External Equity Financing Costs, Financial Flows, and Asset Prices

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Abstract

The recent financial crisis in 2007-2008 suggests that financial shocks, the aggregate disturbances that originate directly in the financial sector, can play an important role as a source of business cycle fluctuations. In this paper, we explore the impact of aggregate shocks to the cost of equity issuance on asset prices in the cross section. We document that an empirical proxy of equity issuance cost shocks forecast future economic activity (output, consumption, and investment), and is a source of systematic risk: exposure to this shock helps price the cross section of stock returns including book-to-market, size, investment, and cash-flow portfolios. We propose a dynamic investment-based model that features an aggregate shock to the firms' cost of external equity issuance, and a collateral constraint. Our central finding is that time-varying external financing costs are crucial for the model to quantitatively capture the joint dynamics of firms' real quantities, financing flows, and asset prices. Furthermore, the model also replicates the failure of the unconditional CAPM in pricing the cross-sectional expected returns.

JEL classification: E23, E44, G12
Keywords: Issuance shocks, asset pricing, book-to-market, investment, costly external financing, collateral constraint

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1 Introduction

We study the impact of financial shocks on asset prices in the cross section. The recent financial crisis in 2007-2008 suggests that shocks in the financial sector can be an important source of business cycle fluctuations. However, the asset pricing literature has mostly focused on the aggregate shocks that originate in the real sector (e.g., aggregate productivity shocks or investment-specific shocks) or shocks on monetary and fiscal policies.[1] The asset pricing implications of financial shocks–that is, aggregate perturbations that originate directly in the financial sector– on the cross section of U.S. publicly traded firms, has largely been unexplored. In particular, the previous studies do not study the joint behavior of asset prices, real quantities, and flows of financing, i.e., debt and equity, in response to financial shocks. In this paper, we aim to fill this gap.

We construct a novel empirical measure of the aggregate shock to the time-varying cost of firms' equity issuance. Building on previous studies (e.g. Eisfeldt and Muir, 2013), we use cross sectional data to recover a proxy for this shock in the data. Specifically, we compute the fraction of U.S. firms that issue equity each year, and we extract the time-series of the innovations in this variable using a vector autoregressive (VAR) model that includes aggregate productivity as a state variable to control for the effect of normal economic fluctuations on firms' equity issuance decisions. We refer to the innovations in the VAR as an (equity) issuance cost shock (ICS), which we interpret as an aggregate disturbance originated in the financial sector. A positive realization of the aggregate issuance cost shock is associated with an increase in the firms' equity issuance beyond what an increase in aggregate productivity would predict. As such, this positive realization of the aggregate issuance cost shock reveals, at least partially, a low cost of external equity issuance, and vice versa. Our analysis is consistent with the view that external equity is costly (e.g., Fazzari et al. 1988; Altinkilic and Hansen 2000), and that these costs vary over time (McLean and Zhao, 2013, and references therein). The costs of external equity include both direct costs, e.g., flotation costs, and indirect costs, e.g., adverse selection costs. Hennessy and Whited (2007) show that the estimated marginal equity flotation costs starts from 5.0% of capital for small firms and 15.1% of capital for large firms, and the indirect costs of external equity are large as well. Bustamonte (2013) estimates firms' average costs of external financing to be 12.7% of firms' capital stock. These costs are substantial, and thus are likely to have an important impact on both firms' performance, and firms' investment

[1]For example, Jermann (1997), Boldrin, Christiano, and Fisher (2001), Kaltenbrunner and Lochstoer (2010), Favilukis and Lin (2013), etc., study the asset pricing implications of aggregate productivity shocks. Papanikolaou (2011) focuses on investment-specific shocks. Gilchrist and Leahy (2002) study the relationship between monetary policy and asset prices. Croce, Nguyen, and Schmid (2012) explore the market price of fiscal policy risk.

and financing decisions.

We document several empirical links between equity issuance cost shocks, aggregate economic activity, and systematic risk. First, a positive ICS (low cost of equity issuance) forecasts an increase in aggregate output, investment, and consumption up to the three-year horizon, even after controlling for the positive impact of the aggregate TFP shock. Second, we show that the ICS is a source of systematic risk. Controlling for the aggregate market factor, we document that firms' exposure to ICS helps explain cross sectional variation in the average returns of several standard portfolio sorts, and that investors require a higher risk premium for holding assets that are more positively exposed to the ICS. In particular, we show that the ICS significantly improves the capital asset pricing model (CAPM) in pricing the cross section of stock returns of portfolios sorted on book-to-market ratio, investment rate, size, and cashflow-to-price; and that the ICS carries a positive price of risk, between 1.3% and 4.9% per year.

To understand and interpret the empirical findings, we propose a dynamic investment-based model that captures the quantitative effects of equity issuance cost shocks on real quantities, financing flows, and asset prices of nonfinancial firms. The key features of the model are: (i) an aggregate disturbance in the cost of equity issuance; and (ii) a collateral constraint, which restricts the amount of debt that firms can issue. The (standard) collateral constraint captures the fact that lenders typically impose a constraint requiring that the fire sale value of capital be sufficient to pay off the loan. The issuance cost shocks represent the stochastic changes that affect the (marginal) cost of external equity issuance of firms. In the model, the issuance cost shock acts as a source of aggregate economic fluctuations that is independent of aggregate productivity shocks, and it affects investor's marginal utility (positive price of risk), consistent with the empirical evidence. That is, the initial disruption is assumed to arise in the financial sector of the economy with no initial disruptions in the nonfinancial sector, which is the sector of the economy that we model here.[2] In particular, after a negative issuance cost shock caused by a disruption in the financial market, fewer funds can be channeled from equity holders to firms. This leads to insufficient external financing available to firms; as a result, firms cut investment and reduce hiring which in turn affect firms' dividends and market value of equity.

The variation in the expected stock returns in the cross section arise endogenously in the model due to the interaction between investment, equity issuance cost shocks, and collateral constraint. The underlying economic mechanism operates as follows. Firms with high idiosyncratic productivity are expanding firms with high investment demand. When a

[2]Most of the existing literature in macroeconomics has focussed on the amplification mechanism generated by financial frictions (Bernanke and Gertler 1989, Kiyotaki and Moore 1997, Bernanke, Gertler, and Gilchrist 1999). In those models, financial frictions serve to exacerbate the negative shocks from the nonfinancial sectors, but not to cause economic fluctuations.

negative issuance cost shock hits the economy, it is more difficult for firms to raise external equity financing because of its higher cost. However, high productivity firms can still finance investment through debt because their collateral value (capital) is increasing. Thus, high productivity firms are still able to increase their dividend payout for an extended period of time and their continuation value still rises. As a result, they act as a hedge against negative issuance cost shocks. These firms therefore have relatively lower risk and hence lower expected returns in equilibrium. Firms with low idiosyncratic productivity experience decreases in their profitability, and they reduce their investment; because their capital stock shrink, the collateral value falls, thus low productivity firms de-leverage. Their dividend payout falls below the steady state level sharply. As a result, their continuation value falls. These firms therefore have relatively higher covariance with negative aggregate issuance shock and hence higher expected returns. In the model, high productivity firms are growth firms, investing firms, and large cap firms, thus the model generates cross sectional return spreads in book-to-market, investment, and size that are consistent with the data.

The model matches the aggregate-level asset pricing and quantity moments, and key properties of the firm-level investment rates and financing flows in debt and equity. We then show that the model successfully replicates the observed level of the value premium, investment spread, and the size premium in the data with reasonable parameter values. Through several comparative statics exercises, we show that the existence of external equity costs being driven by aggregate issuance shocks is crucial for the good quantitative fit of the model. When equity financing is cost free, the model generates a too high equity issuance frequency (50% in the frictionless equity financing model versus 35% in the baseline model with equity financing costs and 38% in the data) and a value premium/investment spread that is too small and even slightly negative. Similarly, when equity financing *is* costly but the costs are not driven by aggregate issuance shock, both of the model implied equity issuance frequency and return spreads are off by an order of magnitude compared to the data. This result is intuitive. Without external equity financing costs, firms issue more equity. Firms also take the advantage of this cost-free marginal source of financing to smooth their dividends in response to the shocks, thus significantly reducing the dispersion in risk in the cross section. Taken together, the results of our analysis suggest that equity market frictions can have a significant impact on asset prices in financial markets.

The model also replicates the failure of the unconditional CAPM model in explaining the cross sectional variation in the expected returns of several portfolio sorts, and that it is the exposure to issuance cost shocks that drive the cross sectional difference in average portfolio returns, in addition to the aggregate productivity shock. In the data, using standard time-series regressions, the sensitivity of the returns of firms with different characteristics to the aggregate stock market factor (market risk) is weakly correlated with its average stock returns. As such, the CAPM generates pricing errors that are close to the return spreads themselves. The model is consistent with these asset pricing results, thus providing an explanation for the failure of the CAPM in the data. According to the model, the aggregate stock market is mostly driven by the standard aggregate productivity shock, and thus it is weakly correlated with issuance cost shocks, which are the main drivers of the return spreads in the cross section.

Related literature: This paper is related to several strands of literature. The model is close to Jermann and Quadrini (2011) who study the impact of credit shocks on macroeconomic quantities. We differ in that we focus on the shocks to the cost of equity issuance and its asset pricing implications. The financial frictions of our model are similar to Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1999), etc. The difference is that the financial sector acts as a source of the business cycle fluctuations in our model (as in Jermann and Quadrini) as opposed to propagating shocks that originate in other sectors of the economy.

This paper also relates to the literature that integrates financial frictions to corporate investment, q-theory, and asset pricing, e.g., Hennessy and Whited (2005,2007), Livdan, Sapriza, and Zhang (2009), Gomes and Schmid (2010), Bolton, Chen, and Wang (2011), DeMarzo, Fishman, He, and Wang (2011), etc. The key difference is that this paper focuses on the asset pricing implications of financial shocks, while the above models focus on firms' financing decision when facing aggregate productivity shocks and various financing frictions.

Our work is closely related to a growing literature that studies asset pricing in production economies. See, for example, Cochrane (1991, 1996), Zhang (2005), Liu, Whited, and Zhang (2009), Belo (2010), Lin (2012), Belo, Lin, and Bazdresch (2013), Kogan and Papanikolaou (2012), Yang (2013), etc. In contrast to the existing literature, which primarily focuses on physical capital investment and expected stock returns, this paper explores the relation between financial shocks, financing flows, and the cross sectional variation of stock returns.

The paper proceeds as follows. Section 2 shows the empirical links between issuance costs shocks, aggregate economic activity, and asset prices in the data. Section 3 presents a dynamic investment-based model with collateral constraints and equity issuance cost shocks. Section 4 presents the calibration and model solution. Section 5 presents the main results. Section 6 provides a detailed analysis of the economic mechanisms driving the results. Finally, Section 7 concludes.

2 Empirical findings

In this section, we construct an empirical proxy of an aggregate measure of equity issuance cost shocks. Then, we investigate the correlation of equity issuance cost shocks with other macroeconomic variables. Finally, we show that the measure of equity issuance shocks is a source of systematic risk and it is priced in the cross section. In particular, together with the market factor, we document that firms' exposure to equity issuance cost shocks helps explain cross sectional variation in the average returns of several standard portfolio sorts, and that investors require a higher risk premium for holding asset that are more positively exposed to the aggregate issuance cost shocks.

2.1 Data

Monthly stock returns are from the Center for Research in Security Prices (CRSP), and accounting information is from the CRSP/Compustat Merged Annual Industrial Files. The sample is from 1971 to 2011 and includes firms with common shares (shrcd=10 and 11) and firms traded on NYSE, AMEX, and NASDAQ (exchcd=$1, 2$, and 3).[3] We omit firms whose primary standard industry classification (SIC) is between 4900 and 4999 (regulated firms) or between 6000 and 6999 (financial firms). We remove observations with negative total asset or negative sale or negative book equity. When cash dividend is missing, we replace it with zero.

We use standard portfolios including 10 book-to-market portfolios, 10 investment portfolios, 10 size (market equity) portfolios, 10 earnings-to-price portfolios, and 10 cashflow-to-price portfolios. The stock market factor and the risk-free returns are obtained from French's website. Portfolio-level quantities such as investment rate, equity issuance, etc., are computed as the medians of all the firms in a portfolio in every given year. Utilization-adjusted total-factor productivity (TFP) is from John Fernald/Kuni Natsuki.[4] Portfolio returns are annualized to match the frequency of the issuance cost shocks.

2.2 Identification of equity issuance cost shocks

The measurement of equity issuance costs is difficult because there is no available data on these costs. As such, we have to rely on a proxy that is correlated with these costs in the data. We construct a proxy of the aggregate equity issuance cost based on the proportion of firms issuing external equity in the cross section of Compustat firms. More specifically, we define that a firm issues equity if its net equity issuance in a given year is positive. Following Eisfeldt and

[3]Our sample ends in 2011 due to the availability of data in constructing equity issuance shocks.
[4]We have also experimented with TFP without adjusting utilization. The results stay unchanged.

Muir (2013), the net equity issuance is computed as Item SSTK (sale of common and preferred stock) - Item PRSTKC (purchase of common and preferred stock) - Item DV(cash dividend) in Compustat Annual files. The time series of the percentage of firms issuing equity is constructed from 1971 to 2011. The top left panel in Figure 1 shows the time series of this series.

[Insert Figure 1 here]

To extract the innovations in the equity issuance cost proxy, which we refer to as the equity issuance cost shock (ICS), we estimate a first order vector autoregressive (VAR) model using log TFP and the percentage of firms issuing equity as the two state variables denoted x_t and s_t, respectively. We include aggregate TFP in the VAR because it is the standard source of economic fluctuations in most macroeconomic models. As such, including the TFP in the VAR allows us to control for variation in equity issuance activity that is driven by changes due to normal economic fluctuations, hence helping us to identify the equity issuance cost component of observed equity issuance waves (or contractions).

As shown in Figure 1, the fraction of firms issuing equity in the sample of Compustat firms exhibits a positive trend. As such, we first apply the one-sided Hodrick-Prescott filter (HP filter, Hodrick and Prescott, 1997) to detrend this variable, as well as the TFP variable (in level).[5] Then, we estimate the following vector-autoregressive system:

$$\begin{pmatrix} x_{t+1} \\ s_{t+1} \end{pmatrix} = A \begin{pmatrix} x_t \\ s_t \end{pmatrix} + \begin{pmatrix} u_{t+1} \\ v_{t+1} \end{pmatrix},$$

where u_{t+1} and v_{t+1} are independent and identically distributed (i.i.d.) normal variables with standard deviations σ_x and σ_s respectively. We use the estimated time series of v_{t+1} as our empirical measure of the innovations to equity issuance disturbances (equity issuance cost shock, which we refer as ICS). We interpret this shock as an aggregate disturbance originated from the financial sector that affects the cost of external equity issuance of the firms in the nonfinancial sector. A high realization of aggregate issuance cost shock is associated with an equity issuance wave by firms, which we interpret as driven (at least partially) by a reduction in the cost of external equity issuance, and vice versa. The variable u_{t+1} is used as the measure of TFP innovations.

