theta'} = \frac{\hat{m}(\Theta+\Delta\Theta)-\hat{m}(\Theta-\Delta\Theta)}{2\Delta\Theta}$.

The t-statistic for the ith parameter estimate is given by

$$t_i = \frac{\hat{\Theta}_i}{\sqrt{\frac{V_{ii}}{T}}},$$

[3] Results of the numerical robustness tests are available upon request.

and the t-statistic for the jth moment difference is given by

$$t_j = \frac{\hat{M}_j - \hat{m}_j(\hat{\Theta})}{\sqrt{\frac{\hat{\Sigma}_{jj}}{T}(1+\frac{T}{N})}}.$$

E Identification in the SMM

We compute the elasticity of moments with respect to model parameters around the baseline SMM estimates following Hennessy and Whited (2007). To calculate the elasticity of the ith moment $\hat{\boldsymbol{m}}_i(\hat{\Theta})$ with respect to the jth parameter Θ_j, we fix all other parameters at their SMM estimates, simulate the model with different values of $\Theta_j \in [0.95\hat{\Theta}_j, 1.05\hat{\Theta}_j]$ (with 1% increments), and compute $\hat{\boldsymbol{m}}_i(\Theta_j;\hat{\Theta})$ respectively, where $\hat{\Theta}_j$ is the SMM estimate of the jth parameter. The elasticity is

$$\epsilon_{i,j} = \frac{\hat{\boldsymbol{m}}_i^+(\Theta_j;\hat{\Theta}) - \hat{\boldsymbol{m}}_i^-(\Theta_j;\hat{\Theta})}{\Theta_j^+ - \Theta_j^-} \times \frac{\hat{\Theta}_j}{\hat{\boldsymbol{m}}_i(\hat{\Theta})}, \tag{32}$$

where Θ_j^- and Θ_j^+ are the average values over $[0.95\hat{\Theta}_j, \hat{\Theta}_j]$ and $[\hat{\Theta}_j, 1.05\hat{\Theta}_j]$, respectively. The values $\hat{\boldsymbol{m}}_i^-(\Theta_j;\hat{\Theta})$ and $\hat{\boldsymbol{m}}_i^+(\Theta_j;\hat{\Theta})$ are averages of the ith moment over the respective range of Θ_j, and $\hat{\boldsymbol{m}}_i(\hat{\Theta})$ is the simulated value of the ith moment at the SMM solution.

Table E.12 presents the estimated elasticities. Numbers in the table measure the percentage change in each moment as a result of a 1% increase in each parameter, ceteris paribus. Note that these elasticities are locally estimated around the SMM solution. It is possible that a moment has a small local sensitivity to a parameter but helps to identify that parameter over a wider range. Overall, the results suggest that parameter estimations are well identified.

Table E.12 supports the intuitive discussion of the moments' selection and also provides additional insights about the model. A 1% increase in the production parameter θ decreases the mean labor share by 0.54%. It also increases the firms' average debt ratio by 2.40% and decreases the volatility of payout ratio by 1.35%. The latter two effects are intuitive since θ increases the optimal level of capital stock, which enhances debt capacity through the collateral effect and stabilizes payouts. The second column shows the expected one-to-one relation between the depreciation rate δ and the firm's average investment rate. It also shows that as capital depreciates more quickly, the firm's debt ratio declines (by 1.09% per 1% increase in δ) because of collateral effects, and payouts become more volatile (by 0.68% per 1% increase in δ). The third column confirms that the enforcement parameter ξ is strongly related to the average debt ratio through the borrowing

Table E.12: Elasticity of moments with respect to parameters

This table reports the elasticity of moments to the model parameters. The elasticities are calculated around the estimated parameters (baseline case) and over a window with a range of 10% (5% deviation on each side) of the estimated value of each parameter. Reading: Around the SMM estimate, a 1% increase in θ is associated with a -0.54% change in the "mean labor share" in simulated data.

