Operating Hedge and Gross Profitability Premium *

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Abstract

In this paper we explore the hedging effect induced by intermediate inputs in production, and its impact on fundamental risk of firm cash flows and stock returns. The hedging effect varies across firms and is weaker for more profitable firms. This leads to more profitable firms having a higher exposure to aggregate profitability shocks, giving rise to a gross profitability premium. Our model captures coexistence of the negatively correlated gross profitability and value factors, addressing an empirical pattern that poses a challenge to the models relying on operating leverage as the primary source of the value premium.

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1 Introduction

Historically, firms with high gross profitability generate higher future stock returns than firms with low gross profitability. Using quintile portfolio sorts, Novy-Marx (2013) documents the spread of 0.31% per month (3.78% annually) between average returns on the more profitable firms relative to the less profitable firms. This pattern goes against the operating leverage mechanism, invoked by several popular models of the value premium, e.g., Zhang (2005), Carlson, Fisher, and Giammarino (2004), Novy-Marx (2010). In this paper, we show that firms with different levels of gross profitability exhibit heterogeneous cash flow risk, which can be explained by an operating hedge property of the production function. This mechanism is distinct from operating leverage, but follows a similarly basic logic. Some of the production costs faced by firms are relatively stable (fixed costs), and tend to magnify the impact of revenue shocks on firms' cash flows, giving rise to operating leverage. In contrast, other costs (input costs) are variable and can be highly cyclical. Such cyclical input costs tend to lower the net risk of firms' cash flows, creating an operating hedge. This effect is more pronounced for the firms with a higher level of input costs relative to revenue, i.e., the firms with a lower level of gross profitability. For more profitable firms, the hedging effect of variable input costs is weaker, and hence such firms exhibit higher cash flow risk, and higher average returns.

We embed a production function with constant elasticity of substitution (CES) between capital and intermediate inputs (including energy, raw materials, semi-finished goods, services, production-related labor, etc.) into a structural asset pricing model with firm production.[1] A stylized static model conveys the core intuition. Exposed to both aggregate and firm-specific profitability shocks,[2] firms use their capital and purchase intermediate inputs to produce output. If the price of intermediate inputs is highly pro-cyclical with respect to aggregate profitability, a negative aggregate

[1]Revenue, variable costs, and gross profit are used in firm-level accounting, whereas gross output, intermediate inputs, and value added are mainly used in industry-level and national-level accounting.

[2]Because our model is set in partial equilibrium, we do not spell out the exact origins of the aggregate profitability shock affecting the entire population of firms. These shocks reflect both the technological shocks affecting profitability across all firms, as well as aggregate "demand" shocks, which may originate as shocks to investor beliefs or tastes, or be driven by government spending shocks. What is important for our purposes is that such common profitability shocks create correlated movements in firm profits relative to their output.

profitability shock leads to a larger proportional reduction in variable costs than in gross output. Thus, variation in variable costs serves as a hedge against aggregate profitability shocks. The strength of the hedging effect varies across firms: if the degree of substitution between capital and intermediate inputs in the production function is sufficiently low, intermediate inputs vary less than firm's revenue in response to firm-specific profitability shocks. As a result, strength of the hedging effect declines in firm's gross profitability. More profitable firms thus have higher exposure to the aggregate profitability shock relative to less profitable firms. With the aggregate profitability shock carrying a positive price of risk, heterogeneity in firms' cash flow risk induced by the hedging property of intermediate inputs gives rise to a positive gross profitability premium.

Our empirical analysis supports operating hedge as an important source of cross-sectional variation in firms' cash flow risk, particularly in relation to gross profitability. First, using the aggregate data from Bureau of Economic Analysis (BEA), we find that the price of intermediate inputs is more volatile than the price of gross output, and both the price and the value of intermediate inputs have an elasticity greater than one with respect to the corresponding properties of gross output. These findings suggest that intermediate inputs potentially offer a hedge against shocks to gross aggregate output. Second, we estimate the elasticity of substitution between capital and intermediate inputs, based on the cross-sectional relation between gross margin and gross profitability implied by our theoretical model. Our estimates show that substitution between capital and intermediate inputs is relatively inelastic. Third, Third, we show that the strength of the operating hedge varies with gross profitability, with the least profitable firms subject to the strongest hedging effect from intermediate inputs. Lastly, we use the utilization-adjusted total factor productivity shock from Basu, Fernald, and Kimball (2006) and Fernald (2014) as a measure of aggregate profitability shocks.[3] We find that firms with different gross profitability differ in their risk exposures, both in their cash flows and stock returns.

We extend our stylized static model to a dynamic setting to address the coexistence of two distinct factors, the gross profitability factor and the value factor (the value-growth return spread),

[3]The total factor productivity shock strongly comoves with macroeconomic variables such as GDP growth and aggregate consumption growth, and carries a positive price of risk, based on the cross-section of industry portfolios constructed by Fama and French.

as well as their negative correlation with each other, as highlighted in Novy-Marx (2013). Besides the aggregate and firm-level profitability shocks, we introduce the aggregate and idiosyncratic investment-specific technology (IST) shocks. Prior studies, e.g., Kogan and Papanikolaou (2013), Kogan and Papanikolaou (2014)), emphasize that stock prices of firms with a higher value of growth opportunities relative to the value of their assets in place are more exposed to the aggregate IST shocks, and earn lower risk premia. Such firms tend to have higher market-to-book ratios, i.e., they are the "growth" firms. The same mechanism is at work in our model, which means that the value factor in the model loads heavily on the aggregate IST shocks, and is distinct from the profitability factor, which loads heavily on aggregate profitability shocks. To account for the negative correlation between the two factors, we further allow idiosyncratic shocks to firm profitability and growth opportunities to be positively correlated, which means that more profitable firms tend to have better investment opportunities. This parametric assumption allows us to control the correlation between the profitability and value factors in the model: more profitable firms tend to have higher loadings on the aggregate IST shocks, which is the opposite of the value factor; similarly, growth firms tend to be more profitability, loading more heavily on the aggregate profitability shocks, relative to value firms. We should note that, all else equal, the negative correlation between the value and profitability factors in the model drives down the average return premia on the two factors, as they exhibit opposite exposures to the same aggregate economic shocks.