[5]We use a one-sided HP filter to avoid any look ahead bias in the aggregate economic activity predictability results, and asset pricing tests reported below. We have also tried different filters for the percentage of firms issuing equity before estimating the VAR system. The results appear to be overall robust to several different ways of filtering data. For example, using simply the growth rate of the variables as a proxy for the innovation produces similar results to those reported here.

2.3 Properties of issuance cost shocks

In this section we report the properties of the issuance cost shocks, and the empirical links between these costs, aggregate economic activity, and systematic risk in the cross section.

2.3.1 Summary statistics

Several important estimates are reported in Table 1. The time series of the equity issuance cost shock (ICS) and TFP shock are reported in the bottom left panel in Figure 1.

[Insert Table 1 here]

The ICS is more volatile than the TFP shock. The standard deviation of the ICS is 3.64% per year, versus 0.85% for the TFP shock. In addition, the two shocks have a very low contemporaneous correlation. As reported in Panel B of Table 1, the correlation of the ICS with the TFP shock is only -10%.

We also investigate the correlation between the ICS and other macroeconomic variables. The contemporaneous correlation between the ICS and aggregate output (ΔGDP), investment (ΔI), and consumption (ΔC) is low. Interestingly, the correlation between the ICS and a proxy of investment specific technology shocks (ISTS, measured as the real quality-adjusted investment price growth) is also very low (-4%). As a result, we can conclude that the ICS captures aggregate fluctuations that are (at least partially) distinct from a standard measure of investment-specific technology shocks.

2.3.2 External finance costs and aggregate economic activity

Despite the low contemporaneous correlation of the ICS with macroeconomic variables, these shocks are strongly correlated with macroeconomic fluctuations. In particular, we show that the ICS predicts several macroeconomic aggregates. To investigate the link between ICS, TFP shocks (TFPS) and future macroeconomic activity, we run the following standard (Fama and French, 1989; Lettau and Ludvigson, 2002) short- and long-horizon predictive regressions

$$\Sigma_{h=1}^{H} y_{t+h} = a + b\text{ICS}_t + c\text{TFPS}_t + e_{it}, \tag{1}$$

in which $\Sigma_{h=1}^{H} y_{t+h}$ is the H-period cumulated value of the predicted variable, and H is the forecast horizon ranging from one year to five years. The following variables are considered for y_t: (i) growth rate in real output (GDP); (ii) investment; and (iii) nondurables consumption. For each regression, we report the slopes (coefficients b and c in equation (1)), the adjusted R^2, and the corresponding t-statistics calculated from standard errors corrected for autocorrelations and heteroskedasticity per Newey and West (1987), with lag equal to one year plus the overlapping period.

[Insert Table 2]

Table 2 shows that the ICS forecasts aggregate economic activity with a positive slope, and this slope is statistically significant up to the three-year horizon. That is, an high ICS (low cost of equity issuance), is associated with higher future output, investment, and consumption. The ICS is thus correlated with future aggregate economic fluctuations, even after controlling for current aggregate productivity. The table also shows that, as expected, a positive TFP shock forecasts high future economic activity up to the three-year horizon, consistent with previous studies (see, for example, Belo and Yu, 2013).

2.3.3 External finance costs, systematic risk, and risk premiums

In addition to being correlated with future aggregate economic activity, we show that the ICS is a source of systematic risk. In particular, we show that firms' exposure to these shocks helps understand cross sectional variation in risk premiums across standard portfolios. To show these links, we investigate a two-factor model using the stock market factor (MKT) and the innovations to equity issuance cost shocks (ICS) as the two factors. We perform two-stage regressions (see, for example, Cochrane, 2005). In the first stage, we run the following time series regression:

$$r_{it}^{e} = a_i + \beta_i^{\mathrm{M}} \times \mathrm{MKT}_t + \beta_i^{\mathrm{I}} \times \mathrm{ICS}_t + e_{it}, \tag{2}$$

where r_{it}^{e} is the portfolio i excess return. This model decomposes the excess return of each portfolio i into three components: (i) the systematic risk due to exposure to the market risk ($\beta_i^{\mathrm{M}} \times \mathrm{MKT}_t$); (ii) the systematic risk due to exposure to equity issuance cost shocks ($\beta_i^{\mathrm{I}} \times \mathrm{ICS}_t$); and (iii) the idiosyncratic risk $e_{i,t}$. a_i is the constant term which can be nonzero since issuance cost shocks are not excess returns. Among these three parts, i) and ii) are nondiversifiable and hence can generate risk premiums.

In the second stage, we estimate the factor risk premiums (λ_M and λ_I) by running the following cross sectional regression:

$$E_T\left[r_{it}^{e}\right] = \beta_i^{\mathrm{M}} \lambda_M + \beta_i^{\mathrm{I}} \lambda_I + \alpha_i, \tag{3}$$

where $E_T\left[r_{it}^{e}\right]$ is the in-sample mean of portfolio i's excess return, and β^{M} and β^{I} are the factor loadings estimated in the first stage. As test assets, we use the following standard portfolio sorts: (i) ten book-to-market portfolios; (ii) ten investment-rate portfolios; (iii) ten size portfolios, (iv) ten earnings-to-price portfolios; and (v) ten cashflow-to-price portfolios.

[Insert Table 3 here]

The two-factor model improves the fit of the CAPM in explaining the returns of the ten portfolios formed on book-to-market ratio. As reported in Panel A Table 3, the high book-to-market portfolio (value firms) outperforms the low book-to-market portfolio (growth firms) by about 7% per annum (Fama and French, 1993). This return spread cannot be explained by CAPM as the abnormal return (α) of the high-minus-low portfolio is 7.46% statistically significant. When the ICS factor is added to the market factor in a two-factor asset pricing model, the root mean squared error (RMSE) decreases significantly relative to the RMSE of the CAPM. As reported in Panel B of Table 3, the RMSE of the two-factor model is only 0.72% per year, whereas the RMSE of the CAPM is 2.16% per year.

To help us understand the source of the improved performance of the two-factor model relative to the CAPM in explaining the variation in the average returns of the book-to-market portfolios, the lower left panels in Panel A in Table 3 reports the estimates from the time-series regressions of the two-factor model. The loadings (betas) on the issuance cost shocks are increasing across the book-to-market portfolios. That is, firms with low book-to-market ratios (growth firms) load less (have a negative covariance) on the issuance cost shocks than firms with high book-to-market ratios (value firms). In addition, Panel B in Table 3 shows that the estimated price of risk (λ_I) of the issuance cost shock is positive, 3.3% per year. These results thus suggest a potential risk explanation for the value premium. The issuance cost shock is a source of systematic risk, and growth firms provide a hedge against these shocks, because these firms tend to have high returns when the ICS is low (that is, periods when it is particularly costly to issue equity), which are periods associated with high marginal utility (as inferred by the positive price of risk of the ICS). Analogously, value firms are risky firms because these firms have a high exposure (covariance) to the IS shocks: these firms have lower returns at times when the ICS is also low (bad economic times). We investigate this risk explanation, both qualitatively and quantitatively, in the theoretical model below.

The two-factor model also improves the fit of the CAPM in explaining the returns of ten portfolios sorted on firms' investment rate, earning-to-price ratio, and cashflow-to-price ratio. The results are also reported in Table 3. These tables show that firms with low investment rates, large size, high earnings-to-price ratios, and high cashflow-to-price ratios have considerably lower returns than firms with high investment rates, small firms, low earnings-to-price ratios, and low cashflow-to-price ratios. Except across the size portfolios, the CAPM cannot explain the cross-sectional variation in the returns of these portfolios (large α). When the ICS factor is added to the previous time series regression, the fit of the model improves. As reported in Panel B of the previous tables, the RMSE of the two-factor model is significantly lower than the RMSE of the CAPM.

The better fit of the two-factor model relative to the CAPM on the previous portfolios follows from the fact that firms with low investment rates, small firms, high earnings-to-price ratios, and high cashflow-to-price ratios (which are firms with high average returns) have significantly higher exposure (betas) with the ICS. Because the price of risk of the ICS shock is estimated to be positive across all these portfolio sorts (the estimate of the price of risk of the ICS ranges from 3.25% per year across investment portfolios to 4.93% per year across earnings to price portfolios; for size portfolios it is small, only 1.3% per year), this result suggest that these firms are risky because they provide low returns with the ICS is low, that is, when it is costly to issue equity and investors' marginal utility is high.[6]

2.3.4 External finance costs and portfolio characteristics

We also investigate the link between the issuance cost shocks and key portfolio characteristics of ten book-to-market portfolios and ten investment portfolios.[7] The results in Table 4 show that the issuance cost shock co-moves with several major portfolio characteristics. More specifically, we estimate the correlations between ICS and portfolio characteristics controlling for TFP by running the following time series regressions

$$Q_{i,t} = a_i + b_i^{\mathrm{T}} \times \mathrm{TFP}_t + b_i^{\mathrm{I}} \times \mathrm{ICS}_t + u_{i,t},$$

where $Q_{i,t}$ denotes a characteristic of portfolio i at year t. TFP_t and ICS_t are the innovations estimated from the VAR system.

The characteristics include change in log investment rate in physical capital ($\Delta \log(\mathrm{IK})$), book-to-market ratio (BM), and financial leverage (LEV). IK is computed as investment (Computstat data item CAPX (capital expenditures) minus SPPE (sales of property, plant, and equipment)) over the physical capital stock (Compustat data item PPENT (net property plant and equipment)). BM is the book equity over market equity ratio, where both book equity and market equity value follow the definitions in Fama and French (1992). LEV is computed as book value of liabilities over the market value of equity. We construct the time series of characteristics for each portfolio by computing the median of the characteristics across all firms within each portfolio for every year.

[Insert Table 4 here]

The regression results are reported in Table 4. In addition, we also report historical averages

[6] The fact that the estimated price of risk of the ICS portfolios is estimated to be smaller than for other portfolio sorts follows from the fact that the size spread is very small across the value-weighted portfolios that we consider here. In equal-weighted size portfolio, the price of risk of ICS is significantly larger.

[7] In on-going research, we are expanding the analysis in this section to other portfolio sorts.

of portfolio characteristics in rows labeled as E[Q]. Panel A reports the regression results for ten book-to-market portfolios. In the cross section, the book-to-market ratio (BM) and the financial leverage (LEV) of value firms load more on issuance cost shocks than growth firms. The changes in log investment rate ($\Delta \log(\text{IK})$) of value firms load less on issuance cost shocks than growth firms. Panel B reports the regression results for 10 investment portfolios. In the cross section, real quantities such as change in log investment rate ($\Delta \log(\text{IK})$) of high investment firms comove more with the issuance cost shocks than low investment firms. The book-to-market ratio (MB) and financial leverage (LEV) of high investment firms comove less with issuance cost shocks than low investment firms.

3 Model

The results from the empirical section show that the equity issuance cost shocks are correlated with aggregate future economic activity, that exposure to these shocks are a source of systematic risk in the economy, and that these shocks are priced. In this section, we present a dynamic investment-based model to help understand these findings. We then calibrate the model to the data to evaluate the extent to which the model can quantitatively (not just qualitatively) explain the empirical links.

The model features a continuum of heterogeneous firms facing aggregate financial shocks, modeled as a time-varying cost of issuing equity, and are subject to a collateral constraint on the amount that firms can borrow. Firms choose optimal levels of physical capital investment, employment, and debt each period to maximize the market value of equity.

3.1 Technology

Firms use physical capital (K_t) and labor (N_t) to produce a homogeneous good (Y_t). To save on notation, we omit firm index j when no confusion is resulted in. The production function is given by

$$Y_t = Z_t X_t^{\theta} \left(K_t^{\alpha} N_t^{1-\alpha} \right)^{\theta}, \tag{4}$$

where X_t represents aggregate productivity and Z_t represents firm-specific productivity. α denotes the capital share and $1-\alpha$ denotes the labor share. The production function exhibits decreasing returns to scale: The curvature parameter satisfies $0 < \theta < 1$ (low θ means high curvature in the production technology). Decreasing returns to scale capture the idea that firms grow by taking on more investment opportunities. Because better opportunities are taken first, an increase in productive scale causes output to increase by a smaller proportion. Alternatively, decreasing returns to scale can be motivated by limited managerial or organizational resources that result in problems of managing large, multi-unit firms such as increasing costs of coordination (e.g., Lucas 1978).

Aggregate productivity follows a random walk process with a drift

$$\Delta x_{t+1} = \mu_x + \sigma_x \varepsilon^x_{t+1}, \tag{5}$$

in which $x_{t+1} = \log(X_{t+1})$, Δ is the first-difference operator, ε^x_{t+1} is an i.i.d. standard normal shock, and μ_x and σ_x are the average growth rate and conditional volatility of aggregate productivity, respectively.

Firm-specific productivity follows the AR(1) process

$$z_{t+1} = \bar{z}(1-\rho_z) + \rho_z z_t + \sigma_z \varepsilon^z_{t+1}, \tag{6}$$

in which $z_{t+1} = \log(Z_{t+1})$, ε^z_{t+1} is an i.i.d. standard normal shock that is uncorrelated across all firms in the economy and independent of ε^x_{t+1}, and $\bar{z}$, ρ_z, and σ_z are the mean, autocorrelation, and conditional volatility of firm-specific productivity, respectively.

Physical capital accumulation is standard given by

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{7}$$

where I_t represents investment and δ denotes the capital depreciation rate.

Following Hayashi (1982) and Zhang (2005), we assume that capital investment entails convex adjustment costs, denoted as G_t, which are given by:

$$G_t = \begin{cases} \frac{c_k^+}{2}\left(\frac{I_t}{K_t}\right)^2 K_t, & I_t \geq 0 \\ \frac{c_k^-}{2}\left(\frac{I_t}{K_t}\right)^2 K_t, & I_t < 0. \end{cases} \tag{8}$$

where c_k^+ and c_k^- determine the upward and downward speed of adjustment, respectively. The capital adjustment costs include planning and installation costs, learning the use of new equipment, or the fact that production is temporarily interrupted. For example, a factory may need to close for a few days while a capital refit is occurring. We allow the capital adjustment costs to be asymmetric to capture costly reversibility of capital, that is, the fact that reducing the capital stock may be more costly than expanding. The costly reversibility can arise because of resale losses due to transaction costs or the market for lemons phenomenon.