	θ	δ	ξ	κ
Mean labor share	-0.54	0.00	0.04	0.00
Mean investment rate	0.00	1.00	0.00	0.00
Mean debt ratio	2.40	-1.09	2.50	0.00
SD payout ratio	-1.35	0.68	-1.01	-0.11

constraint. It also shows that an increase in ξ decreases the volatility of payouts, which is intuitive given the increase in the use of debt. Finally, the last column confirms that the volatility of the payout ratio is sensitive to the changes in the equity cost parameter κ.

F The model extension with a corporate debt limit

In this section, we show the effect of including an exogenous corporate debt limit on equilibrium conditions of the model. In particular, we add $b_{t+1} \leq \bar{B}$ as an additional constraint to the firm's problem. We assume that the debt limit is set at 50% of the baseline steady-state debt level using Equation 4:

$$\bar{B} = 0.5 \times \underbrace{\frac{1+r_{ss}}{\xi} \times \left(\xi k_{ss} - F(z_{ss}, k_{ss}, n_{ss})\right)}_{\substack{\text{corporate debt in the} \\ \text{steady state of the baseline model}}}. \tag{33}$$

This new constraint effectively replaces the borrowing enforcement constraint because the debt limit is below the debt level allowed under the constraint. The firm's problem is

$$V(s;k,b) = \max_{n,k',b'} \Big\{ d + \mathbb{E}\big[m' V(s';k',b')\big] \Big\}, \tag{34}$$

$$\text{subject to} \quad \phi(d) + wn + k' + b = F(z,k,n) + (1-\delta)k + \frac{b'}{R}, \tag{35}$$

$$b' \leq \bar{B}. \tag{36}$$

Let γ denote the Lagrangian multiplier for the debt limit. The FOCs are

$$n \quad : \quad w = F_n(z,k,b), \tag{37}$$

$$k' \quad : \quad \frac{1}{\phi_d(d)} = \mathbb{E}\Big[m' \frac{1-\delta+F_k(z,k,b)}{\phi_d(d')}\Big], \tag{38}$$

$$b' \quad : \quad \frac{1}{\phi_d(d)R} - \gamma = \mathbb{E}\big[m' \frac{1}{\phi_d(d')}\big]. \tag{39}$$

The household problem remains the same as in the baseline case, as does the definition of the general equilibrium. To solve for the equilibrium of this extension, we substitute the firm's optimality conditions derived here for the ones in the baseline model, and we adjust the numerical solution to accommodate the debt limit constraint as an occasionally binding constraint and check for the Kuhn-Tucker conditions at each grid point.

G The model extension with a corporate buyback limit

In this section, we show the effect of including an exogenous restriction on corporate buybacks on equilibrium conditions of the model. The policy limit imposes $d_t \leq \bar{D}$ as an additional constraint to the firm's problem. Let λ denote the Lagrangian multiplier for the buyback limit. The firm's optimality conditions become

$$n \quad : \quad \frac{w}{1-\mu\frac{\phi_d(d)}{1-\lambda}} = F_n(z,k,n), \tag{40}$$

$$k' \quad : \quad \frac{1-\lambda}{\phi_d(d)} - \xi\mu = \mathbb{E}\Big[m' \frac{1-\delta+(1-\mu'\frac{\phi_d(d')}{1-\lambda'})F_k(z',k',n')}{\frac{\phi_d(d')}{1-\lambda'}}\Big], \tag{41}$$

$$b' \quad : \quad \frac{1-\lambda}{\phi_d(d)R} - \xi\mu\frac{1}{1+r} = \mathbb{E}\big[m' \frac{1-\lambda'}{\phi_d(d')}\big]. \tag{42}$$

The household problem and the definition of the general equilibrium remain the same as in the baseline case. To solve for the equilibrium, we substitute the firm's optimality conditions derived here for the ones in the baseline model. In the numerical solution, we treat this additional constraint as an occasionally binding constraint and check for the Kuhn-Tucker conditions at each grid point.

H Both Policy Limits at the Same Time

Proposals to restrict the corporate use of debt and proposals to restrict share repurchases have been advanced independently, which is why we have considered them independently. What might happen, though, if both proposals were adopted? In this section, we examine the impact of adopting both proposals together.[4] That is, both debt and buyback constraints are simultaneously added to the firms' problem, and the effect of productivity shocks is examined.