In calibration, our model generates the annualized gross profitability premium (based on the quintile sorts on gross profitability, with value-weighted portfolios) of 3.13%, relative to 3.69% in the data. Similarly, the value premium is 3.4% in the model, relative to 5.43% in the data. The correlation between the profitability factor and the value factor is -0.27 in the model versus -0.5 in the data. Related to this correlation pattern, the model generates a larger average return spread among profitability-sorted portfolios when including value factor in the asset pricing tests. More generally, our model replicates the failure of the CAPM to price the cross-sections of stocks sorted on gross profitability, and on book-to-market ratios.

Relation to prior literature

Our study uncovers a novel hedging effect induced by the cyclicality of variable costs that have not been explored in the existing literature. Economically, intermediate inputs and variable costs, more generally, are featured at the top of the income statement and represent on average about 70% of the gross outputs (or revenues). Variable costs are a significant component of firms' profits, and their cyclical properties affect firm cash flow risk in an economically significant way. Our paper is closely related to the literature on the effect of operating leverage on asset prices. Zhang (2005) and Carlson, Fisher, and Giammarino (2004) show how operating leverage can generate a value spread in a neoclassical model of firm investment. Novy-Marx (2010) proposes an empirical measure of operating leverage and documents its positive predictive power for cross-sectional stock returns. While these papers deal with the leverage effect induced by fixed costs, we focus on the hedging property of variable input costs.

A recent strand of related literature focuses on the effects of labor costs on stock return risk, emphasizing wage rigidity as a source of operating leverage. For instance, Danthine and Donaldson (2002) show that wage rigidity can induce a strong labor leverage and improve the performance of asset pricing models with production to better match aggregate market volatility and equity premium. Favilukis and Lin (2015) examine the quantitative effect of wage rigidity and labor leverage on both the equity premium and value premium. Donangelo, Gourio, Kehrig, and Palacios (2018) document that firms with high labor shares have higher expected returns than firms with low labor shares. Favilukis, Lin, and Zhao (2017) examine the effect of labor leverage on the credit market. Our paper offers a complementary perspective relative to these prior studies. The above papers focus on stickiness of wages of existing workers (selling, general, and administrative (SG&A) expenses, which include a labor component, also tend to have low cyclicality). We emphasize high cyclicality of variable input costs, which include the cost of labor used in production of finished goods. A more comprehensive description of how labor costs affect firms' cash flow risk should combine the properties of the intensive margin (wage stickiness emphasized in the above studies) with those of the extensive margin (employment dynamics and worker mobility), which is relevant for the properties of variable input costs. Such a deeper dive into the properties of labor costs is beyond the scope of this paper.

Asset pricing implications of our paper connect it closely to the growing literature that investigates the relation between firm stock returns and accounting measures, such as firm profitability and valuation ratios. While value premium has been extensively studied in the literature,[4], the sources of profitability premium are relatively less understood. Kogan and Papanikolaou (2013) show that firm heterogeneity in growth options gives rise to a sizable profitability premium. All cross-sectional return factors in their model are driven by investment-specific technological shocks, and hence their model cannot generate a profitability factor in returns that is negatively correlated with the value factor. Ma and Yan (2015) extend the idea of Garlappi and Yan (2011) and find that the performance of the value and gross profitability strategies varies with credit conditions. Their model has a single firm-level state variable, and, like the models of the value premium emphasizing operating leverage (e.g., Carlson, Fisher, and Giammarino (2004), Zhang (2005)) faces the challenge of generating the coexistence of positive unconditional gross profitability and value premia. Wang and Yu (2015) and Lam, Wang, and Wei (2014) compare the risk-based and behavioral explanations of gross profitability premium and argue that the empirical evidence is more consistent with investors' under-reaction to news on firm fundamentals. Akbas, Jiang, and Koch (2017) find the recent trajectory of a firm's profits predicts future profitability and stock returns. Bouchaud, Krueger, Landier, and Thesmar (2018) propose a theoretical explanation for the profitability premium based on sticky expectations.

2 Data and Empirical Benchmark

We first summarize some empirical evidence on the profitability premium and the value premium. In the following sections, we relate our theoretical model to these empirical results.

We draw stock return data from the Center for Research in Security Prices (CRSP), the

[4]Studies on the value premium include Lakonishok, Shleifer, and Vishny (1994), Berk, Green, and Naik (1999), Gomes, Kogan, and Zhang (2003), Carlson, Fisher, and Giammarino (2004), Zhang (2005), Lettau and Wachter (2007), Garleanu, Kogan, and Panageas (2012), Choi (2013), Kogan and Papanikolaou (2014), Donangelo (2017), Kogan, Papanikolaou, and Stoffman (2019) among many others.

accounting data from the Compustat Annual North America. Following Novy-Marx (2013), we define the gross profitability, which we refer to as GP/A, as revenue (Compustat item REVT) minus cost of goods sold (Compustat item COGS) divided by total asset (Compustat item AT), that is, (REVT − COGS)/AT. We define book-to-market equity ratio following Fama and French (1992).[5] We remove firms in the financial industries and only keep in our sample firms with a share code (SHRCD) 10 or 11, and exchange code (EXCHCD) of 1, 2, or 3. Our final sample covers the time period from July 1963 to December 2014.