Following Belo, Lin, and Bazdresch (2013), the real wage rate is an increasing function of the aggregate productivity shock and is given by

$$W_t = \exp(\omega \Delta x_t), \tag{9}$$

with $0 < \omega < 1$. In this specification, the constraint $0 < \omega < 1$ allows us to capture the empirical fact that the aggregate real wage rate is less volatile than aggregate output as well as some procyclicality of the real wage rate, as reported in Merz and Yashiv (2007) in U.S. data. In the online appendix, we consider a specification of the aggregate wage rate that is a function of both the aggregate productivity and the equity issuance cost shocks (we discuss the equity issuance cost shock in subsection 3.3). Adding this additional effect in a reasonable calibration of the model has a very small impact on all the quantitative results reported here.

The firm also incurs fixed operating costs of production that are independent of firm size, which are captured by $F_t = fX_t$, with $f > 0$. We scale the fixed operating costs by aggregate productivity to allow for growth in the economy.

3.2 Collateral constraint

Firms use equity and debt to finance investment. At the beginning of time t, firms can issue an amount of debt, denoted as B_t, which must be repaid at the beginning of period $t+1$. The firm's ability to borrow is bounded by the limited enforceability as firms can default on their obligations. Following Hennessy and Whited (2005), we assume that the only asset available for liquidation is the physical capital K_{t+1}. In particular, we require that the liquidation value of capital is greater than or equal to the debt payment. It follows that the collateral constraint is given by

$$B_{t+1} \leq \bar{S} K_{t+1}. \tag{10}$$

The variable $0 < \bar{S} < 1$ affects the tightness of the collateral constraint, and therefore, the borrowing capacity of the firm. Due to collateral constraint, the interest rate, denoted by r_f, is the riskfree rate which is also constant due to the specification of the stochastic discount rate which will be discussed in section 3.4.

Firms also incur adjustment costs, denoted by Φ_t when changing the amount of debt outstanding,

$$\Phi_t = \begin{cases} \frac{c_b^+}{2} \left(\frac{\Delta B_t}{B_t} \right)^2 B_t, & \Delta B_t \geq 0 \\ \frac{c_b^-}{2} \left(\frac{\Delta B_t}{B_t} \right)^2 B_t, & \Delta B_t < 0, \end{cases} \tag{11}$$

where $\Delta B_t = B_t - B_{t-1}$. Debt adjustment costs capture the fact that adjusting capital structure is costly; convexity implies a persistent debt growth process which is consistent with the data.

3.3 Costly external equity financing

Taxable corporate profits are equal to output less wage bills, fixed production costs, capital depreciation and interest expenses: $Y_t - W_t N_t - F_t - \delta K_t - r_f B_t$. It follows that the firm's budget constraint can be written as

$$E_t = (1-\tau)\left(Y_t - W_t N_t - F_t\right) + \tau\delta K_t + \tau r_f B_t - I_t - G_t + B_{t+1} - (1+r_f)B_t - \Phi_t, \qquad (12)$$

where τ is the corporate tax rate, $\tau\delta K_t$ is the depreciation tax shield and $\tau r_f B_t$ is the interest tax shield, and E_t is the firm's payout.

When the sum of investment, capital and debt adjustment costs exceed the sum of after tax operating profits and debt financing, firms can take external funds by means of seasoned equity offerings. External equity H_t is given by

$$H_t = \max\left(-E_t, 0\right). \qquad (13)$$

External equity is costly (e.g., Fazzari et al. 1988; Altinkilic and Hansen 2000). As is discussed in Hennessy and Whited (2007), the main costs of external equity involve flotation costs and adverse selection costs. For example, Altinkilic and Hansen (2000) provide detailed evidence regarding flotation costs. Myers and Majluf (1984) and Krasker (1986) show that the cost of external equity is increasing in asymmetric information in equity markets. We do not explicitly model asymmetric information in our model. Rather, we attempt to capture the effect of adverse selection costs and underwriting fees in a reduced-form fashion. More specifically, we parameterize the equity issuance costs as[8]

$$\Psi\left(H_t\right) = \left[\eta_1 \exp\left[-\eta_2\left(\xi_t/\bar{\xi}\right)\right] H_t\right] \mathbf{1}_{\{H_t>0\}} \qquad (14)$$

where ξ_t is an aggregate shock that affects the external equity financing costs, which follows an AR(1) process,

$$\xi_{t+1} = (1-\rho_\xi)\bar{\xi} + \rho_\xi \xi_t + \sigma_\xi \varepsilon^\xi_{t+1}, \qquad (15)$$

with $\bar{\xi}$, ρ_ξ, and σ_ξ are the mean, first-order autocorrelation coefficient and conditional volatility of the ξ_{t+1} and ε^ξ_{t+1} is an i.i.d. standard normal shock that is independent of ε^x_{t+1} and ε^z_{t+1}.

The key feature of the formulation of external equity costs different from the existing literature is that external equity costs are subject to an aggregate disturbance independent of aggregate shocks to productivity. We interpret this shock as perturbations of external financing

[8]We have experimented various formulations of equity issuance costs including a combination of fixed costs, linear costs and convex costs. We find the simple linear cost structure works well in capturing the properties of equity issuance such as persistence and volatility.

that are not driven by firms' capital demand originated from the real sector; rather this shock directly originates from the financial sector. More specifically, a high realization of ξ_t implies low costs of external equity financing, vice versa.

Finally, firms do not incur costs when paying dividends or repurchasing shares. The effective cash flow D_t distributed to shareholders is given by

$$D_t = E_t - \Psi_t. \tag{16}$$

3.4 Firm's problem

We specify the stochastic discount factor as

$$M_{t,t+1} = \frac{1}{1+r_f} \frac{e^{-\gamma_x \Delta x_{t+1} - \gamma_\xi \Delta \xi_{t+1}}}{\mathbb{E}_t \left[e^{-\gamma_x \Delta x_{t+1} - \gamma_\xi \Delta \xi_{t+1}} \right]}, \tag{17}$$

where r_f is the risk-free rate. We discuss the sign of the price of risk parameters (γ_x and γ_ξ) in the calibration section below. The risk-free rate is set to be constant. This allows us to focus on risk premia as the main driver of the results in the model as well as to avoid parameter proliferation.

Firms solve the maximization problem by choosing capital investment, labor, and debt optimally:

$$V_t = \max_{I_t, N_t, B_{t+1}} D_t + \mathbb{E}_t[M_{t,t+1} V_{t+1}], \tag{18}$$

subject to firms' capital accumulation equation (Eq. 7), collateral constraint (Eq. 14), budget constraint (Eq. 12), and cash flow equation (Eq. (16)).

3.5 Optimality conditions

Let q_t and μ_t be the Lagrangian multiplier associated Eqs. (7) and (16). The first-order conditions with respect to I_t, K_{t+1}, and B_{t+1} are, respectively,[9]

$$q_t = \left(1 + \Psi'(H_t) \mathbf{1}_{\{H_t > 0\}}\right) \left[1 + \frac{\partial G_t}{\partial I_t}\right], \tag{19}$$

$$q_t - \mu_t \bar{S} = \mathbb{E}_t M_{t,t+1} \left\{ \left((1 + \Psi'(H_{t+1})\, \mathbf{1}_{\{H_t > 0\}} \right) \left[\frac{\partial E_{t+1}}{\partial K_{t+1}} + (1-\delta) \left(1 + \frac{\partial G_{t+1}}{\partial I_{t+1}}\right) \right] \right\}, \tag{20}$$

$$\text{and } \mu_t - \mathbb{E}_t \left[M_{t,t+1} \left(1 + \Psi'(H_{t+1}) \mathbf{1}_{\{H_{t+1} > 0\}}\right) \frac{\partial E_{t+1}}{\partial B_{t+1}} \right] = \left(1 + \Psi'(H_t) \mathbf{1}_{\{H_t > 0\}}\right) \frac{\partial E_t}{\partial B_{t+1}}, \tag{21}$$

[9]These first-order conditions are taken in the differentiable regions of the relevant variables.

where $\Psi'(H_t)$ is the partial derivative of $\Psi(H_t)$ with respect to H_t and $\mathbf{1}_{\{\}}$ is the indicator function.

Eq. (19) is the optimality condition for investment that equates the marginal cost of investing in capital, $\left(1+\Psi'(H_t)\mathbf{1}_{\{H_t>0\}}\right)\left[1+\frac{\partial G_t}{\partial I_t}\right]$, with its marginal benefit q_t. Here q_t is known as the marginal q of investment. However it differs from the standard q–theory of investment (e.g., Hayashi 1983) in that the marginal cost of investment is the marginal capital adjustment cost $\left(1+\frac{\partial G_t}{\partial I_t}\right)$ augmented by the marginal cost of issuance $\left(1+\Psi'(H_t)\mathbf{1}_{\{H_t>0\}}\right)$. When firms take external equity financing, i.e., $H_t > 0$, the marginal cost of investment is $\left(1+\eta_1 \exp\left[-\eta_2\left(\xi_t/\bar{\xi}\right)\right]\right)\left[1+\frac{\partial G_t}{\partial I_t}\right]$, larger than that implied by the standard q-theory without financial frictions. More important, in contrast to the standard models, because marginal issuance cost depends on the fluctuations of aggregate issuance shock ξ_t, the variations of marginal cost of investment is not only driven by shocks from the real sector, e.g., aggregate productivity shocks, but by the perturbations in the financial sector as well. In particular, the marginal cost of investment is inversely related to the realization of ξ_t. In the end, when firms use retained earnings to finance investment, i.e., $H_t = 0$, marginal cost of investment reduces to that implied by the standard models since $\Psi'(H_t)\mathbf{1}_{\{H_t>0\}} = 0$.

Eqs. (20) and (21) are the Euler equations that describe the optimality conditions for capital and debt. Intuitively, Eq. (20) states that to generate one additional unit capital at the beginning of next period, (K_{t+1}), the firm must pay the price of capital, $q_t - \mu_t\bar{S}$. Different from the standard model where the price of capital simply equals the marginal q of investment, here the price of capital also depends on $\mu_t\bar{S}$. When the collateral constraint binds, $\mu_t \geq 0$ measures the tightness of the constraint. One additional unit of capital K_{t+1} will relax the constraint and reduce the effective marginal cost of investment by $\mu_t\bar{S}$ where $\bar{S}$ is the fraction of K_{t+1} that can be liquidated. The next-period marginal benefit of this additional unit of capital depends on the marginal benefit of investing in real technology $\frac{\partial E_{t+1}}{\partial K_{t+1}} + (1-\delta)\left(1+\frac{\partial G_{t+1}}{\partial I_{t+1}}\right)$ and the reduction of the future marginal cost of issuance $1+\Psi'\left(H_{t+1}\right)\mathbf{1}_{\{H_{t+1}>0\}}$ due to the increase in the retained earnings caused by one additional unit of capital K_{t+1}.

Eq. (21) states that to raise one additional unit of debt at the beginning of next period, (B_{t+1}), the firm must pay the shadow price of debt μ_t plus the next-period interest expense of repaying this additional debt net of the reduction in the marginal debt adjustment cost $-\mathbb{E}_t\left[M_{t,t+1}\left(1+\Psi'(H_{t+1})\mathbf{1}_{\{H_{t+1}>0\}}\right)\frac{\partial E_{t+1}}{\partial B_{t+1}}\right] = \mathbb{E}_t\left[M_{t,t+1}\left(1+\Psi'(H_{t+1})\mathbf{1}_{\{H_{t+1}>0\}}\right)\left((1+r_f(1-\tau)) - abs(\frac{\partial \Phi_{t+1}}{\partial B_{t+1}})\right)\right]$.[10] This marginal cost is increasing the marginal issuance cost $\Psi'(H_{t+1})\mathbf{1}_{\{H_{t+1}>0\}}$ because firms may need to take on costly external equity financing to repay the debt due next period. The marginal benefit

[10](Note $\frac{\partial E_{t+1}}{\partial B_{t+1}} = -\left(1+r_f(1-\tau)\right) + abs(\frac{\partial \Phi_{t+1}}{\partial B_{t+1}})$ is mostly negative with reasonable parameter values of c_b^+ and c_b^-)

of debt $\left(1+\Psi'(H_t)\mathbf{1}_{\{H_t>0\}}\right)\frac{\partial E_t}{\partial B_{t+1}}$ is the benefit of one additional unit of debt financing to be used in production, $\frac{\partial E_t}{\partial B_{t+1}}$, augmented by the reduction in the marginal issuance cost $\left(1+\Psi'(H_t)\mathbf{1}_{\{H_t>0\}}\right)$ due to the substitution of debt financing for equity financing at the margin.

3.6 Equilibrium risk and return

In the model, risk and expected stock returns are determined endogenously along with the firm's optimal production decisions. To make the link explicit, we can evaluate the value function in equation (18) at the optimum and obtain

$$V_t = D_t + \mathbb{E}_t\left[M_{t,t+1}V_{t+1}\right] \tag{22}$$

$$\Rightarrow \quad 1 = \mathbb{E}_t\left[M_{t,t+1}R^s_{t+1}\right] \tag{23}$$

in which equation (22) is the Bellman equation for the value function, and the Euler equation (23) follows from the standard formula for stock return $R^s_{t+1} = V_{t+1}/\left[V_t - D_t\right]$. Substituting the stochastic discount from Eq. (17) into Eq. (23), and some algebra, yields the following equilibrium asset pricing equation:[11]

$$\mathbb{E}_t\left[r^e_{t+1}\right] = \lambda_x \times \beta^x + \lambda_\xi \times \beta^\xi \tag{24}$$

in which $r^e_{t+1} = R^s_{t+1} - R_f$ is the stock excess return, $R_f \equiv 1 + r_f = \mathbb{E}_t\left[M_{t,t+1}\right]^{-1}$ is the gross risk-free rate, $\lambda_x = \gamma_x Var(\Delta x_{t+1})$ and $\lambda_\xi = \gamma_\xi Var(\Delta \xi_{t+1})$ are the price of risk of the aggregate productivity shock and aggregate issuance cost shock, respectively, and $\beta^x = Cov\left(r^e_{t+1}, \Delta x_{t+1}\right)/Var(\Delta x_{t+1})$ and $\beta^\xi = Cov\left(r^e_{t+1}, \Delta \xi_{t+1}\right)$ are the sensitivity (betas) of the firm's excess stock returns with respect to the two aggregate shocks in the economy.

According to equation (24), the equilibrium risk premiums in the model are determined by the endogenous covariances of the firm's excess stock returns with the two aggregate shocks (quantity of risk) and its corresponding prices of risk. The sign of the price of risk of the two aggregate shocks is determined by the two factor loading parameters (γ_x and γ_ξ) in the stochastic discount factor in Eq. (17). The pre-specified sign of the loadings imply a positive price of risk of the aggregate productivity shock and a positive price of risk for the equity issuance cost shock. Thus, all else equal, assets with returns that have a high positive covariance with the aggregate productivity shock are risky and offer high average returns in equilibrium. Similarly, all else equal, assets with returns that have a high positive covariance with the

[11]This derivation is standard. Equation (23) implies $\mathbb{E}_t\left[M_{t,t+1}\left(R^s_{t+1} - R_f\right)\right] = 0$ because $\mathbb{E}_t\left[M_{t,t+1}\right]R_f = 1$. Using a first-order log-linear approximation of the SDF $M_{t,t+1}$ defined in Eq. (17), and applying the formula for covariance $Cov(X,Y) = \mathbb{E}[XY] - \mathbb{E}[X]\mathbb{E}[Y]$ to the previous equation, plus some algebra, yields equation (24).

aggregate equity issuance cost shock are risky and offer high average returns in equilibrium.