Consider a one-standard-deviation positive productivity shock. Figure H.1 shows the responses. For comparison, the baseline model responses are shown in dashed lines. Figures H.1(e) and H.1(f) show that the two policy limits effectively shut down external financing through equity and debt issuance, respectively. This effect leaves the firm with inadequate resources to pay for the increase in investments and hiring in response to the productivity shock. The firm depends largely on internal financing. This affects the firm both in the short run and in the long run.

In the short run, the investment response to the shock is weaker and considerably delayed compared with the benchmark. Figure H.1(c) shows that, in response to the shock, the firm increases its capital by 1.7% and reaches its peak capital stock in period 15, as opposed to a 2.0% response with a peak in period 7 in the unconstrained baseline economy. The hiring response is immediate. But the firm increases employment by only 0.3%, which is much weaker than the 0.9% increase in the benchmark economy. In combination, these policies jointly reduce firms' investment and hiring responses by more than the sum of the two policies if implemented separately.

[4] We thank Patrick Bolton for suggesting that we examine this issue.

Figure H.1: Effects of exogenous debt and buyback limits on responses to productivity shocks

These figures show the dynamics of model variables in response to a one-standard-deviation shock to the firm's productivity at time 1. The firm is at the steady state at time 0. Dashed lines are from the baseline model. Solid lines are generated by a version of the model with both debt and buyback constraints imposed on the firms. The constraints are similar to the ones that we use to study the separate effect of each policy limit.