We examine the standard gross profitability strategy and the value strategy by constructing quintile portfolios sorted by GP/A and book-to-market ratio, respectively, and report their portfolio characteristics and summaries of stock return properties. Panel A of Table 1 reports the GP/A portfolio characteristics. Consistent with Novy-Marx (2013), we find that high-GP/A firms have lower book-to-market ratios and higher Tobin's Q. They also exhibit higher gross margin, higher investment rate, and higher recent stock returns than low-GP/A firms. The gross margin increases from 0.19 for low-GP/A firms to 0.44 for high-GP/A firms. Interestingly, while financial leverage declines with GP/A, operating leverage rises strongly with GP/A. Given the existing studies on the relation between operating leverage and stock returns, we revisit how operating leverage affects the gross profitability premium in Section 3.

[Insert Table 1 Here]

Panel B of Table 1 reports the value-weighted portfolio returns and the asset pricing test results, including the CAPM and Fama and French (1992) three-factor model tests, for the quintile port-

[5]Other variables include: firm size is the market cap at the end of previous June. Momentum is the prior 2-12 month returns. Financial leverage is the sum of total debt in current liability (Compustat item DLC) and total long-term debt (Compustat item item DLTT), divided by the sum of DLC, DLTT, and firm's market cap. Operating leverage is defined as (REVT-COGS)/(REVT-COGS-XSGA), where Compustat item XSGA is the selling, general and administrative expense. Q is the sum of market value, long-term debt (Compustat item DLC), preferred stock redemption value (Compustat item PSTKRV), minus the total inventories (Compustat item INVT) and deferred tax in balance sheet (Compustat item TXDB), divided by gross property, plant and equipment (Compustat item PPEGT). Cash holding is cash and short-term investments (Compustat item CHE) divided by PPEGT. R&D intensity is research and development expense (Compustat item XRD) divided by PPEGT. Investment rate is the capital expenditure (Compustat item CAPX) dividend by lagged PPEGT. Gross margin is the (REVT-COGS)/REVTS.

folios sorted by GP/A.[6] High-profitability firms have higher average returns than low-profitability firms. The annualized return spread is 3.69% per year with a Sharpe ratio of 0.35. CAPM fails to capture the gross profitability premium, as the difference in market beta between high and low GP/A portfolios is only 0.01 (t-statistic = 0.35). Controlling for Fama and French (1992) three factors further increases the return spread, due to the similarity of high (low) GP/A and growth (value) firms. Indeed, the coefficient of the GP/A spread portfolio on the high-minus-low (HML) value premium factor is -0.48 (t-statistic = -6.71), giving rise to an abnormal return of 6.37% per year (t-statistic = 4.56). These results replicate the finding in Novy-Marx (2013) that the gross profitability is the "other side of value."

Table 2 reports the main characteristics (Panel A), returns, and the asset pricing test results (Panel B) for quintile portfolios sorted by the book-to-market ratio. Once again, we observe that high book-to-market (value) firms have lower gross profitability than low book-to-market (growth) firms. Value firms also have higher financial and operating leverage (this is in contrast to the findings for the GP/A firms), lower Tobin's Q and gross margin, lower research and development expenditure, and a lower investment rate.

For our sample period, the value-weighted return spread between the high- and low book-to-market portfolios (the value premium) has an average of 5.43% per year, with a Sharpe ratio of 0.40. The unconditional CAPM fails to capture the value premium, while including the HML factor into the pricing model reduces the estimated alpha of the value premium, and makes it statistically insignificant. In an untabulated analysis, we find the correlation between the gross profitability factor and the value factor to be -0.50. These properties of the gross profitability premium, value premium, and the negative correlation between the corresponding return factors, serve as target moments for our economic model in the next section.

[Insert Table 2 Here]

[6] For the rest of the paper, we only report the result for the value-weighted strategy, but the equal weighted strategy generates a very similar conclusion. These results are available upon request.

3 A static model of operating hedge and profitability premium

In this section, we propose a production-based asset pricing model for the gross profitability premium. Section 3.1 describes a statistic model to illustrate the intuition of our explanation for the gross profitability premium. We substantiate this explanation with empirical evidence in Section 3.2. In Section 3.3, we extend the static model to a dynamic setting and offer a unified explanation for the negatively correlated gross profitability premium and value premium.

3.1 The model

In this section we develop a static model, which captures the core intuition of the operating hedge mechanism. We consider a firm using two types of productive inputs: capital K and intermediate inputs E. We assume a production function with a constant elasticity of substitution (CES) between capital and intermediate inputs. The firm's gross profit π is the difference between revenue and input costs:

$$\pi = \max_{E} \left\{ X \left[(ZE)^{\frac{\eta-1}{\eta}} + K^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} - PE \right\}, \tag{1}$$

where X represents the systematic component of profitability, common to all firms, Z is the idiosyncratic profitability shock, P is the price of intermediate inputs, and $\eta > 0$ measures the elasticity of substitution between capital and intermediate inputs. Firms take the price of intermediate inputs as given and choose the quantity of intermediate inputs to maximize total profits. The quantity of capital is fixed for simplicity (we introduce capital accumulation in the dynamic version of the model).

The share of the intermediate inputs can be calculated from the first–order condition:

$$ES = \frac{(ZE)^{\frac{\eta-1}{\eta}}}{(ZE)^{\frac{\eta-1}{\eta}} + K^{\frac{\eta-1}{\eta}}}. \tag{2}$$

This implies that firm profits are given by

$$\pi = X\left[(ZE)^{\frac{\eta-1}{\eta}} + K^{\frac{\eta-1}{\eta}}\right]^{\frac{1}{\eta-1}} K^{\frac{\eta-1}{\eta}}. \tag{3}$$

This implies that firm's gross profitability, i.e., the gross profit per unit of capital (GP/A), increases with the firm idiosyncratic profitability Z:

$$\text{GP/A} \equiv \frac{\pi}{K} = X\left[\left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}} + 1\right]^{\frac{1}{\eta-1}}. \tag{4}$$

The elasticity of intermediate inputs with respect to the firm idiosyncratic profitability is given by

$$\frac{\partial \log E}{\partial \log Z} = \eta\left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}} + (\eta-1). \tag{5}$$

The elasticity of gross profit with respect to the aggregate profitability shock, β_X, is

$$\begin{aligned}\beta_X = \frac{\partial \log \pi}{\partial \log X} &= \frac{\partial \log P}{\partial \log X} + \frac{1}{\eta}\frac{\partial \log E}{\partial \log X} \\ &= \frac{\partial \log P}{\partial \log X} + \left(1 - \frac{\partial \log P}{\partial \log X}\right)\left[\left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}} + 1\right],\end{aligned} \tag{6}$$

where $\partial \log P/\partial \log X$ measures the cyclicality of the intermediate input price.