4 Model solution

This section presents the model solutions. The model is solved at a monthly frequency, which is the frequency of the stock return data used in the empirical tests. Because all the firm-level accounting variables in the data are only available at an annual frequency, we time-aggregate the simulated accounting data to make the model-implied moments comparable with those in the data.

Table 5 reports the parameter values used in the baseline calibration of the model. The model is calibrated using parameter values reported in previous studies, whenever possible, or by matching the selected moments in the data reported in Table 6. To evaluate the model fit, the table reports the target moments in both the data and the model. To generate the model's implied moments, we simulate $3,600$ firms for $1,000$ monthly periods. We drop the first 400 months to neutralize the impact of the initial condition. The remaining 600 months of simulated data are treated as those from the economy's stationary distribution. We then simulate 100 artificial samples and report the cross-sample average results as model moments. Because we do not explicitly target the cross section of return spreads (and abnormal returns) in the baseline calibration, we use these moments to evaluate the model in Section 6.

[Insert Table 5 here]
[Insert Table 6 here]

Firm's technology: general parameters. We set the returns to scale in the production function to be $\theta = 0.7$, consistent with the estimates in Burnside, Eichenbaum, and Rebelo (1995). The share of capital in the production function is set to be $\alpha = 0.36$, following Gomes (2001). The capital depreciation rate δ_k is set to be 1% per month, as in Bloom (2009). The fixed operating cost f is set to match the average aggregate physical capital-to-market equity ratio (KM) of 0.62 as closely as possible, subject to the requirement that the endogenous firm value in the model be positive. Thus, we set $f = 0.07$, which allows us to obtain an average aggregate KM of 0.41. We set corporate tax rate to be 0.35 consistent with Hennessy and Whited (2005, 2007). We set the liquidation cost parameter $\bar{S} = 0.6$ which implies an average book leverage ratio (book debt to total assets ratio) at 0.6, consistent with the data.

Firm's technology: adjustment costs. We calibrate the capital and debt adjustment cost parameters to match several cross-sectional and time-series moments of firms' investment rates and debt growth rates. The convex capital adjustment costs are set to be $c_k^+ = c_k^- = 2$. Table

6 shows that this calibration of the model matches reasonably well the volatility of firm-level investment rates. We calibrate the debt adjustment cost $c_b^+ = 3$ and $c_b^- = 15$ to match the volatility of debt growth rates. We set the equity issuance cost parameters $\eta_1 = 0.2$ and $\eta_2 = -10$ which imply the average equity issuance frequency at 35%, close to the data moment at 38%. It also implies the volatility of equity-issuance-to-book-equity ratio is 0.18, the same as the data.

Stochastic processes. In the model, the aggregate productivity shock is essentially a profitability shock. We set the conditional volatility of the aggregate productivity shock to be $\sigma_x = 0.055$ to match the volatility of aggregate profits (0.14 in the data and 0.12 the model). In the data, we measure aggregate profits using data from the National Income and Product Accounts (NIPA). Given the volatility of the aggregate productivity shock, we set the conditional volatility of the aggregate issuance cost shock to be $\sigma_\xi = 0.035$ and the persistence of the aggregate issuance cost shock to be $\rho_\xi = 0.98$ so that the implied volatility and persistence of aggregate percentage equity issuance are 13% and 0.60, respectively, close to the data moments at 13% and 0.51.

To calibrate the persistence and conditional volatility of the firm-specific productivity shock, we use the same values reported in Zhang (2005), $\rho_z = 0.97$ and $\sigma_z = 0.10$. The long-run average level of firm-specific productivity, $\bar{z}$, is a scaling variable. We set $\bar{z} = -0.9$, which implies that the average detrended long-run physical capital in the economy is 2. In the data, the wage rate per worker is smoother than aggregate output. We set the parameters $\omega = .9$ in the wage rate specification to match the annual volatility of HP-filtered aggregate wage rate per worker (1.40 in the data and 1.32 in the model). To calibrate the stochastic discount factor, we set the real risk-free to be $r_f = 1.65\%$ per annum. We set the loading of the stochastic discount factor on the aggregate productivity shock to be $\gamma_x = 3$, and the loading of the stochastic discount factor aggregate issuance shock to be $\gamma_\xi = 9$ by matching the average aggregate stock market return. We conduct comparative statics in Section 6 to evaluate the impact of the stochastic discount factor loading parameters on the model's performance.

5 Main results

We replicate the portfolio sorts and asset pricing tests performed in the empirical section using the artificial data obtained from the simulation of the model. At this stage of the research, we focus on book-to-market and investment portfolios. Furthermore, we also show that the model replicates the financing flows of the portfolios.

5.1 The cross section of stock returns

Book-to-market portfolios Panel A in Table 6 reports the average value-weighted excess returns of the ten book-to-market portfolios in the model. The calibration of the baseline model generates a pattern of average excess returns across the book-to-market portfolios that is similar to the pattern in the data. Growth firms earn subsequently lower returns on average than value firms. The size of the value premium is comparable with the data. In the model, the value premium is 6.9% per annum, which is close to the 7% per annum value premium reported in Table 8.

[Insert Table 6 here]

Panel A in Table 6 also shows that the Sharpe ratios of the book-to-market portfolios are increasing in firms' current book-to-market ratios, consistent with the data. The Sharpe ratio of the portfolio of value firms is about four times larger (in the real data is two times larger) than the Sharpe ratio of the growth firms. Panel B reports the factor loadings of the book-to-market portfolios with the market excess returns and the issuance shock as two factors, the same as in Eq. (2). The loadings on market portfolios are flat and around 1, while the loadings on the issuance shock is increasing in book-to-market ratio. Moreover, the loadings of growth firms are negative suggesting that growth firms are a hedge against issuance cost shocks while the loadings of value firms are positive, consistent with the data. The difference in the issuance cost shock betas is sizable which explains why the value premium is mostly driven by the issuance cost shock.

Investment portfolios Panel A in Table 7 reports the average value-weighted excess returns of the ten investment portfolios in the model. High investment firms earn subsequently lower returns on average than low investment firms, consistent with the data. The size of the investment spread is comparable with the data. In the model, the investment spread is 5% per annum, which is slightly higher than 3.2% per annum investment spread reported in the data reported in Table 7. The model also replicates the pattern that the Sharpe ratios of the investment portfolios are decreasing in investment rates.

[Insert Table 7 here]

Panel B in Table 7 reports the factor loadings of the investment portfolios with the market portfolio and the issuance cost shock as the two factors. Like the book-to-market portfolios, the loadings on market portfolios are flat and around 1, while the loadings on the issuance shock is decreasing in investment rates. Moreover, the loadings of low investment firms (positive loadings) is two times as large (in absolute value) as the loadings of the high investment firms (negative loadings); this difference is responsible the sizable investment return spread in the model.

5.2 Asset pricing tests

Finally, we investigate whether the model can replicate the failure of the unconditional CAPM model in explaining the value premium and investment return spreads in the data.

Panel A in Table 6 shows that the baseline model matches well the failure of the unconditional CAPM in explaining the average returns of the book-to-market portfolios. The pricing error of the value premium is large, 7% per annum, which is more than 13.2 standard errors from zero and slightly larger than the value premium itself (6.9% per annum). As in the data, the CAPM fails in the model because the growth firms have relatively higher market betas (b), and hence higher risk according to the CAPM, but relatively lower average returns. The model generates large and statistically significant pricing errors (See Table 8), with a mean absolute pricing error that is very close to the data (2.2% per annum in the model versus 2.7% in the data).

The analysis of the asset pricing test results across the portfolios sorted on investment rate (reported in Panel A of Table 7 and Table 8) is qualitatively similar to the analysis across the ten boot-to-market portfolios, and so here we briefly state the main results. As in the data, the unconditional CAPM in the model is unable to fully explain the investment return spreads. The mean absolute pricing error is 1.4% per annum (in the data it is 2.8%). The pricing error of the investment portfolio is 5.1% per annum, close to the data moment of 7% per annum.

The significant magnitude of the CAPM pricing errors in the model, especially for the ten book-to-market portfolios, is an improvement over the standard neoclassical investment-based model in which aggregate productivity is the only source of aggregate risk. Zhang (2005) shows that the standard neoclassical model can generate a sizeable value premium. As shown in Belo and Lin (2012), however, the value premium is completely explained in that model by variation in market betas, a pattern that does not appear to be consistent with the data, at least during our sample period. As a result, the model-implied CAPM pricing errors in the standard investment-based model with one aggregate shock are counterfactually too small and indistinguishable from zero. Belo, Lin, and Bazdresch (2013) show that an aggregate shock to adjustment costs in labor hiring and investment help explain the failure of CAPM in an investment-based asset pricing model. However, the aggregate adjustment cost shock in Belo, Lin, and Bazdresch (2013) is different from the issuance shock. The aggregate issuance shocks are shocks originated from the financial sector that affect the supply of capital, while the adjustment costs shock is from real sector which affects the efficiency of hiring or investment decisions.

5.3 Real investment and capital structure

The model replicates the patterns of real quantities and financial leverage of book-to-market portfolios and investment portfolios. Panel C in Table 6 shows that the model generates a negative relationship between the investment and book-to-market ratios, as well as a negative relationship of debt growth and book-to-market ratios. The model also produces a positive relation between book-to-market ratio and financial leverage. All of these patterns are consistent with data.

Panels D to F in Table 6 report the model implied loadings of book-to-market portfolios' characteristics (investment rates in Panel D, and financial leverage in Panel F) on the two fundamental shocks in the model: aggregate productivity shocks and issuance shocks. Growth firms' investment responds positively to the issuance cost shock and this response is higher than that of value firms, consistent with the data. The model also implies that financial leverage of growth firms respond less than value firms, which is also consistent with the data. Taken together, the model shows that issuance cost shocks also drive the financing flows in addition to driving the expected stock returns.

Similarly, Panel C in Table 7 shows that the model generates a positive relationship between the investment and debt growth across ten investment portfolios. The model also produces a negative relation between investment rates and financial leverage ratios across investment portfolios. Panels D to F (investment in Panel D, and financial leverage in Panel E) in Table 7 shows that the investment of high investment firms respond to the issuance cost shocks more strongly than low investment firms; furthermore, financial leverage ratios of low investment respond more strongly than high investment firms, consistent with the data.

6 Inspecting the mechanism

In this section we perform several analyses to show the economic forces driving the overall good fit of the model.

6.1 The driver of the cross section of stock returns

The theoretical model proposed in Section 3 implies that risk premiums in the economy are determined by Eq. (24). To understand the return spreads, we must thus understand the endogenous sensitivity of the returns of the book-to-market and investment portfolios to the two aggregate risk factors (quantity of risk), as well as the role of the corresponding prices of risk. To facilitate the exposition, the analysis in this section focuses on the ten book-to-market portfolios.

6.1.1 Quantity of risk

To be consistent with the empirical model in Eq. (2), we will implement the exact procedure in section 2 and construct a two-factor model composed of a market factor and issuance shock factor using the simulated data. Given that market factor is most driven by the TFP shock (the TFP shock alone can explain more than 95% variation in the market returns), this factor model is in spirit similar to Eq. (24). The value premium is driven by the differential exposure of the returns of the book-to-market portfolios to the aggregate issuance shock, and not so much by differential exposure to the market factor (aggregate productivity shock). To show this result, we compute the sensitivity (betas) of the returns of the book-to-market portfolios with respect to the two factors in the economy by running the following time-series regression in the simulated data:

$$r_{it}^{e} = a_i + \beta_i^m \times r_t^m + \beta_i^\xi \times \Delta\xi_t + e_{it}, \tag{25}$$

in which r_{it}^e is the monthly excess return of the i^{th} book-to-market portfolio, r_t^m is the market excess returns, and $\Delta\xi_t$ is the aggregate issuance shock. Figure 2 plots the sensitivity of the returns of each portfolio to the two factors. To highlight the cross-sectional dispersion in the exposure to the shocks, we report the portfolio sensitivity to each factor relative to the average (across portfolios) sensitivity.

[Insert Figure 2 Here]

The top two panels in Figure 2 documents an important feature of the model. The sensitivity of the returns of the book-to-market portfolios to the market factor (aggregate productivity shock) is almost flat across the portfolios. In contrast, the dispersion in the sensitivity to the aggregate issuance shock is large, and it is monotonically increasing across the book-to-market portfolios. In particular, the sensitivity of the value firms to the issuance shock is more than two times larger than the sensitivity of the growth firms. Furthermore, the sensitivities of growth firms are negative implying that growth firms are a hedge against aggregate issuance cost shocks. This differential exposure is the fundamental difference in the quantity of risk of the book-to-market portfolios in the model, and explain why the growth firms have lower average returns in equilibrium.

The bottom two panels in Figure 2 document the feature of the model for the investment portfolios. The sensitivity to the market factor is flat across the portfolios while the dispersion in the sensitivity to the aggregate issuance shock is large, and it is monotonically decreasing across the investment portfolios with high investment firms having negative betas implying that investment firms are a hedge against aggregate issuance cost shock.

The previous analysis also helps understand why the CAPM is unable to explain the cross-sectional variation in the average returns of the book-to-market (and investment) portfolios. In the baseline model, almost all of the variation of the aggregate stock market return is driven by shocks to aggregate productivity. Across panels, a multivariate time-series regression of the aggregate stock market return on the two risk factors has an average regression $R^2 \approx 98\%$, a univariate regression on the aggregate productivity shock has an average regression $R^2 \approx 95\%$, but a univariate regression on the aggregate issuance shock has an average regression $R^2 \approx 3\%$ (results not tabulated). Thus, because the aggregate stock market return is mostly driven by the aggregate productivity shock, the market factor alone fails to capture the differential exposure of the book-to-market and investment portfolios to the issuance cost shock.

6.1.2 Price of risk

According to Eq. (24), the impact of the differential firms' exposure to the aggregate shocks on equilibrium risk premiums depends on the price of risk of these shocks. To evaluate the importance of the price of risk of the two aggregate risk factors on the model's results, we perform comparative statics with respect to the loadings (γ_x and γ_ξ) of the stochastic discount factor on the two aggregate shocks.

Table 8 reports selected model-implied moments from several alternative specifications of the model, which we compare against the moments in the data (specification 0) and in the baseline calibration of the model (specification 1). In specifications 2 and 3, we specify the stochastic discount factor to have a low loading on the issuance shock ($\gamma_\xi = 0$ versus $\gamma_\xi = 9$ in the baseline model) and a low loading on the aggregate productivity shock ($\gamma_x = 0$ versus $\gamma_x = 3$ in the baseline model), respectively. In these two specifications, we keep all the other model parameters equal to the baseline specification.