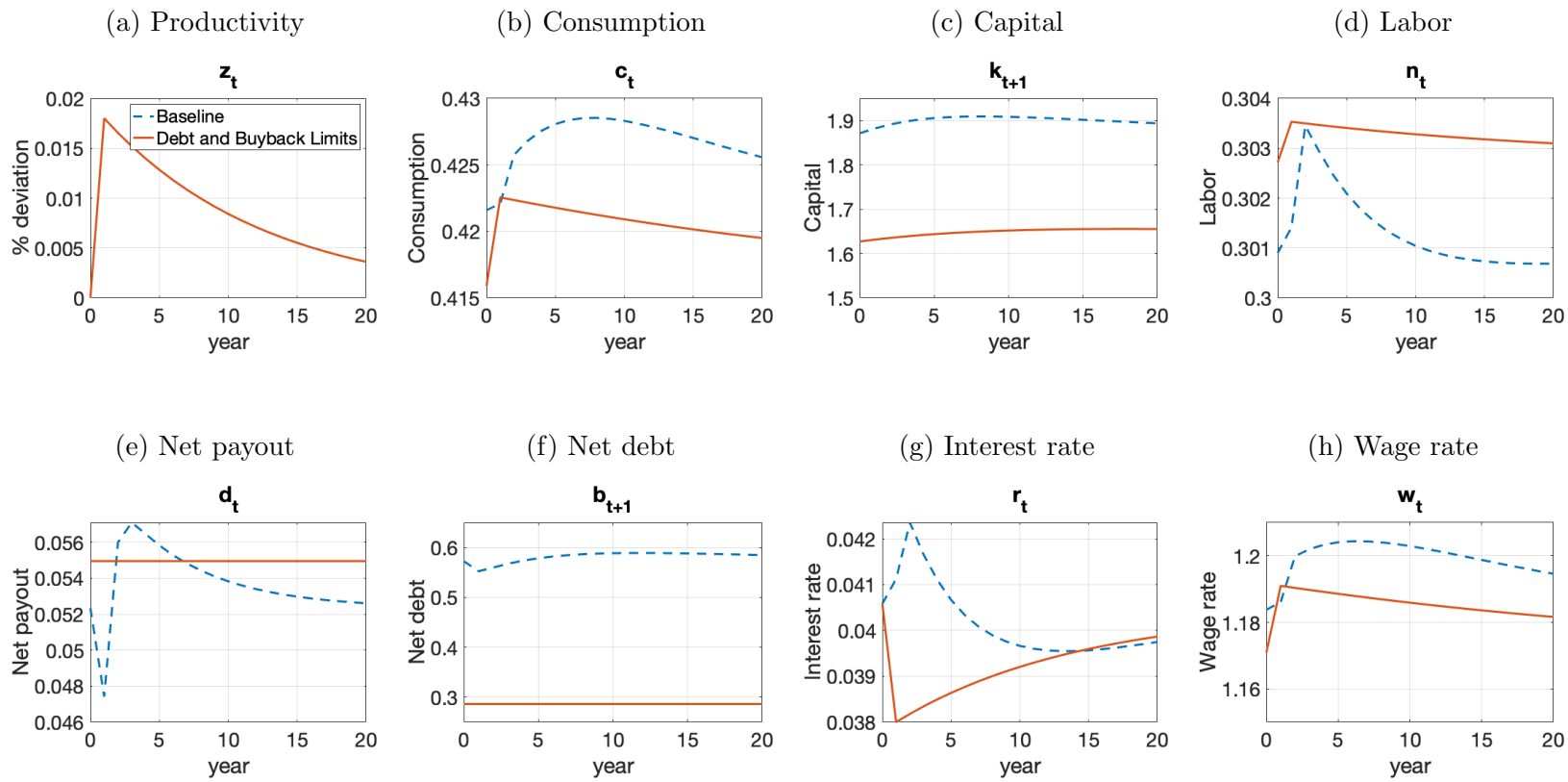


Table H.13: Comparing the long-run impact of policies on the economy

This table shows the long-run impact of the policies to limit debt and buybacks, and a combination of both policies, on the economy. The numbers reflect the comparison between steady-state values in the constrained economy and in the baseline unconstrained economy.

		Debt limit	Buyback limit	Both limits
Capital stock	k	↓16.6%	↓ 1.0%	↓ 13.0%
Consumption	c	↓ 2.4%	↓ 0.8%	↓ 1.4%
Labor input	n	↑ 0.1%	↓ 0.7%	↑ 0.6%
Wage rate	w	↓ 2.3%	↓ 1.1%	↓ 1.1%
Interest rate	r	0%	0%	0%
Net payout	d	↑ 8.5%	↑ 5.0%	↑ 5.0%
Net debt	b	↓ 50%	0%	↓ 50%

The long-run effects are significant. The steady-state capital stock is smaller by 13.0%, and wages are lower by 1.1%. Household consumption is lower by 1.4% even though households work more by 0.6%. Table H.13 compares the steady states of the unconstrained benchmark with each of the three policy regimes. The debt limit policy is most damaging for wages and consumption. When both policies are applied jointly, there is a considerable increase in labor, which mitigates the wage rate decline to some extent. The two policies display significant interactions. Their impacts are not just additive in a simple sense because of the labor adjustments.

I An Alternative Functional Form for Equity Issuance Cost

In the baseline model, the payout adjustment cost takes a quadratic functional form to prevent kinks in the model solution. This functional form, however, imposes two implicit assumptions. First, the adjustment cost is symmetric, that is increasing payouts is as costly as raising equity. Second, there is no fixed cost of equity issuance. We consider an alternative adjustment cost function that relaxes both assumptions:

$$\phi(d_t) = d_t + [\kappa_0 + \kappa(d_t - \bar{d})^2] \times \mathbb{1}\{d_t < \bar{d}\}. \tag{43}$$

The function $\mathbb{1}\{d_t < \bar{d}\}$ is an indicator function that takes the value of one when the firm is decreasing net payout relative to the long-run target (i.e., raising equity) and zero otherwise. The parameter κ_0 is a fixed cost. The adjustment cost function in Equation 43 is asymmetric, that is

increasing payouts is not costly but raising equity is, and imposes a fixed cost on equity issuance.