To demonstrate how a firm's exposure to the aggregate profitability shock varies with its gross profitability, which is monotonically increasing in its profitability Z (see Equation (4)), we take the partial derivative of β_X with respect to $\log Z$:

$$\begin{aligned}\frac{\partial \beta_X}{\partial \log Z} &= \left(\frac{\eta-1}{\eta}\right)\left(1 - \frac{\partial \log P}{\partial \log X}\right)\left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}}\left(1 + \frac{\partial \log E}{\partial \log Z}\right) \\ &= (\eta-1)\left(1 - \frac{\partial \log P}{\partial \log X}\right)\left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}}\left[1 + \left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}}\right].\end{aligned} \tag{7}$$

The last two terms in Eq. (8) are always positive, so to obtain $\partial \beta_X/\partial \log Z > 0$, we require one of the two conditions below:

1. $\eta > 1$ and $\partial \log P / \partial \log X < 1$; or

2. $\eta < 1$ and $\partial \log P / \partial \log X > 1$.

The first condition states that the substitution between capital and intermediate inputs is highly elastic and the price of intermediate inputs is not procyclical (or "sticky") with respect to the aggregate profitability shock; the second condition is the opposite of the first condition, with the inelastic capital-intermediate input substitution and a highly procyclical input price. Our empirical analysis in Section 3.2 strongly supports the second condition: $\eta < 1$ and $\frac{\partial \log P}{\partial \log X} > 1$.

Under the condition (2) above, firms with higher idiosyncratic productivity Z have higher gross profitability and higher exposure to the aggregate profitability shock. This relation arises as follows. Firm gross profit is increasing in firm revenue and decreasing in its intermediate input costs. Because the intermediate input price is highly procyclical, i.e., $\partial \log P / \partial \log X > 1$, input costs provide a hedging effect with respect to the aggregate profitability shock. This is because in response to a negative aggregate profitability shock, a highly procyclical inputs cost leads to a larger percentage input cost reduction than the percentage impact on revenue.[7] When the elasticity of substitution between capital and intermediate inputs is low ($\eta < 1$), higher values of firm-specific profitability Z imply lower levels of input costs relative to firm revenue. This means that the hedging effect is weaker for more profitable firms. As a result, in the model, more profitable firms have a higher aggregate profitability shock exposure (β_X) than less profitable firms, which gives rise to the profitability premium.

3.2 Empirical evidence

In this subsection, we analyze empirical evidence related to our proposed economic explanation. The two key parameters for a positive gross profitability premium in our model are the cyclicality of inputs prices ($\partial \log P / \partial \log X$) and the elasticity of substitution between capital and intermediate

[7] Note that while the input cost falls more than revenue in percentage terms in response to a negative aggregate profitability shock, the gross profit (the difference between revenue and input cost) declines, because the level of revenue is higher than the level of the input cost, with the latter representing about 70% of the former on average. In other words, the gross profit remains procyclical with respect to aggregate profitability shocks despite the intermediate input hedging effect.

inputs (η). When $\partial \log P / \partial \log X > 1$ and $\eta < 1$, our model predicts a positive gross profitability premium. We provide empirical evidence for these two assumptions in Subsection 3.2.1 and Subsection 3.2.2. In Subsection 3.2.3, we examine the implication of our economic mechanism on the relative volatility of sales and gross profits at the aggregate level and the firm level, respectively. We explore the exposures of cash flow and stock returns of gross profitability portfolios using a measure of an aggregate profitability shock in Subsection 3.2.4. Lastly, we study the relation between the gross profitability premium and operating leverage in Section 3.2.5.

3.2.1 Cyclicality of intermediate inputs and value added

As we discuss above, $\partial \log P / \partial \log X$ measures the cyclicality of the intermediate input price with respect to the aggregate profitability shock. When this elasticity measure exceeds one, the intermediate input is more procyclial than the gross output, so intermediate input provides a hedge relative to aggregate profitability shocks. In this section, we examine the cyclicality of the aggregate measures of intermediate input (II) and value added (VA) with respect to gross output (GO).

Our data on the indices of price, quantity, and value of gross output, intermediate input, and value added are from the GDP-by-industry account from the Bureau of Economic Analysis (BEA), aggregate across all industries. We further deflate the price and value indices by the Consumer Price Index. The data are annual from 1947 to 2014.

Table 3 reports our estimation results. In Panel A, we report the mean and standard deviation of the growth rate of the price, quantity, and value for gross output, intermediate inputs, and value added. Panel A shows that intermediate inputs are more volatile for than gross outputs. The volatility of input price (quantity) is 2.23% (3.86%) per year, which is about 50% (37%) higher than the volatility of output price (quantity). The price and quantity taken together, the value of intermediate input is 45% more volatile than the value of gross output. Furthermore, since gross output and intermediate input values are highly correlated (correlation coefficient of 0.92 , untabulated), intermediate inputs provide a hedge against negative profitability shocks. Indeed, the volatility of the value added is only 2.52%, lower than 2.9% for the gross output.