[Insert Table 8 Here]

Specification 2 in Table 8 shows that decreasing the size of the loading of the stochastic discount factor on the aggregate issuance shock has a nontrivial effect on the properties of firms' investment rates, debt growth and issuance. Investment rates and equity-issuance-to-book-equity ratios become more volatile than the baseline model. All of the interesting effects are reflected in the moments of asset prices. Here, the value premium drops substantially (6.94% in the baseline model to −2.9% here), whereas the investment spread remains large. However, the market excess return also falls substantially (5.8% in the baseline model to 1.6% here).

This analysis shows that a sufficiently large and positive price of risk for the issuance shock is crucial for the model to generate positive and sizeable value premium and market premium.

Specification 3 in Table 8 shows that the effect on asset prices is again substantial when the factor loading on aggregate productivity shock is set to zero. The risk premium in the aggregate stock market is significantly reduced (from 5.8% in the baseline model to 4% here), and the value premium also drops substantially (6.9% in the baseline model to 1.7% here); furthermore, the investment spread also falls dramatically (5.15% in the baseline model to 1.8% here). This result thus confirms that the aggregate productivity shock also contributes significantly to the the cross sectional variations in expected returns.

6.1.3 Intuition

Why do the returns of firms with currently high book-to-market ratio (low investment rates and small size) have higher positive covariance with the aggregate issuance shock in equilibrium? Given the positive price of risk of this shock, understanding this endogenous covariance is essential to understanding the return spreads on book-to-market and investment.

To illustrate the economic mechanism behind the previous analyses, Figures 3 and 4 show impulse responses of selected endogenous variables in the baseline calibration of the model to a 1% negative aggregate issuance shock (an increase in the equity financing cost), and to a 1% negative aggregate productivity shock, respectively. We report the responses of each variable relative to its (time-detrended) long-run average level. Because all firms in the economy are ex ante identical, we generate cross-sectional heterogeneity by examining the response of two firms in which their respective firm-specific productivity level is set 1% above and 1% below the long-run average level of firm productivity (we label these two firms as high and low productivity firms, respectively); furthermore, their productivity levels gradually mean revert to the average level following Eq. (6).[12] The high and low productivity firms correspond roughly to the growth (high investment and big cap) and value (low investment and small cap) firms in the model. Even though the difference in productivity is not the only difference across these firms, it is clearly an important state variable.

[Insert Figure 3 Here]

Figure 3 shows that after a negative issuance shock, the high productivity firms increase their investment while the low productivity firms decrease their investment. Due to the increase in the cost of external equity financing, external equity falls upon impact for high productivity firms. The increase in investment and adjustment costs are financed by an increase in debt

[12] The long-run average level is determined by setting all shocks to the long-run average level, i.e., $z = -0.9$, $\xi = -0.51$, and $\Delta x = 0$.

growth. This happens because high productivity firms accumulate more capital which allows them to pledge for more debt. While for low productivity firms, the issuance falls slightly upon impact, but their debt growth falls substantially because their capital decreases causing them to have less capital to be collateralized. The dividends of the high productivity firms increase upon impact and stay above the steady state level for an extended period of time; the dividends of low productivity firms also increase on impact, but this increase is relatively smaller and the dividends fall below the steady level after less than ten months. As a result of the response of firms' profits and dividends over time, the continuation value (the present value of all future dividends at time $t + 1$) of the high productivity firm increases substantially on impact, but the continuation value of the low productivity firm decreases (relative to its long-run average level) on impact. Because current dividends represent a small fraction of total firm value, the properties of firm-level stock returns are mostly determined by the change in the continuation value, the standard capital gains component of stock returns. As such, the returns of the high productivity/low book-to-market (high investment) firms have a negative covariance with the issuance shock while the returns of the low productivity/high book-to-market (low investment) firms have positive covariance with the issuance shock. Because the stochastic discount factor (marginal utility) is increasing in this shock due to its positive price of risk, the differential covariance implies that, all else equal, high book-to-market firms have higher risk than low book-to-market firms because the returns of the low book-to-market (growth) firms are a hedge against the issuance shock.

[Insert Figure 4 Here]

We now turn to the analysis of firms' responses to a negative aggregate productivity shock. Figure 4 shows that firms' responses to this shock also go in the right direction for explaining the cross sectional return spread in the data. After a negative aggregate productivity shock, the high productivity firm increases its investment, whereas the low productivity firm only slightly increase investment on impact (relative to the average long-run level), but decreases after the shock. High productivity firms use debt to finance the increase in investment and the external equity stay almost unchanged; low productivity firms increase equity to finance investment upon impact because their debt decrease. The dividends of high productivity firms fall substantially because of the need to finance investment. The dividends of the low productivity firm also decrease on impact because of its lower output, but this decrease is substantially smaller. After impact, the dividends and sales of the high productivity firm increase to above the steady state level sharply. In turn, the continuation value of the high productivity firm increases on impact, but the continuation value of the low productivity firm decreases. Thus, the returns of the high productivity/low book-to-market firms have a negative covariance with the aggregate productivity shock while the returns of the low productivity/high book-to-market firms have a positive covariance with the aggregate productivity shocks. Because marginal utility is increasing in this shock due to its positive price of risk, this higher covariance implies that, all else equal, high book-to-market firms have higher risk than low book-to-market firms. This analysis shows that aggregate productivity shocks also contribute to the risk dispersion across book-to-market (and investment) firms.

6.2 The role of equity issuance costs

The existence of external equity issuance costs is important for the overall good fit of the model. To show this importance, we compute the model-implied moments from an alternative calibration of the issuance cost function, which we report in Table 8. In specifications 4, we shut down the issuance cost completely ($\eta_1 = 0$). In terms of quantities, specification 4 in Table 8 shows that by removing issuance costs, the model generates a firm-level investment rate and issuance to book equity ratio being too volatile (the volatilities are 0.14/0.18 in the baseline model compared to 0.28/0.66 here, respectively) while debt growth too smooth (the volatility is 0.16 in the baseline model compared to 0.04 here).

We now turn to the analysis of the effects of equity issuance costs on asset prices. Removing equity issuance costs significantly reduces the value premium and the investment return spread relative to the baseline model. For example, the value premium and investment spread are −5.8% and 1.7% without issuance cost, respectively. These values are all considerably smaller than the those 7% and 3.2% return spread observed in the data and 6.9% and 5.2% in the baseline model.

Another interesting comparative statics is the specification 5 where we shut down the issuance shock on the cost of external equity financing ($\eta_2 = 0$). The model implied investment rates becomes more volatile while debt growth rates becomes smoother. Removing the aggregate shocks on equity issuance costs also significantly reduces the value premium and the investment return spread relative to the baseline model. The value premium and investment spread are −4.9% and 1.3% without issuance cost shocks, respectively, considerably smaller than 6.9% and 5.2% in the baseline model. Taken together, equity issuance costs driving by the aggregate issuance shocks play a key role in determining both real quantities and asset prices.

6.3 Discussion: shocks to debt financing costs

So far, we have studied the impact of the aggregate external equity issuance shock on real quantities, financing flows and asset prices. Here, we briefly discuss the impact of an aggregate shock on debt financing costs on asset prices when we allow the liquidation value of capital to be time-varying. In the model, the collateral constraint captures the idea that the lender can fully observe whether or not the borrower is fulfilling his or her contractual obligations. But, the lender does not have tools available to enforce the contractual obligations. For instance, even if the bank knows that firms (borrowers) are not exerting effort or are diverting funds, it may be difficult to prove in court. In the model, the parameter that determines the fire sale value of liquidated capital (i.e., the tightness of collateral constraint), $\bar{S}$, is set to constant. A recent literature on the impact of macroeconomic quantities of credit shocks highlights the role of stochastic tightness of collateral constraint in generating recessions in DSGE models (e.g., Jermann and Quadrini 2011; Khan and Thomas 2013). We have also experimented with a stochastic $\bar{S}_t$. More specifically, we assume $\bar{S}_t$ follows an AR(1) process

$$\log \bar{S}_{t+1} = (1 - \rho_S) \log \bar{S} + \rho_S \log \bar{S}_t + +\sigma_S \varepsilon^S_{t+1},$$

with $\bar{S}$, ρ_S, and σ_S are the mean, first-order autocorrelation coefficient and conditional volatility of the $\log \bar{S}_{t+1}$ and ε^S_{t+1} is an i.i.d. standard normal shock that is independent of ε^x_{t+1} and ε^z_{t+1}. We find that such an aggregate shock on collateral constraint does not generate significant cross sectional variations in expected stock returns (Results available upon request). The reason is that $\bar{S}_{t+1}$ affects investment decisions only if the collateral constraint binds. However the collateral constraint only binds occasionally in the model, partly because firms use equity financing to avoid hitting a binding constraint. Given that shocks on constraint only affect investment decision occasionally, it does not affect dividend/continuation values of firms significantly.

7 Conclusion

We show that aggregate shocks to the cost of external equity financing have significant impact on real quantities, financing flows, and asset prices in the cross section of public traded firms. An empirical proxy of the aggregate shock of equity issuance prices the cross section of stock returns including book-to-market, investment, size, and cash-flow portfolios. We build an investment-based asset pricing model featuring aggregate shocks to the cost of firms' external equity issuance and collateral constraint to interpret the links in the data. We show that costly equity issuance and issuance shocks are crucial for the model to quantitatively capture the joint dynamics of firms' real quantities, financing flows, and asset prices. We also offer an novel explanation for the failure of the unconditional CAPM model in pricing the cross-section of expected stock returns.

Our results have implications for asset pricing, corporate finance, and macroeconomics literature. Our findings suggest that financial shocks, in particular, equity issuance shocks can have a significant impact on asset prices. Financial frictions, which are typically ignored in the macroeconomic economics literature, can thus be a useful source of information for quantifying business cycle fluctuations. Our results suggest that incorporating aggregate shocks to firms external equity financing in current DSGE models can be important for an accurate understanding of aggregate quantity and financing flows dynamics over the business cycle.

References

Altinkilic, Oya, and Robert S. Hansen, 2000, Are there economies of scale in underwriting fees? Evidence of rising external financing costs, Review of Financial Studies 13, 191-218.

Belo, Frederico, 2010, Production-based measures of risk for asset pricing. Journal of Monetary Economics 57, 146–163.

Belo, Frederico, and Xiaoji Lin, 2012, The inventory growth spread, *Review of Financial Studies*, 25(1), 278–313.

Belo, Frederico., and Jianfeng Yu, 2013, Government Investment and the Stock Market, Journal of Monetary Economics, 60(3): 325-339.

Belo, Frederico, Lin, X., and S Bazdresch, 2012, Labor hiring, investment, and stock return predictability in the cross section. Forthcoming. Journal of Political Economy.

Bernanke, Ben, and Mark Gertler. 1989. Agency Costs, Net Worth, and Business Fluctuations. American Economic Review, 79(1): 14-31.

Bernanke, Ben, Mark Gertler, and Simon Gilchrist. 1999. The Financial Accelerator in a Quantitative Business Cycle Framework", in Taylor, J. B. and M. Woodford (editors), Handbook of Macroeconomics, Volume 1C, chapter 21, Amsterdam: Elsevier Science.

Bloom, Nicholas, 2009, The impact of uncertainty shocks, *Econometrica*, 77(3), 623–685.

Boldrin, M., L. Christiano and J. Fisher. 2001. Habit persistence, asset returns, and the business cycle, *American Economic Review* 91 (1), 149–166.

Bolton, P., Chen, H., Wang, N., 2011. A unified theory of Tobin's q, corporate investment, financing, and risk management. Forthcoming. Journal of Finance.

Burnside, Craig, Michael Eichenbaum, and Sergio Rebelo, 1995, Capital utilization and returns to scale, *NBER macroeconomics annual 1995,* vol. 10, ed. Ben S. Bernanke and Julio J. Rotemberg, 67–110. Cambridge: MIT press.

Bustamonte, Maria Cecilia, 2013, How do Frictions affect Corporate Investment? A structural approach, Working paper, London School of Economics

Cochrane, J. H., 1991. Production-based asset pricing and the link between stock returns and economic fluctuations. Journal of Finance 46, 209–237.

Cochrane, J. H., 1996. A cross-sectional test of an investment-based asset pricing model. Journal of Political Economy 104, 572–621.

Croce, Max., T. Nguyen and L. Schmid, 2012, Fiscal Policies and Asset Prices. Review of Financial Studies, 25(9): 1-38.

DeMarzo, P., Fishman, M., He, Z., Wang, N., 2011. Dynamic agency and the q theory of investment. Forthcoming. Journal of Finance.

Eisfeldt, Andrea., and Tyler Muir, 2013, Aggregate Issuance and Savings Waves, Working paper, UCLA

Fama, E. F., French, K. R., 1992. The cross section of expected stock returns. Journal of Finance 47, 427–465.

Fama, E. F., French, K. R., 1993. Common risk factors in return of stocks and bonds. Journal of Financial Economics 33, 3–56.

Favilukis, Jack, and Xiaoji Lin, 2013, Wage rigidity: A quantitative solution to several asset pricing puzzles. Working paper, London School of Economics and Ohio State University

Fazzari, Steven, R. Glenn Hubbard, and Bruce Petersen, 1988, Financing constraints and corporate investment, Brookings Papers on Economic Activity 1, 144-195.

Gomes, J., and L. Schmid, 2010, Levered returns, Journal of Finance, 65(2): 467-494.

Gilchrist, Simon and John Leahy, 2002. Monetary policy and asset prices, Journal of Monetary Economics, 75–97.

Hayashi, F., 1982. Tobin's marginal q and average q: a neoclassical interpretation. Econometrica 50, 213–224.

Hennessy, Christopher A., and Toni M. Whited. 2005. Debt Dynamics". Journal of Finance, 60(3): 1129-65.

Hennessy, Christopher A., and Toni M. Whited. 2007. How costly is external financing? Evidence from a structural estimation, The Journal of Finance, 2007, 1705-1745.

Hodrick, Robert, and Edward C. Prescott (1997), "Postwar U.S. Business Cycles: An Empirical Investigation," Journal of Money, Credit, and Banking, 29 (1), 1-16.

Jermann, U. 1998. Asset pricing in production economies, *Journal of Monetary Economics* 41, 257–275.

Jermann, Urban , and Vicenzo Quadrini, 2012, Macroeconomic Effects of Financial Shocks, American Economic Review, 238-71.

Kaltenbrunner, Georg, and Lars Lochstoer, 2010, Long-run risk through consumption smoothing, Review of Financial Studies.

Khan, Aubhik, and Julia Thomas, 2013, Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity. Forthcoming Journal of Political Economy.