We adjust the numerical solution to accommodate the kink introduced by Equation 43. At each grid point, we first assume that $d \geq \bar{d}$ and solve the system of equations with no payout adjustment cost due to the indicator function, i.e., $\phi_{d_t} = d_t$. If the solution finds that the firm is issuing equity $d < \bar{d}$, the system is re-solved while imposing the equity issuance cost, i.e., $\phi(d_t) = d_t + \kappa_0 + \kappa(d_t - \bar{d})^2$. We then check the new solution to make sure that the firm is issuing equity, and do this process iteratively until we achieve consistency between the optimal solution and the imposed adjustment cost function. The logic behind this procedure is that, at each grid point, if the firm finds it optimal to increase payouts ($d \geq \bar{d}$), then imposing equity issuance cost does not make the firm want to deviate from this optimal policy. But the opposite is not necessarily true.

We conduct two exercises to evaluate the effects of the adjustment cost functional form on the main results. First, we simulate the model setting the fixed equity issuance cost at various levels and compare the simulated moments with the baseline specification and the actual data. Table I.14 shows the results. We simulate three different versions of the model by setting the parameter κ_0 so that the fixed equity issuance cost is equal to 5%, 10%, or 15% of the equity issuance size in response to a one-standard deviation productivity shock in the baseline model. The simulated moments under the new adjust cost statistically indifferent from the baseline case. The results suggest that the introduction of the asymmetry and the fixed cost does not significantly changes the firm behavior along these dimensions.

Next, to better understand the effects of the alternative equity adjustment cost function, we evaluate the impulse responses. Figure I.2 shows responses to a one-standard deviation productivity shock in a model that uses the adjustment cost function in Equation 43, where we set the fixed cost of equity issuance to 10% of the issue size. We add the responses from the baseline model in dashed lines as a benchmark. Model responses are in the same direction in both economies. Figures I.2(e) and I.2(f) show that introducing asymmetry and fixed cost in the adjustment cost does not change the dynamics of the financing-growth relation. The results suggest that the combination of limited commitment and tax benefits of debt is the dominant economic mechanism, even in the presence of more complex equity issuance cost structure.

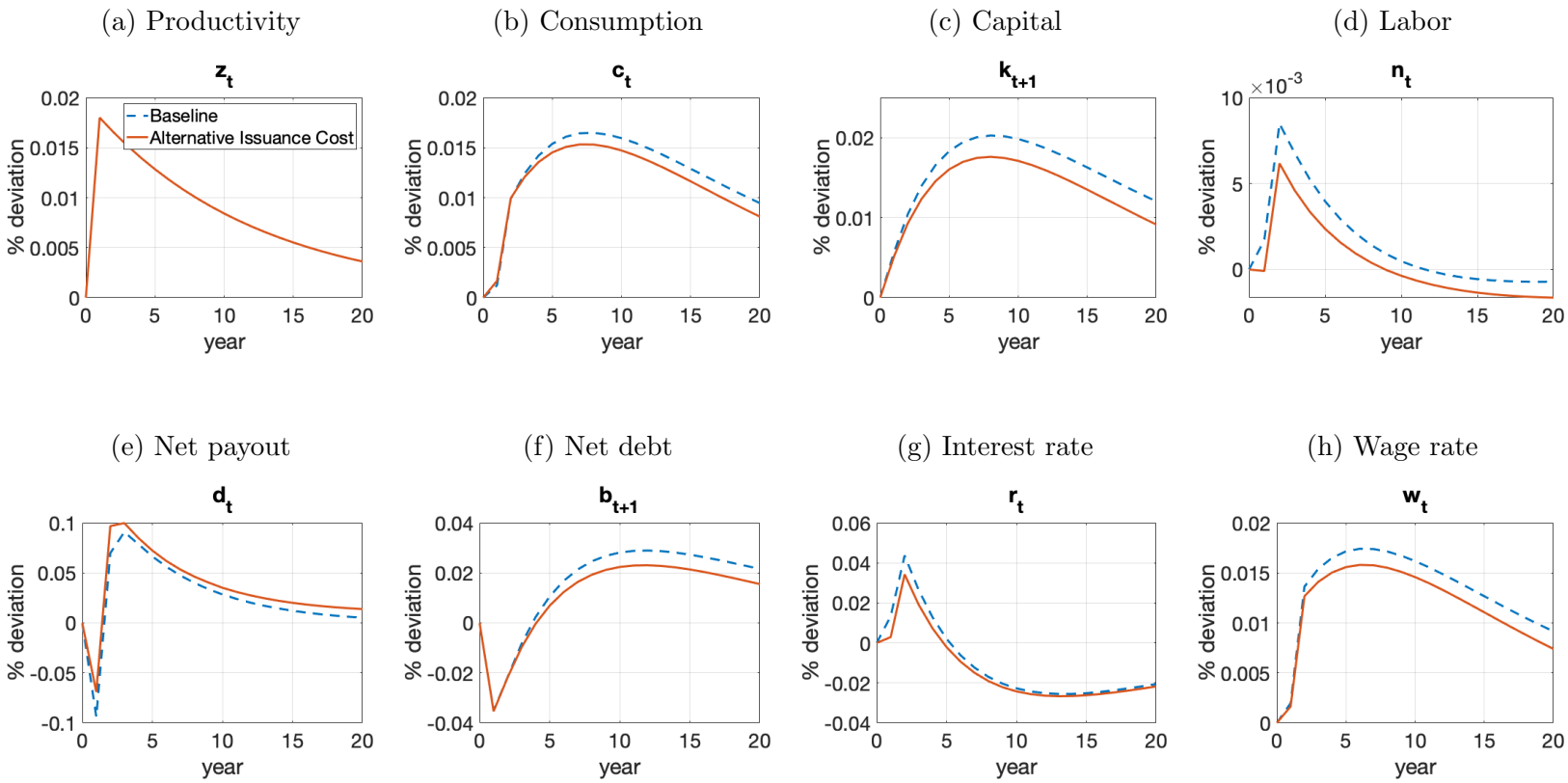
The magnitude of responses, however, are different. In response to the same positive productivity shock, the increases in consumption, capital stock, employment, as well as the financing variables are weaker in the model with the alternative issuance cost than in the baseline model. This is because some of the resources in the economy are wasted because of the deadweight fixed