[Insert Table 3 Here]

Panel B of Table 3 reports the elasticity of intermediate input and value added with respect to gross output. In the first specification, when we regress the growth rate of input price on the growth rate of output price, the elasticity of intermediate input price is 1.33, more than 9 standard deviations from zero. This result suggests that when the price of gross output rises, the price of intermediate inputs increases even more. In the next two specifications, we examine the elasticity of the values of intermediate input and value added. Similar to the pattern of the price indices, one percent increase in the value of gross output is associated with an average increase of 1.34 percent in the value of intermediate inputs. In contrast, the corresponding change in value added is only 0.74 percent. Jointly, these results provide empirical evidence for the condition on cyclicality of the input price index, $\partial \log P / \partial \log X > 1$. This condition, in turn, implies that time-variation in intermediate input costs serves as a hedge against aggregate fluctuations in output.

3.2.2 Elasticity of substitution between capital and intermediate inputs

In this subsection, we provide direct estimation of the elasticity of substitution between capital and intermediate inputs (η). A lower value of η implies the quantity of intermediate inputs responds less to profitability shocks (see Equation A.5 in the Appendix) due to the inflexibility in adjusting input quantity in the CES production function. One way to estimate this elasticity of substitution is to compare the exposures of revenues and gross profits to aggregate profitability shocks. The rationale can be found in Equation (A.11) in the Appendix in our paper. One drawback of this estimation procedure is its dependence on specific measures of aggregate profitability shocks.[8] Here we propose a new alternative approach to estimate η without the need to specify measures of aggregate profitability shocks. From Equation (4), we can show that:

$$\log \mathrm{GM} = (1-\eta) \log \mathrm{GP/A} + (\eta - 1) \log X \tag{8}$$

[8]For instance, Donangelo, Gourio, Kehrig, and Palacios (2018) offer a two-stage procedure to estimate the elasticity of substitution between capital and labor. Their procedure first separately estimates the sensitivity of revenue and profit to aggregate shocks and then performs regression analysis to estimate the elasticity. Since this estimation involves two stages, any measurement errors from the first-stage time-series regression may bias the elasticity estimate in the second-stage cross-sectional regression.

where GM is a firm's gross margin, defined as gross profit divided by revenue. Because X is a common shock affecting all firms, we can use the cross-sectional relation between gross profitability (GP/A) and gross margin (GM) to determine whether η is greater or less than one. If the correlation between these two variables is positive, η should be less than one, and greater than one otherwise. Therefore, η can be directly estimated from the cross-sectional regressions of the logarithm of firm's gross margin on the logarithm of firm's gross profitability. This estimate does not depend on specific measures of the aggregate profitability shock because $\log X$ only affects the intercept in the cross-sectional regression.

Table 4 reports our estimates of η. In Panel A, we estimate η at the portfolio level using 10 gross profitability portfolios and 10 book-to-market portfolios. Our results indicate strongly that η is below one. Using the 10 GP/A portfolios, the estimated η is 0.612, with a standard error of 0.031. When we use the 10 book-to-market portfolios, the estimated η is lower at 0.371 with a standard error of 0.035. When we pool these 20 portfolios together, the estimated η is 0.573, with the standard error down to 0.025. Therefore, when we focus on the portfolios that are related to the gross profitability premium and the value premium, we set η below one.

[Insert Table 4 Here]

The elasticity of substitution between capital and intermediate inputs can differ by industries, due to differences in technologies and industrial organizations. In Panel B, we provide estimates of η for 14 industries from the GDP-by-industry account at BEA. For each industry, we run the same Fama-MacBeth cross-sectional regression at the firm level, and report the estimated η and its standard error. Panel B shows that there is indeed a large dispersion in η across these 14 industries. The lowest η is 0.51 for the industry "educations services, health care, and social assistance", and the highest η is 0.878 for the industry "finance, insurance, real estate, rental, and leasing". However, the estimated values of η are well below one for all industries, which directly supports the second condition in our interpretation of a positive gross profitability premium.[9]

[9] Complementarity between capital and intermediate inputs (and other production inputs such as labor) in the production function is intuitive. Take one example from Jones (2011): "Textile producers require raw materials, knitting machines, a healthy and trained labor force, knowledge of how to produce, security, business licenses,

3.2.3 Cash flow elasticities at aggregate, firm, and portfolio levels

When $\partial \log P / \partial \log X > 1$ and $\eta < 1$, the response of variable cost to the aggregate profitability shock in our model is greater than the response of revenue. Thus, at the aggregate level, we expect sales growth to be more volatile than the gross profit growth and the elasticity of gross profits to sales to be less than one. In contrast, the response of variable cost to a positive idiosyncratic profitability shock is less than the response of the revenue when $\eta < 1$, as evident from Equation (5). The key difference is that aggregate profitability shocks correlate with changes in input prices, while firm-level idiosyncratic shocks do not.

We examine cash flow elasticities in Table 5. Panel A1 of Table 5 reports the summary statistics of the aggregate sales growth (ΔlogASale) and aggregate gross profit growth (ΔlogAGP), which are aggregated from firms in our Compustat sample. Consistent with the finding based on the data from the GDP-by-industry account (Table 3), the aggregate sales growth is more volatile than aggregate gross profit growth (5.75% versus 4.99% per year, respectively). When we regress the aggregate gross profit growth onto the aggregate sales growth, the estimated coefficient from the time series regression is 0.75 and very close to 0.74 from Table 3, although the sample here only includes public companies.

[Insert Table 5 Here]

The result is quite different at the firm level. In Panel B of Table 5, we report the estimates of the firm-level sales growth and gross profit growth. Panel B1 shows that the firm-level gross profit growth is more volatile than the firm-level sales growth (26.7% versus 21.1%). When we relate firm-level gross profit growth to firm-level sales growth in Fama-MacBeth regressions, the estimated coefficient is 1.14, above one, as shown in Panel B2.