Kiyotaki, Nobuhiro, and John H. Moore. 1997. Credit Cycles". Journal of Political Economy, 105(2): 211-48.

Kogan, Leonid and Dimitris Papanikolaou. 2012. Growth Opportunities, Technology Shocks and Asset Prices. Forthcoming Journal of Finance

Krasker, William S., 1986, Stock price movements in response to stock issues under asymmetric information, Journal of Finance 41, 93-105.

Lettau, Martin., and Sydney Ludvigson, 2002, Time–Varying Risk Premia and the Cost of Capital: An Alternative Implication of the Q-Theory of Investment," Journal of Monetary Economics, 49:31–66

Lettau, Martin., and Jessica Wachter, 2007, Why is Long-horizon Equity Less Risky? A Duration-based Explanation of the Value Premium, Journal of Finance, LXII(1), 55-92.

Lin, Xiaoji, Endogenous Technological Progress and the Cross Section of Stock Returns, 2012, Journal of Financial Economics, 103 (2): 411-427.

Liu, L. X., Whited T., Zhang, L., 2009. Investment-based expected stock returns. Journal of Political Economy 117, 1105–1139.

Livdan, D., Sapriza, H., Zhang, L., 2009. Financially constrained stock returns. Journal of Finance 64, 1827–1862.

Lucas, Robert, 1979, On the Size Distribution of Business Firms, Bell Journal of Economics, 508-523.

McLean, R. David and Mengxin Zhao, 2013, The Business Cycle, Investor Sentiment, and Costly External Finance, Journal of Finance, forthcoming.

Merz, Monika, and Eran Yashiv, 2007, Labor and the market value of the firm, *American Economic Review*, 97(4), 1419–1431.

McGrattan, E. 1999. Application of weighted residual methods to dynamic economic models. In *Computational Methods for the Study of Dynamic Economies*, Chapter 6, eds. R. Marimon and A. Scott. Oxford: Oxford University Press.

Myers, Stewart C. and Nicholas Majluf, 1984, Corporate financing and investment decisions when firms have information that investors do not have, Journal of Financial Economics 13, 187-221

Papanikolaou, Dimitris. 2011. Investment Shocks and Asset Prices. Journal of Political Economy. 119(4): 639-685

Rouwenhorst, G., 1995. Asset pricing implications of equilibrium business cycle models. In: Cooley, T. F. (Ed.), Frontiers of Business Cycle Research. Princeton University Press, Princeton, NJ, pp. 294–330.

Tauchen, J., and R. Hussey. 1991. Quadrature-based methods for obtaining approximate solutions to nonlinear asset pricing models. Econometrica 59 (2): 371-396.

Yang, Fan, 2012, Investment shocks and the commodity basis spread, Journal of Financial Economics, forthcoming.

Zhang, Lu, 2005. The value premium. Journal of Finance 60, 67–103.

A-1 Making the Model Stationary

It is easy to verify that all variables grow with X_t on the balanced growth path. Define

$$\{V_t, D_t, E_t, Y_t, K_t, B_t, N_t, I_t, H_t, G_t, \Phi_t, \Psi_t, F_t\} = \\ \{v_t X_t, d_t X_t, e_t X_t, y_t X_t, k_t X_{t-1}, b_t X_{t-1}, n_t X_{t-1}, i_t X_t, h_t X_t, g_t X_t, \phi_t X_t, \psi_t X_t, f X_t\} \quad (26)$$

where $\{v_t, d_t, e_t, y_t, k_t, b_t, n_t, i_t, h_t, g_t, \phi_t, \psi_t, f\}$ are detrended stationary variables.

The stationary optimization problem can be written as follows:

$$v(\Delta x_t, z_t, \xi_t, k_t, b_t) = \max_{i_t, b_{t+1}, n_t} d_t + \mathbb{E}_t\left[M_{t,t+1}\frac{X_{t+1}}{X_t}v(x_{t+1}, z_{t+1}, \xi_{t+1}, k_{t+1}, b_{t+1})\right] \tag{27}$$

$$s.t. \quad d_t = e_t - \psi_t \tag{28}$$

$$h_t = \max(-e_t, 0) \tag{29}$$

$$e_t = (1-\tau)(y_t - W_t n_t \frac{X_{t-1}}{X_t} - f) + \tau\delta k_t \frac{X_{t-1}}{X_t} + \tau r_f b_t \frac{X_{t-1}}{X_t} - i_t - g_t + b_{t+1} - (1+r_f)b_t\frac{X_{t-1}}{X_t} - \phi_t \tag{30}$$

$$k_{t+1} = (1-\delta)k_t\frac{X_{t-1}}{X_t} + i_t \tag{31}$$

$$b_{t+1} \leq \bar{S}k_{t+1} \tag{32}$$

where the stationary output and various adjustment costss are given as follows:

$$y_t = Z_t\left(\frac{X_t}{X_{t-1}}\right)^{-\theta}\left(k_t^{\alpha}n_t^{1-\alpha}\right)^{\theta} \tag{33}$$

$$g_t = \begin{cases} \frac{c_k^+}{2}\left(\frac{i_t}{k_t}\right)^2 k_t\frac{X_t}{X_{t-1}}, & i_t \geq 0 \\ \frac{c_k^-}{2}\left(\frac{i_t}{k_t}\right)^2 k_t\frac{X_t}{X_{t-1}}, & i_t < 0. \end{cases} \tag{34}$$

$$\phi_t = \begin{cases} \frac{c_d^+}{2}\left(\frac{\Delta b_t}{b_t}\right)^2 b_t\frac{X_t}{X_{t-1}}, & \Delta b_t \geq 0 \\ \frac{c_d^-}{2}\left(\frac{\Delta b_t}{b_t}\right)^2 b_t\frac{X_t}{X_{t-1}}, & \Delta b_t < 0. \end{cases} \tag{35}$$

$$\psi_t = \left[\eta_1 \exp\left[-\eta_2\left(\xi_t/\bar{\xi}\right)\right] h_t\right] \mathbf{1}_{\{h_t>0\}} \tag{36}$$

where $\Delta b_t = b_{t+1} - b_t\frac{X_{t-1}}{X_t}$. The optimal labor demand n_t^* can be solved by using the first-order condition with respect to labor,

$$n_t^* = \left[\theta(1-\alpha)Z_t\left(\frac{X_t}{X_{t-1}}\right)^{1-\theta} K_t^{\alpha\theta}W_t^{-1}\right]^{\frac{1}{1-(1-\alpha)\theta}}. \tag{37}$$

Finally, the stock return is given as follows:

$$R_{t+1} = \frac{V_{t+1}}{V_t - D_t} = \frac{v_{t+1}\frac{X_{t+1}}{X_t}}{v_t - d_t}. \tag{38}$$

A-2 Numerical Algorithm

To solve the model numerically, we use the value function iteration procedure to solve the firm's maximization problem. The value function and the optimal decision rule are solved on a grid in a discrete state space. We specify a grid of 25 points for capital and debt, respectively, with upper bounds $\bar{k}$ and $\bar{b}$ that are large enough to be nonbinding. The grids for capital and labor stocks are constructed recursively, following McGrattan (1999), that is, $k_i = k_{i-1} + c_{k1} \exp(c_{k2}(i-2))$, where $i = 1,...,25$ is the index of grids points and c_{k1} and c_{k2} are two constants chosen to provide the desired number of grid points and two upper bounds $\bar{k}$ and $\bar{b}$, given two pre-specified lower bounds $\underline{\mathrm{k}}$ and $\underline{\mathrm{b}}$. The advantage of this recursive construction is that more grid points are assigned around $\underline{k}$ and $\underline{\mathrm{b}}$, where the value function has most of its curvature.

The aggregate productivity shock ε_t^x is an i.i.d. standard normal shock. We discretize ε_t^x into 3 grid points using Gauss-Hermite quadrature. The state variables ξ and z have continuous support in the theoretical model, but they have to be transformed into discrete state space for the numerical implementation. The popular method of Tauchen and Hussey (1991) does not work well when the persistence level is above 0.9. Because both the aggregate adjustment cost wedge and idiosyncratic productivity processes are highly persistent, we use the method described in Rouwenhorst (1995) for a quadrature of the Gaussian shocks. We use 9 grid points for the ξ process and 3 grid points for the z process. In all cases, the results are robust to finer grids as well. Once the discrete state space is available, the conditional expectation can be carried out simply as a matrix multiplication. Cubic spline interpolation is used extensively to obtain optimal investment and hiring that do not lie directly on the grid points. Finally, we use a simple discrete global search routine in maximizing the firm's problem.

Table 1 : Properties of issuance cost shocks

This table reports the results from the VAR(1) estimates of the issuance cost shock (ICS) and TFP shocks, as well as the correlation of these variables with macroeconomic variables: the growth rate of aggregate GDP (ΔGDP), Investment (ΔI), and Consumption (ΔC), and a proxy of investment-specific technological shocks (ISTS real quality-adjusted investment price growth). ICS is the innovation to percentage issuance in the VAR (the proxy for the equity issuance cost shock). TFP is the innovation to TFP in the VAR. The data is annual from 1971 to 2011.

Panel A: Summary statistics

Description	Parameter	Value	
Mean level of the percentage of firms issued		38.76	
Standard deviation of the percentage of firms issued		12.63	
Standard deviation of TFP shock	σ_x	0.85	
Standard deviation of the issuance cost shock (ICS)	σ_s	3.64	
Matrix for the shocks process	A	0.71	−0.01
		−0.15	0.51

Panel B: Correlation matrix

	ΔGDP	ΔI	ΔC	ISTS	ICS
ΔI	0.80				
ΔC	0.86	0.63			
ISTS	0.30	0.36	0.13		
ICS	0.06	0.28	0.07	−0.04	
TFP	0.08	0.55	0.09	0.09	−0.10

Table 2 : Issuance cost shocks and aggregate economic activity

This table reports results from long-horizon predictability regressions of $\Sigma_h^H d_{it+h}$, in which d_i is either the growth rate of output (Panel A), the growth rate of investment (Panel B), or the growth rate of nondurables consumption (Panel C), and H is the forecast horizon in years. The regressors are the H-period lagged values of the total factor productivity shock (TFP), and issuance cost shock (ICS). For each regression, we report the OLS estimate of the slope coefficient, slope, and the Newey-West corrected t-statistic, [t], and the adjusted R2. The sample is annual from 1971 to 2010.

			Forecast horizon in years				
Panel	Regressors		1	2	3	4	5
			Output				
A	TFP	Slope	1.20	1.82	2.22	1.24	−0.40
		$[t]$	2.95	3.21	3.57	1.80	−0.74
	ICS	Slope	0.04	0.18	0.23	0.16	0.10
		$[t]$	0.81	2.33	1.79	1.00	0.51
		R^2	22.70	21.46	19.78	4.52	1.10
			Investment				
B	TFP	Slope	2.55	4.73	5.39	3.29	−1.53
		$[t]$	1.59	1.92	2.37	1.46	−0.77
	ICS	Slope	0.33	0.74	1.18	0.85	0.40
		$[t]$	1.54	2.48	2.68	1.69	0.58
		R^2	14.56	19.19	19.30	6.27	2.05
			Consumption				
C	TFP	Slope	0.82	1.19	1.54	1.16	0.23
		$[t]$	2.59	2.53	2.87	1.70	0.29
	ICS	Slope	0.06	0.18	0.18	0.15	0.13
		$[t]$	1.48	2.38	2.30	1.11	0.93
		R^2	18.94	19.05	17.94	7.35	1.28

Table 3 : Issuance cost shocks and systematic risk in the cross section

TThis table reports the portfolio average returns, and the CAPM and a two factor-model test results using several portfolio sorts as test assets. Each sort is based on 10 portfolios, and we report portfolios 1 (Low, L), and 10 (High, H). H-L stands for the high-minus-low portfolio. E[r^e] is the average annualized ($\times$1200) portfolio excess stock return; $\sigma[r^e]$ are the annualized standard deviation of the portfolio excess returns; $[t]$ are heteroscedasticity and autocorrelation consistent t-statistics (Newey-West). Panel A reports the results from time-series regressions. α are the portfolio average abnormal returns, obtained as the intercept from monthly CAPM regression, reported in annual percentage ($\times$1200); MKT and ICS (issuance cost shock) are the portfolio market and issuance cost shock betas, respectively, obtained from a the time series regression of the portfolio excess returns on the market and the ICS factors (we do not report the intercept from the previous regression because it is not meaningful - the intercept does not have to be zero since the ICS factor is not an excess return). Panel B reports the results from cross-sectional regressions. λ_M is the estimated price of risk of the market factor; λ_I is the estimated price of risk of the issuance cost shock; RMSE is the root mean squared errors across portfolios; $\varkappa^2$ is the p-value of the chi-square test that the pricing errors are jointly zero. The sample is from July 1971 to June 2011.

	10 Book-to-Market			10 Investment			10 Size			10 Earnings-to-price			10 Cashflow-to-price		
	Panel A: Time series regressions														
	L	H	H-L	L	H	H-L	L	H	H-L	L	H	H-L	L	H	H-L
E[r^e]	4.62	11.69	7.07	7.47	4.14	−3.32	9.10	5.50	−3.61	4.72	10.97	6.25	4.52	10.82	6.30
[t]	1.51	4.65	2.18	3.06	1.03	−1.02	2.25	2.07	−0.74	1.64	4.13	2.26	1.48	5.03	2.14
σ[r^e]	22.66	24.72	21.85	20.76	33.90	22.77	28.76	18.43	22.95	24.81	21.74	20.40	24.52	18.88	18.77
α	−2.17	5.29	7.46	1.67	−5.34	−7.02	2.04	−0.37	−2.40	−2.52	4.92	7.44	−2.70	5.50	8.20
[t]	−1.54	2.60	2.29	0.86	−1.91	−2.34	0.49	−0.44	−0.49	−1.83	2.83	2.82	−1.78	4.07	3.16
MKT	1.11	1.05	−0.06	0.95	1.56	0.61	1.16	0.96	−0.20	1.19	0.99	−0.20	1.18	0.87	−0.31
[t]	18.41	7.93	−0.40	9.04	8.82	2.91	8.21	27.24	−1.14	14.12	11.03	−1.19	16.97	10.24	−2.22
R^2	0.84	0.63	0.00	0.73	0.73	0.25	0.56	0.95	0.03	0.80	0.72	0.03	0.81	0.74	0.10
MKT	1.14	0.99	−0.15	0.89	1.55	0.67	1.08	0.98	−0.10	1.20	0.96	−0.24	1.21	0.84	−0.36
[t]	18.33	11.86	−1.29	12.30	8.00	3.13	9.19	32.88	−0.70	13.31	11.09	−1.39	16.69	11.28	−2.76
ICS	−0.68	1.55	2.24	1.60	0.03	−1.57	1.99	−0.54	−2.53	−0.28	0.78	1.06	−0.56	0.73	1.29
[t]	−1.97	2.54	2.59	4.79	0.04	−1.76	3.91	−3.28	−3.82	−0.58	1.57	1.14	−1.37	2.28	1.92
R^2	0.85	0.68	0.14	0.80	0.73	0.31	0.63	0.96	0.18	0.80	0.74	0.07	0.82	0.76	0.16
	Panel B: Cross-sectional regressions														
	CAPM	2F		CAPM	2F		CAPM	2F		CAPM	2F		CAPM	2F	
λ_M	8.40	6.50		5.71	4.83		7.70	6.78		8.18	6.08		7.94	6.55	
[t]	3.48	2.75		2.38	1.92		2.62	2.94		3.44	2.42		3.37	2.70	
λ_I		3.28			3.25			1.29			4.93			4.54	
[t]		2.07			2.00			0.63			1.91			1.88	
RMSE	2.16	0.72		2.75	2.04		0.71	0.43		2.48	1.01		2.38	1.18	
χ^2 (p)	6.48	45.66		0.00	0.43		25.26	36.60		0.38	45.24		8.50	53.36	

Table 4 : Issuance cost shocks and portfolio characteristics

This table reports results from time series regressions of portfolio characteristics, which include change in log investment rate in physical capital ($\Delta \log(\text{IK})$), book-to-market ratio (BM), and financial leverage (LEV), The regressors are the total factor productivity shock (TFP) and issuance cost shock (ICS), which are estimated from the VAR system. For each regression, we report the OLS estimate of the slope coefficient, slope, and the Newey-West corrected t-statistic, [t], and the adjusted R2. E[Q] represents historical averages of portfolio characteristics. Panel A reports the results for 10 book-to-market portfolios. Panel B reports the results for 10 investment portfolios. The sample is annual from 1971 to 2010.