Table I.14: Effects of alternative equity issuance cost functions on simulated moments

This table shows simulated moments generated from a model in which the payout adjustment cost function is asymmetric and features a fixed cost of equity issuance, as in Equation 43. The fixed issuance cost parameter is set at κ_0 =0.0003, 0.0005, and 0.0008, which respectively set the fixed cost at 5%, 10%, or 15% of the equity issuance size in response to a one-standard deviation productivity shock in the baseline model. The rest of the parameters are set at the baseline estimated values. The table also contains the moments from actual data and baseline simulations as benchmarks. Appendix A provides variable definitions in the actual data and the model.

Moments	Actual	Model simulations			
		Baseline	Fixed issuance cost at x% of issue size		
			$x = 5\%$	$x = 10\%$	$x = 15\%$
Mean labor share	0.626	0.626	0.624	0.624	0.624
Mean investment rate	0.079	0.079	0.079	0.079	0.079
Mean debt ratio	0.306	0.306	0.305	0.305	0.305
SD net payout ratio	0.012	0.012	0.012	0.013	0.013
Corr(asset growth, net payout)	-0.347	-0.433	-0.441	-0.439	-0.437
Corr(asset growth, debt issue)	0.164	-0.198	-0.210	-0.208	-0.206
Mean net payout ratio	0.019	0.028	0.028	0.028	0.028
SD investment rate	0.009	0.007	0.007	0.007	0.007
SD debt ratio	0.169	0.015	0.015	0.015	0.015

cost of equity issuance. So the economy cannot respond to productivity shocks as efficiently.

Figure I.2: Effects of an alternative form of equity issuance cost on responses to productivity shocks

These figures show the effect of an asymmetric equity adjustment cost function that features fixed issuance costs, as shown in Equation 43, on the dynamics of model variables in response to a one-standard-deviation shock to productivity at time 1. We set $\kappa_0 = 0.005$ to set the fixed issuance cost at 10% of the equity issuance size in response to a one-standard deviation productivity shock. Dashed lines show the baseline model as a benchmark. The firm is at the steady state at time 0. Vertical axes show percentage deviations from the steady state.