To interpret this difference between aggregate and firm-level results through the lens of the model, note that idiosyncratic profitability is in general more volatile than the aggregate profitability shock. With that, the impact of idiosyncratic shocks at the firm level may overwhelm

transportation networks, electricity, etc. These inputs enter in a complementary fashion, in the sense that problems with any input can substantially reduce overall outputs. Without electricity or production knowledge or raw materials or security or business licenses, production is likely to be severely curtailed".

the effect of aggregate shocks, resulting in gross profit growth being more volatile than the sales growth, and the sales elasticity of gross profits to be greater than one at the firm level. This leads to the difference in the sales elasticity of gross profits at the aggregate level and the firm level.

To further illustrate the different degrees of hedging effect across GP/A portfolios, we estimate cash flow elasticities at different levels of firm profitability in Panel C, using the five portfolios of firms sorted on GP/A. In the first two rows, we regress the portfolio growth rate of gross profits onto the portfolio sales growth. A coefficient of less than one means that gross profits respond less to changes in portfolio revenues (in growth rates), indicating that the variable component of firm costs helps hedge against variation in revenue. The result shows that the estimated coefficient increases from 0.4 for the low-GP/A portfolio to 1.06 for the high-GP/A portfolio. Therefore, the degree of intermediate inputs hedging is strongest among stocks with low gross profitability, consistent with our economic interpretation for the gross profitability premium. The next two rows report the elasticity of operating profits with respect to the gross profits. Because the difference between gross profits and operating profits is the "fixed cost" (measured by SG&A), this elasticity reflects the degree of operating leverage induced by SG&A. Unlike the finding in the first two rows, we do not observe a clear monotonic pattern in the elasticity of operating profits with respect to gross profits, which suggests that operating leverage is unlikely to be the main driving force for the gross profitability premium.[10] When the intermediate input hedging and operating leverage are taken together, as reported in the last two rows of Panel C, we find the elasticity of operating profits with respect to revenues increases from the low- to the high-GP/A portfolio.

3.2.4 Cash flow and return risk exposures of GP/A portfolios

In this subsection, we provide empirical evidence on cash flow and return exposures to the aggregate profitability shock across gross profitability portfolios. We use the utilization-adjusted total factor productivity shock (dTFP) from Basu, Fernald, and Kimball (2006) and Fernald (2014) as our proxy for aggregate profitability shocks.

[10] We examine the effect of operating leverage on gross profitability premium in Section 3.2.5 using a firm-level measure of operating leverage.

Table 7 Panel A shows that the estimated cash flow betas of gross profitability portfolios at the annual frequency. In the first specification, the exposure of gross profit growth to the aggregate profitability shock, $\beta_{\text{TFP}}(\text{GP})$, increases from low- to high-GP/A portfolios, with their difference being statistically significant. Economically, a 1% increase in TFP is associated with a 1.43% (t-stat = 4.01) increase in the difference in the growth rate of gross profits between the high and low GP/A portfolios. Looking into the source of this difference, we find that the pattern in the sales beta ($\beta_{\text{TFP}}(\text{Sale})$) and COGS beta ($\beta_{\text{TFP}}(\text{COGS})$) is rather flat, with their difference between high- and low-GP/A portfolio insignificant from zero. Therefore, consistent with the economic channel of our theoretical model, it is the compositional difference between sales and COGS, rather than the difference in the cyclicality of sales and COGS across the GP/A portfolios, that creates the cross-sectional difference in their cash flow betas.

[Insert Table 7 Here]

Reinforcing our findings on the cash flow beta, the returns of gross profitability portfolios also display an increasing pattern in their exposures to the aggregate profitability shock. Table 7 Panel B reports the return betas of the GP/A portfolios from two asset pricing models. In the first model, we augment CAPM with the addition of dTFP as the second risk factor. In line with the pattern of the cash flow exposure, we find the return beta increases from -1.07 for low GP/A firms to 0.66 for high GP/A firms, with the difference of 1.73 (t-stat = 1.90) in this two-factor model. As we discuss in the dynamic extension of our theoretical model in the next section, a firm's gross profitability is also affected by its growth options and hence exposures to the aggregate investment shocks. As such, the exposure to the aggregate profitability shock can be potentially weakened by the value effect. Therefore, in the dynamic version of our asset pricing model, we further control the value factor and the size factor from Fama and French (1992), in addition to the market factor. Indeed, we find a stronger pattern in return betas in this 4-factor model. The aggregate TFP beta is -1.26 for the low GP/A firms, as compared with 1.24 for the high GP/A firms. The difference in their TFP exposures is 2.8 standard deviations from zero.

So far, we have established empirical evidence for the different exposures of gross profitability portfolios to the aggregate profitability shock. To generate cross-sectional risk premia among GP/A portfolios, the aggregate profitability shock needs to be a priced risk factor. In the rest of this subsection, we examine the price of risk for the aggregate profitability shock measure, dTFP. We first investigate the relation between dTFP and standard macroeconomic variables, including GDP growth, durable and nondurable consumption growth, service growth, as well as fixed investment growth. To alleviate the lead-lag relation among these variables, we conduct our analysis at relatively lower frequencies. Specifically, we run regressions of K-year growth rate of these macro variables on the K-year dTFP, which is standardized to have a unit standard deviation. We choose K to be either 3 and 5 years, which both fall into the range of business cycle frequencies. Panel A1 of Table 8 reports the estimated coefficients. When K = 3, a one-standard deviation increase in dTFP is associated with 1.6% increase in GDP, 4.94% increase in durable consumption, about 1.8% increase in both nondurable consumption and service, and 2.69% increase in fixed investment. Except for the investment, all other coefficients are statistically significant at the 5% level. The result is qualitatively similar but quantitative stronger when K = 5. For instance, at the 5-year horizon, a one-standard deviation increase in dTFP coincides with 4.72% increase in GDP and 4.36% increase in nondurable consumption. The strong procyclicality of dTFP suggests that the aggregate profitability shock carries a positive price of risk.