	Panel A: 10 Book-to-market						Panel B: 10 Investment					
$\Delta \log(\text{IK})$	G	2	4	6	8	V	L	2	4	6	8	H
E[Q]	-0.01	0.00	0.00	0.00	0.00	0.01		-0.01	0.00	0.00	0.00	0.00
TFP	-3.59	-3.10	-2.45	-1.38	-3.56	-0.34		-3.63	-2.81	-2.21	-1.54	-2.53
[t]	-1.45	-1.60	-0.88	-0.42	-1.14	-0.17		-1.14	-1.15	-1.01	-0.78	-1.33
ICS	1.00	1.38	0.43	0.07	-0.54	0.13		-0.20	-0.26	0.07	0.48	1.13
[t]	1.94	3.73	0.81	0.12	-0.78	0.26		-0.32	-0.57	0.18	1.13	2.71
R^2	0.13	0.21	0.03	0.01	0.04	0.00		0.04	0.04	0.03	0.04	0.16
BM												
E[Q]	0.19	0.35	0.58	0.83	1.22	7.58	1.08	1.03	0.87	0.74	0.64	0.46
TFP	0.46	1.06	2.26	4.18	8.12	51.00	6.08	5.24	2.44	2.54	2.01	1.76
[t]	0.37	0.50	0.71	0.97	1.25	0.33	0.75	0.85	0.48	0.55	0.44	0.55
ICS	0.38	0.88	1.55	2.22	3.15	11.81	2.92	3.19	2.19	1.80	1.49	0.87
[t]	1.14	1.61	1.95	2.19	2.54	0.41	1.88	2.16	1.79	1.65	1.49	1.09
R^2	0.04	0.06	0.07	0.08	0.09	0.00	0.05	0.08	0.05	0.05	0.04	0.02
LEV												
E[Q]	0.16	0.26	0.46	0.68	0.97	8.90	1.06	0.98	0.78	0.62	0.47	0.31
TFP	-1.07	-0.28	0.34	2.64	5.01	127.74	6.35	5.80	0.42	1.41	0.67	-1.06
[t]	-1.09	-0.15	0.13	0.62	0.94	0.61	0.77	0.98	0.09	0.33	0.18	-0.35
ICS	0.07	0.08	0.77	0.94	1.85	17.13	1.10	2.10	1.35	0.93	0.53	0.38
[t]	0.28	0.19	1.18	1.05	1.46	0.45	0.63	1.56	1.21	1.02	0.63	0.48
R^2	0.03	0.00	0.03	0.02	0.05	0.01	0.02	0.07	0.03	0.02	0.01	0.01

Table 5 : Calibration

This table presents the calibrated parameter values of the baseline model.

Parameter	Symbol	Value
Technology		
Capital share in the production function	α	0.36
Returns to scale	θ	0.70
Corporate tax rate	τ	0.35
Rate of depreciation for capital	δ	0.01
Fixed operating cost	f	0.07
Adjustment cost parameters in capital	c_k^+/c_k^-	2/2
Adjustment cost parameters in debt	c_d^+/c_d^-	3/15
Issuance shock parameters	η_1/η_2	0.2/10
Stochastic processes		
Sensitivity of the wage rate to aggregate productivity	ω	0.90
Average growth rate of aggregate productivity	μ_x	0.13/12
Conditional volatility of aggregate productivity	σ_x	0.06
Average level of firm-specific productivity	$\bar{z}$	-0.90
Persistence coefficient of firm-specific productivity	ρ_z	0.97
Conditional volatility of firm-specific productivity	σ_z	0.10
Average level of issuance disturbance	$\bar{\xi}$	-0.51
Persistence coefficient of issuance disturbance	ρ_ξ	0.98
Conditional volatility of issuance disturbance	σ_ξ	0.035
Real risk-free rate	r_f	1.65/12
Loading of the SDF on aggregate productivity shock	γ_x	3.0
Loading of the SDF on the issuance shock	γ_ξ	9.0

Table 6 : Target moments

This table presents the selected target moments used for the calibration of the baseline model. We compare the moments in the data with moments of simulated data. The model-implied moments are the mean value of the corresponding moments across simulations. The time series of the firm-level moments are computed using pooled (across all firms and years) data. The real data are from 1972 to 2011. The reported statistics for the model are obtained from 100 samples of simulated data, each with 3,600 firms and 600 monthly observations.

Moment	Data	Model
Asset prices		
Average stock market excess return (%)	6.25	5.85
Sharpe ratio of aggregate stock market	0.33	.33
Average real risk-free rate (%)	1.65	1.65
Average aggregate capital-to-market-equity ratio	0.62	0.41
Real quantities and input prices		
Standard deviation of aggregate profits	0.14	0.12
Standard deviation of wage rate	1.40	1.32
Standard deviation of aggregate percentage issuance	0.13	0.13
Persistence of aggregate percentage issuance	0.60	0.51
Firm-level investment rate, debt growth, and issuance		
Standard deviation of IK	0.17	0.14
Standard deviation of ΔB	0.24	0.16
Standard deviation of ES	0.18	0.18

Table 7 : 10 book-to-market portfolios in simulated data

This table reports the CAPM and a two factor-model test results using ten book-to-market portfolios as test assets in the simulated data. Panel A reports the results from time-series regressions. r^e is the average annualized ($\times 1200$) portfolio excess stock return; $\sigma[r^e]$ are the annualized standard deviation of the portfolio excess returns; S.R. are the Sharpe ratios. $[t]$ are heteroscedasticity and autocorrelation consistent t-statistics (Newey-West); α are the portfolio average abnormal returns, obtained as the intercept from monthly CAPM regression, reported in annual percentage ($\times 1200$); MKT and IS (issuance cost shock) are the portfolio market and issuance cost shock betas, respectively, obtained from a the time series regression of the portfolio excess returns on the market and the IS factors (we do not report the intercept from the regression because it is not meaningful - the intercept does not have to be zero since the ICS factor is not an excess return). H-L stands for the high-minus-low book-to-market portfolio (value spread). Panel B reports the results from time series regressions of the two factor model with MKT and ICS as two factors. Panel C reports the characteristics (IK is investment;ΔDebt is the debt growth rate; Lev is the financial leverage ratio) of the book-to-market portfolios. Panels D and E report the factor loadings of portfolio characteristics (IK in panel D and Lev in panel E) on the two aggregate shocks in the model (TFP and ICS). The reported statistics for are obtained from 100 samples of simulated data, each with 3,600 firms and 600 monthly observations.

	G	2	3	4	5	6	7	8	9	V	V-G
Panel A: Book-to-market portfolio returns											
$E[r^e]$	2.38	2.51	4.45	6.79	6.8	6.8	7.13	8.48	9	9.32	6.94
$\sigma[r^e]$	18.31	17.93	17.80	17.41	17.44	17.44	17.83	18.04	18.00	18.27	3.39
S.R.	0.13	0.14	0.25	0.39	0.39	0.39	0.4	0.47	0.5	0.51	2.05
[t]	0.92	0.96	1.71	2.67	2.66	2.66	2.75	3.26	3.46	3.54	13.16
α	−3.58	−3.49	−1.4	1.08	1.07	1.05	1.32	2.66	3.17	3.44	7.02
[t]	−12.84	−12.37	−6.31	4.63	4.61	4.56	5.43	9.66	9.97	10.17	13.27
MKT	1.02	1.03	1.00	0.97	0.98	0.98	0.99	0.99	1.00	1.01	−0.02
[t]	210.3	210.09	262	244.99	247.68	253.38	242.63	217.24	199.33	179.81	−1.59
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.01
Panel B: Two factor regression											
MKT	1.02	1.03	1.00	0.98	0.98	0.98	1.00	1.00	1.00	1.01	−0.01
[t]	218.39	216.11	268.76	242.28	245.38	253.65	248.21	224.28	204.59	190.19	−0.97
ICS	−0.05	−0.05	−0.03	0.01	0.01	0.02	0.02	0.04	0.05	0.06	0.12
[t]	−6.97	−6.12	−4.03	2.68	2.42	3.34	3.89	4.71	5.02	5.26	6.52
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.2

Table 6 : 10 book-to-market portfolios in simulated data (cont.)

	G	2	3	4	5	6	7	8	9	V
					Panel C: Characteristics					
IK	0.28	0.19	0.2	0.17	0.15	0.12	0.08	0.05	0.03	0.02
ΔDebt	0.19	0.08	0.09	0.06	0.03	0.00	-0.05	-0.08	-0.11	-0.14
Lev	0.36	0.39	0.38	0.36	0.38	0.41	0.44	0.42	0.46	0.52
					Panel D: Factor regression of investment rate					
β^x	1.62	1.51	1.18	0.84	0.85	0.84	0.83	0.79	0.76	0.78
[t]	5.22	4.66	4.44	4.44	4.55	4.49	4.59	4.67	4.63	4.76
β^{IS}	1.20	1.53	1.31	0.83	0.86	0.87	0.89	0.86	0.81	0.85
[t]	2.39	2.82	2.69	2.37	2.48	2.52	2.62	2.71	2.80	2.91
R^2	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.07
					Panel E: Factor regression of financial leverage					
β^x	0.04	0.03	0.01	0.01	0.02	0.02	0.04	0.02	0.01	0.06
[t]	1.52	1.22	0.27	0.32	0.78	0.66	0.90	0.60	0.35	1.01
β^{IS}	0.00	0.05	0.08	0.02	0.05	0.04	0.02	0.11	0.12	0.11
[t]	0.01	0.94	1.24	0.31	0.6	0.4	0.17	1.16	1.05	0.62
R^2	0.01	0.01	0.00	-0.02	-0.01	-0.01	0.00	0.01	0.01	0.00

Table 7 : 10 investment rate portfolios in simulated data

This table reports the CAPM and a two factor-model test results using ten investment portfolios as test assets in the simulated data. Panel A reports the results from time-series regressions. r^e is the average annualized ($\times 1200$) portfolio excess stock return; $\sigma[r^e]$ are the annualized standard deviation of the portfolio excess returns; S.R. are the Sharpe ratios. $[t]$ are heteroscedasticity and autocorrelation consistent t-statistics (Newey-West); α are the portfolio average abnormal returns, obtained as the intercept from monthly CAPM regression, reported in annual percentage ($\times 1200$); MKT and IS (issuance cost shock) are the portfolio market and issuance cost shock betas, respectively, obtained from a the time series regression of the portfolio excess returns on the market and the IS factors (we do not report the intercept from the previous regression because it is not meaningful - the intercept does not have to be zero since the ICS factor is not an excess return). H-L stands for the L-minus-H investment portfolio (investment spread). Panel B reports the results from time series regressions of the two factor model with MKT and ICS as two factors. Panel C reports the characteristics (IK is investment;ΔDebt is the debt growth rate; Lev is the financial leverage ratio) of the book-to-market portfolios. Panels D and E report the factor loadings of portfolio characteristics (IK in panel D and Lev in panel E) on the two aggregate shocks in the model (TFP and ICS). The reported statistics for are obtained from 100 samples of simulated data, each with 3,600 firms and 600 monthly observations.

	L	2	3	4	5	6	7	8	9	H	L-H
Panel A: Investment rate portfolio returns											
$E[r^e]$	8.43	8.12	7.74	7.02	6.25	6.11	5.42	4.70	4.48	3.28	5.15
$\sigma[r^e]$	18.33	18.04	18.00	18.00	17.86	17.97	18.07	18.08	17.92	18.22	2.96
S.R.	0.46	0.45	0.43	0.39	0.35	0.34	0.30	0.26	0.25	0.18	1.74
[t]	3.20	3.12	2.98	2.70	2.41	2.36	2.09	1.81	1.73	1.27	11.89
α	2.54	2.30	1.93	1.20	0.42	0.29	−0.41	−1.15	−1.36	−2.57	5.10
[t]	9.07	8.63	7.27	4.62	1.68	1.18	−1.65	−4.50	−5.80	−10.20	11.73
MKT	1.01	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.01
[t]	207.76	227.27	228.4	229.65	238.18	246.18	239.18	241.42	248.93	230.29	1.29
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.01
Panel B: Two factor regression											
MKT	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.02
[t]	218.78	233.49	231.28	228.13	237.38	242.17	234.95	238.3	248.76	237.35	2.10
ICS	0.05	0.04	0.03	0.02	0.01	0.00	−0.01	−0.02	−0.02	−0.04	0.09
[t]	5.48	5.43	4.17	2.29	0.98	0.69	−1.07	−2.42	−4.1	−6.51	6.51
R^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.17

Table 7 : 10 investment rate portfolios in simulated data (cont.)