[Insert Table 8 Here]

Before we move onto the formal asset pricing test on the price of risk for dTFP, we compare the responses of these macro variables to their responses to the gross profitability premium. In our model, the gross profitability premium is driven by the aggregate profitability shock, so the long-short gross profitability portfolio is a factor-mimicking portfolio for the aggregate profitability shock, and we expect similar responses of macro variables to the long-short portfolio return to those in Panel A1. This is indeed what we find, as reported in Panel A2. For example, when K = 3, the coefficient for GDPG is 1.35, as compared to 1.6 for dTFP in Panel A1. When K = 5, the coefficient on nondurable consumption growth is 3.64%, which is again close to 4.36% in Panel A1. The quantitative similarity in the responses of macroeconomic variables to dTFP and the long-short GP/A portfolio return reinforces the economic interpretation of our model that the aggregate profitability shock is the risk factor that drives the gross profitability premium.

In Panel B of Table 8, we test the price of risk for dTFP using Fama and French 17 and 30 industry portfolios with the GMM stochastic discount factor (SDF) test. We specify the SDF as a linear function of risk factors and use GMM to estimate their prices of risk. We only report the results from the first-stage estimation using identity weighting matrix due to its robustness, but the results are quantitatively similar when the optimal weighting matrix is used in the second-stage estimation. The benchmark model is a two-factor model with the market factor and dTFP as the risk factors, and as a comparison, we also report the result for CAPM. Panel B shows that the inclusion of dTFP has significantly improve the model fit of the industry portfolios. The mean absolute error (MAE) reduces from 1.35% per year in CAPM to 0.94% in the case of Fama and French 17 industry portfolios, and reduces from 1.5% to 1.13% in the case of Fama and French 30 industry portfolios. More importantly, the estimated price of risk for dTFP is positive for both sets of testing industry portfolios, being slightly higher at 36.5 when 17 industry portfolios are used. Therefore, the aggregate profitability shock is not only the driving force the gross profitability premium, but also helps to explain the cross-sectional difference in the industry portfolio returns.

3.2.5 Profitability premium and the operating leverage

Our model abstracts from a direct specification of operating costs, including wage bills and selling, general, and administrative (SG&A) expenses, which may potentially affect firms' risk premium. As discussed in the introduction, the literature has documented the effects of operating leverage and labor leverage on the cross-sectional stock returns (e.g., Carlson, Fisher, and Giammarino (2004), Novy-Marx (2010), Favilukis and Lin (2015), Donangelo, Gourio, Kehrig, and Palacios (2018)). Our results in Panel A of Table 1 show that operating leverage increases monotonically from low to high GP/A portfolios. A natural question is whether the gross profitability premium is driven by the existence of operating leverage.

We address this question by forming 5-by-5 portfolios sequentially sorted on operating leverage (OL) and GP/A. Table 9 reports the average excess returns (Panel A), the CAPM alphas (Panel

B), and alphas from Fama-French three-factor model (Panel C) for these 25 portfolios. We also report the Hi-Lo GP/A portfolio return (alpha) spread within each OL quintile, and the average Hi-Lo return (alpha) spread across OL quintiles, which can be interpreted as the conditional gross profitability premium. In Panel A, we find that although the gross profitability premiums within each OL quintile are all positive, none of them are statistically significant. The average conditional gross profitability premium is 2.14% per year, with a t-statistic of 1.25. Therefore, the evidence indicates that controlling for operating leverage, the gross profitability premium has been weakened by almost 58% from 3.69% per year in Table 1.

[Insert Table 9 Here]

However, Panel B and Panel C show that the weaker gross profitability premium is due to the exposures to the standard risk exposures. When we control for the market factor, the average conditional gross profitability premium becomes 4.97% per year (t-statistic = 2.49), which is even stronger than 3.6% for the unconditional gross profitability premium in Table 1. When we control for Fama-French three factors, the average conditional gross profitability premium remains strong at 5.75% per year (t-statistic = 4.16).

This result may not be surprising. Despite the strong increasing pattern in operating leverage across GP/A portfolios, the financial leverage displays an opposite pattern. It decreases from 0.33 for low GP/A firms to 0.07 for high GP/A firms (Panel A of Table 1). When we take into account both types of leverage, the overall leverage effect is non-monotonic. Furthermore, if operating leverage is the underlying mechanism, the gross profitability premium should increase with OL. Again, none of the returns, CAPM alphas, and Fama-French 3-factor alphas display this pattern. Therefore, the results in Table 9 indicate that the positive gross profitability premium is unlikely to be largely driven by the effect of operating leverage. It is beyond the scope of this paper to study how firms optimally choose variable costs, fixed operating costs, and financial leverage in their risk management. We leave this interesting question for future research.

3.3 The full dynamic model and simulation analysis

The previous two subsections illustrate and provide empirical evidence for our proposed economic mechanism for the gross profitability premium. One drawback of the static model is its couter-factural implication for the value premium. Intuitively, in this simple setup, more profitable firms also have higher valuation ratios and higher risk premiums than less profitable firms due to the exposure to the aggregate profitability shock, so the static model predicts that firms with higher valuation ratios (growth firms) have higher average returns than firms with lower valuations ratios (value firms). This implies a negative value premium. To reconcile the coexistence of a positive profitability premium and a positive value premium, we propose a full dynamic model by incorporating features in Kogan and Papanikolaou (2014) into our illustrative static model and study its quantitative implications for the gross profitability premium and the value premium.