Panel C: Characteristics										
IK	−0.01	0.03	0.06	0.09	0.12	0.14	0.16	0.19	0.25	0.37
ΔDebt	−0.15	−0.11	−0.07	−0.04	0	0.02	0.04	0.07	0.14	0.29
Lev	0.58	0.48	0.44	0.42	0.41	0.39	0.39	0.37	0.34	0.31
Panel D: Factor regression of investment rate										
β^x	0.55	0.75	0.85	0.95	0.98	0.95	1.01	1.10	1.07	1.80
[t]	4.24	4.61	4.83	4.77	4.82	4.97	4.61	4.54	4.78	5.2
β^{IS}	0.86	0.87	0.87	0.98	0.97	1.01	1.14	1.08	1.03	1.19
[t]	2.84	2.75	2.71	2.61	2.61	2.54	2.65	2.55	2.57	2.19
R^2	0.07	0.07	0.06	0.06	0.05	0.05	0.05	0.04	0.04	0.04
Panel E: Factor regression of financial leverage										
β^x	0.02	0	0	0.03	0.02	0.02	0.03	0.05	0.04	0.02
[t]	0.4	0.26	0.13	0.6	0.75	0.7	0.98	2.27	1.91	1.33
β^{IS}	0.09	0.08	0.06	0.06	0.04	0.05	0.06	0.05	0.03	0.02
[t]	0.79	0.6	0.67	0.6	0.57	0.75	0.93	0.8	0.57	0.35
R^2	−0.01	−0.01	−0.01	−0.01	−0.01	0	0.01	0.04	0.02	0

Table 8 : Selected data versus model-implied moments across alternative calibrations

This table presents several comparative statics exercises. The reported statistics for the model are obtained from 100 samples of simulated data, each with 3,600 firms and 600 monthly observations.

	Quantities			Asset prices						
		SD		Market	IK spread			Value spread		
Spec.	IK	ΔB	ES	r^e	r^e	α	mae	r^e	α	mae
0-Data										
	0.17	0.24	0.18	6.25	3.22	7.02	2.83	7.07	7.46	2.77
1-Baseline										
	0.14	0.16	0.18	5.83	5.15	5.10	1.42	6.94	7.02	2.23
2-Low price of risk of aggregate issuance shock ($\gamma_\xi = 0$)										
	0.21	0.16	0.37	1.63	7.02	6.50	2.8	−2.89	−2.55	1.83
3-Low price of risk of aggregate productivity shock ($\gamma_x = 0$)										
	0.13	0.14	0.22	4.04	1.82	1.79	0.46	1.74	1.74	0.54
4-No issuance cost ($\eta_1 = 0$)										
	0.28	0.04	0.66	8.20	1.71	−0.02	0.17	−5.79	0.44	0.18
5-No issuance shock ($\eta_2 = 0$)										
	0.25	0.06	0.14	7.48	1.34	−0.11	0.21	−4.94	0.49	0.23

Figure 1 : Equity issuance, aggregate TFP, and shocks

This figure reports the time series of the fraction of equity issuers in the cross section (top left Panel), the time series of aggregate TFP growth (adjusted for capacity utilization) (top right Panel), and the time series of the equity issuance cost shock (ICS) and TFP shock (obtained as the residuals from the VAR(1) system). The data is annual from 1971 to 2011.

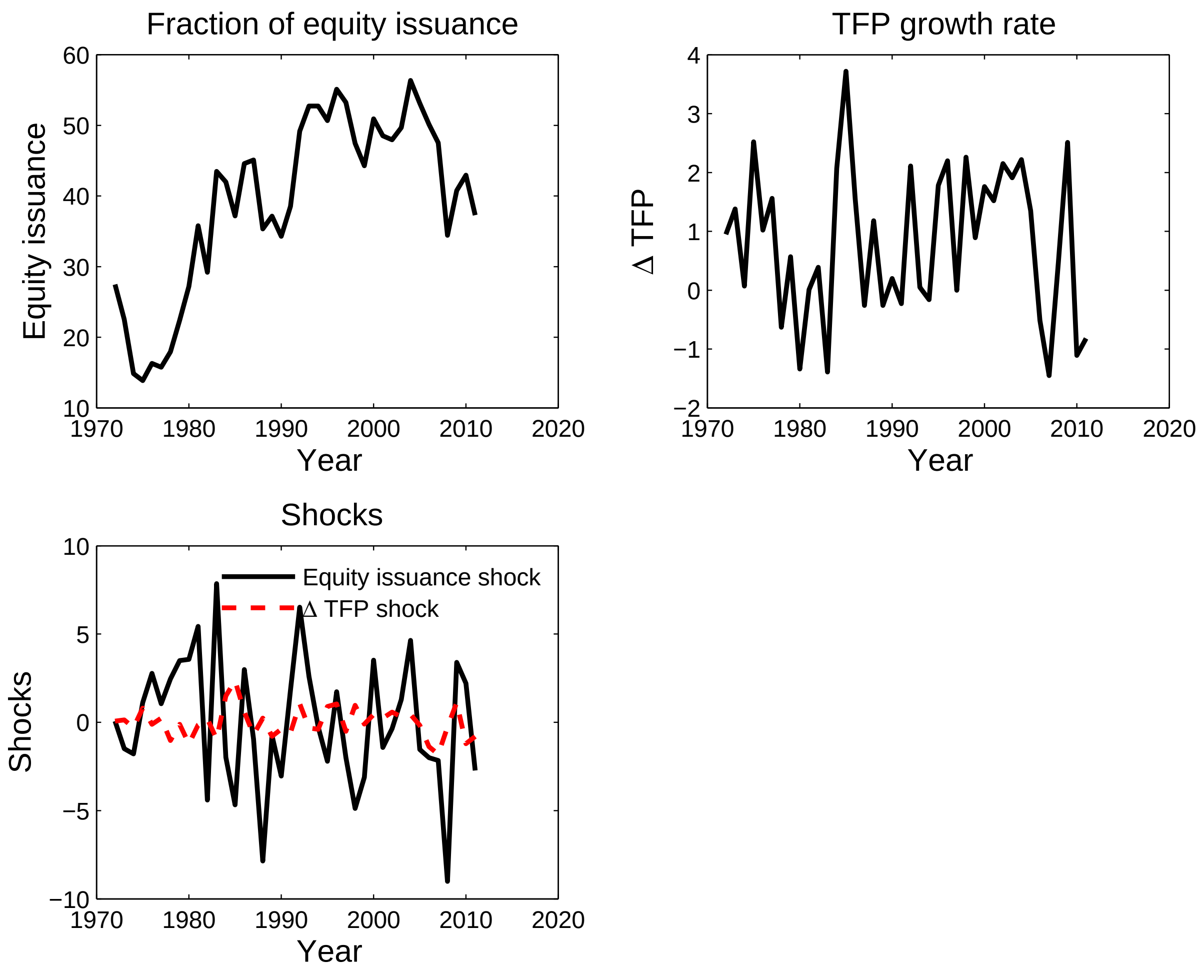

Figure 2 : Market and equity issuance cost shock betas

This figure reports the risk exposures of the ten book-to-market and investment portfolios using data simulated from the model. It reports the slope coefficients from the following time-series regressions $r^e_{it} = a_i + \beta^m_i \times r^m_t + \beta^\xi_i \times \Delta\xi_t + e_{it}$, in which r^e_{it} is the monthly excess return of the i^{th} portfolio, r^m_t is the market excess returns, and $\Delta\xi_t$ is the aggregate equity issuance cost shock. The slope coefficients for each portfolio are expressed relative to the average of the corresponding slope coefficients across portfolios. The reported statistics for the model are obtained as averages from 100 samples of simulated data, each with 3,600 firms and 600 monthly observations.

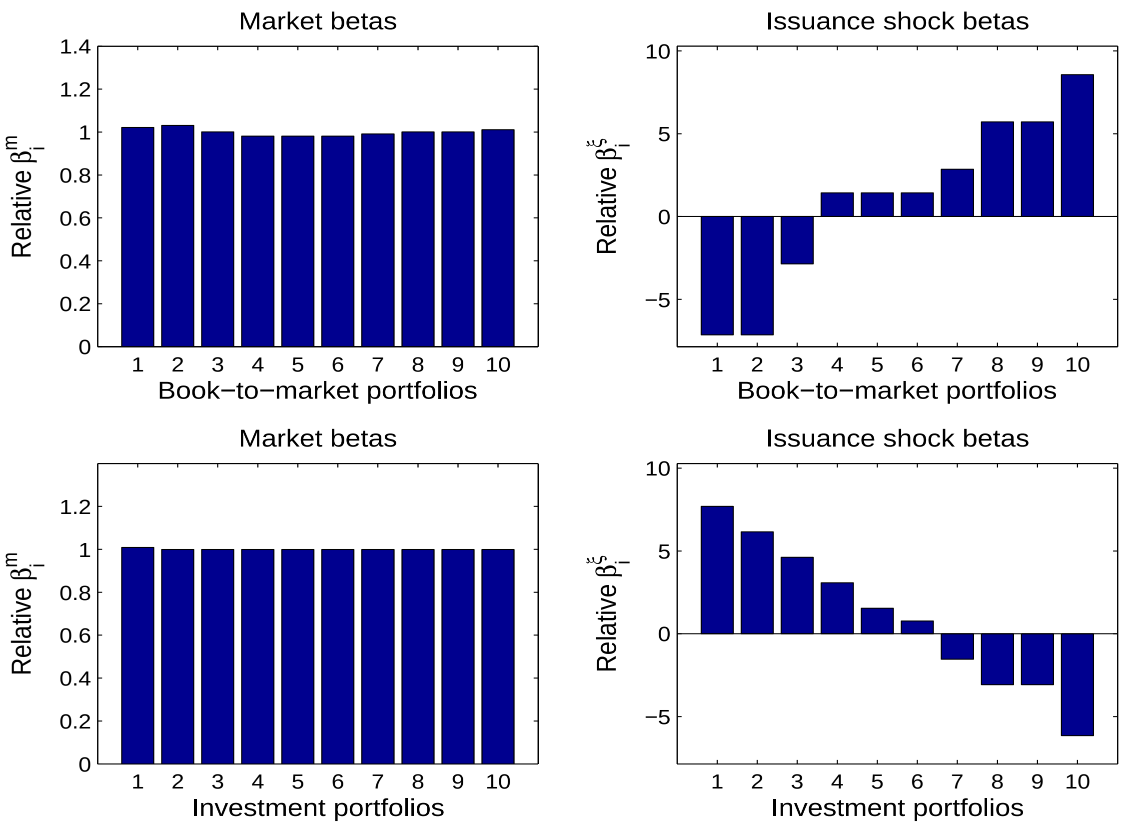

Figure 3 : Impulse response to an aggregate equity issuance cost shock

Impulse responses of selected endogenous variables in the baseline calibration of the model to a 1% negative aggregate equity issuance cost shock. The responses are measured in percent deviation relative to the long-run average values (time detrended, when applicable). To generate the response of a high productivity (H) firm, we add a positive 1% firm-specific productivity shock. To generate the response of a low productivity firm (L), we add a negative 1% firm-specific productivity shock. The frequency of the data is monthly. IK is firms' investment rate, ΔB is firms' debt change, SDF is the stochastic discount factor (consumers' marginal utility), Sales is measured as output Y, Profits is after tax corporate profits, Div is firms' dividends, and V is the continuation value of the firm (price of the firm after dividends).

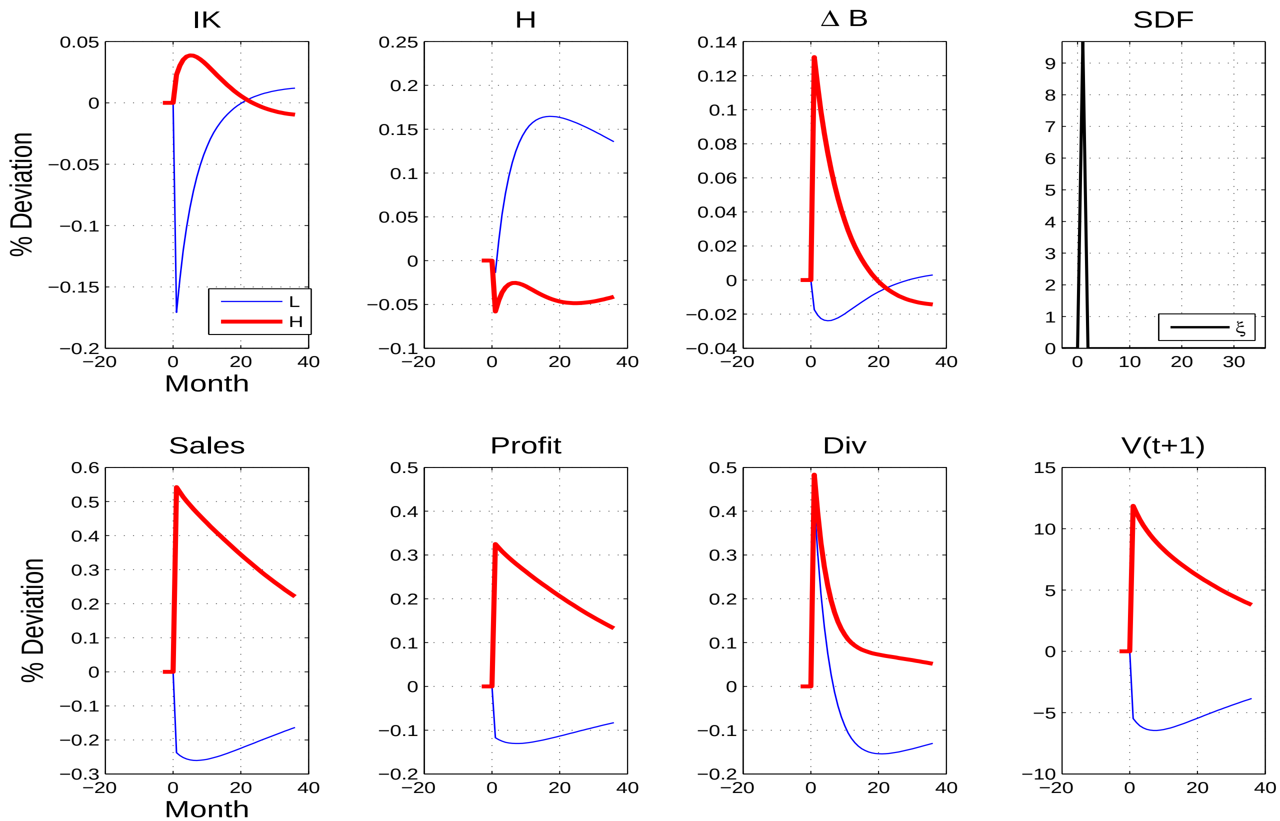

Figure 4 : Impulse response to an aggregate productivity shock

Impulse responses of selected endogenous variables in the baseline calibration of the model to a 1% negative aggregate productivity shock. The responses are measured in percent deviation relative to the long-run average values (time detrended, when applicable). To generate the response of a high productivity (H) firm, we add a positive 1% firm-specific productivity shock. To generate the response of a low productivity firm (L), we add a negative 1% firm-specific productivity shock. The frequency of the data is monthly. IK is firms' investment rate, ΔB is firms' debt change, SDF is the stochastic discount factor (consumers' marginal utility), Sales is measured as output Y, Profits is after tax corporate profits, Div is firms' dividends, and V is the continuation value of the firm (price of the firm after dividends).