There are a continuum of firms in the cross section. The basic unit of production is projects. Each project uses capital, which is normalized to be 1, and E_{jt} units of intermediate inputs. Projects are identical within a firm, and firms differ in their firm-specific input efficiency in producing outputs. They also differ in their firm-specific investment shocks, capturing different arrival rates of incoming projects. The production function of a project takes a form of a constant elasticity of substitution. For each project of firm j, the gross profit π_{jt} from this project is the difference between revenue and input costs:

$$\pi_{jt} = Y_t \max_{E_{jt}} \left\{ X_t \left[(Z_{jt} E_{jt})^{\frac{\eta-1}{\eta}} + 1 \right]^{\frac{\eta}{\eta-1}} - P_t E_{jt} \right\} \tag{9}$$

where Z_{jt} is idiosyncratic profitability, X_t is the stationary component of aggregate profitability that is the same as X_t in the static model, Y_t is the permanent component of the aggregate profitability that also captures the cointegrated co-movement of gross profits and input prices (we refer to Y_t shock as the aggregate growth shock), P_t is the price of intermediate inputs (E_{jt}), normalized by Y_t, η measures the elasticity of substitution between capital and intermediate inputs. As we see below, although the inclusion of he aggregate growth shock better matches the aggregate moments, it does not drive the cross-sectional risk premium. Firms take the process for P_t as given and choose intermediate inputs to maximize profits within each period. In our setting, π_{jt} is the gross profitability for firm j at time t, due to the normalization of capital per project to one unit.

The first order condition implies that the maximized gross profit from a project is:

$$\pi_{jt} = \left[(Z_{jt} E_{jt})^{\frac{\eta-1}{\eta}} + 1 \right]^{\frac{1}{\eta-1}} X_t Y_t. \tag{10}$$

Defining the number of projects (or capital stock) operated by firm j as K_{jt}, the total gross profit is thus $K_{jt}\pi_{jt}$.

Firms accumulate capital with arrivals of new projects. The law of motion for capital stock is:

$$K_{jt+1} = (1 - \delta)K_{jt} + \delta S_t A_{jt} K_{jt}, \tag{11}$$

where S_t and A_{jt} measure the aggregate and firm-specific investment shocks, respectively, which jointly capture the intensity of new project arrivals, and δ is the depreciation rate. We allow A shocks and Z shocks to be positively correlated, consistent with the empirical observation that more profitable firms also have greater investment opportunities. As shown below, the cross-sectional variation in book-to-market ratio is mainly driven by A_{jt}. In addition, firms with higher A_{jt} have higher exposures to S_t than firms with lower A_{jt}. This is the channel for a positive value premium in the model.

For given processes governing the pricing kernel (M), the input price, the aggregate profitability shock (X), the aggregate growth shock (Y), the aggregate investment shock (S), the idiosyncratic profitability shock (Z), and firm-specific investment shock (A), which we specify below, a firm's value can be written recursively as:[11]

$$\begin{aligned} V_{jt} &= K_{jt}\pi_{jt} + E_t[M_{t+1} V_{jt+1}] \\ &\text{s.t. } (10) - (11) \end{aligned} \tag{12}$$

Using the lower case variables to represent the logarithmic transformation of the correspond-

[11]We abstract from operating cost, which is included in the exogenous leverage ratio as discussed below.

ing level variables, we assume the exogenous variables x, s, z, and a follow AR(1) processes, respectively:

$$x_{t+1} = \rho_x x_t + (1-\rho_x)\bar{x} + \sigma_x \epsilon^x_{t+1} \tag{13}$$

$$s_{t+1} = \rho_s s_t + (1-\rho_s)\bar{s} + \sigma_s \epsilon^s_{t+1} \tag{14}$$

$$z_{jt+1} = \rho_z z_{jt} + (1-\rho_z)\bar{z} + \sigma_z \epsilon^z_{jt+1} + \mu_z \tag{15}$$

$$a_{jt+1} = \rho_a a_{jt} + \sigma_a \epsilon^a_{jt+1} \tag{16}$$

and y follows a random walk

$$\Delta y_{t+1} = \sigma_y \epsilon^y_{t+1}. \tag{17}$$

We assume the intermediate input price P_t is a function of the stationary component of the aggregate profitability X_t as follows:

$$\log P_t = \log p_0 + p_1 \log X_t, \tag{18}$$

where $p_0 > 0$ and $p_1 > 0$ capture the level and the cyclicality of the intermediate input price.

The pricing kernel is a function of the three aggregate shocks, ϵ^x_t, ϵ^y_t, and ϵ^s_t:

$$M_{t+1} = \exp\left(-r_f - \gamma_x\sigma_x\epsilon^x_{t+1} - \gamma_y\sigma_y\epsilon^y_{t+1} - \gamma_s\sigma_s\epsilon^s_{t+1} - \frac{1}{2}\gamma_x^2\sigma_x^2 - \frac{1}{2}\gamma_y^2\sigma_y^2 - \frac{1}{2}\gamma_s^2\sigma_s^2\right), \tag{19}$$

where $\gamma_x > 0$, $\gamma_y > 0$, and $\gamma_s < 0$ are the prices of risks for the aggregate profitability shock, the aggregate growth shock, and the aggregate investment shock, respectively, and r_f is the risk-free rate.

Since the economy is homogenous of degree one with respect to capital stock, it can be shown that $V_{jt}(X_t, Y_t, S_t, Z_{jt}, A_{it}, K_{it}) = K_{jt}v_{jt}(X_t, Y_t, S_t, Z_{jt}, A_{it})$. The firm value can be re-written as:

$$v_{jt} = \pi_{jt} + E_t[M_{t+1}v_{jt+1}][(1-\delta) + \delta A_{jt}S_t] \tag{20}$$

The normalized value function v_{jt} is also the market-to-book for firm j at time t. Since y follows a random walk, we can further simplify this problem as:

$$\hat{v}_{jt} = \hat{\pi}_{jt} + E_t[M_{t+1}\hat{v}_{jt+1} \exp(\mu_y + \sigma_y \epsilon^y_{t+1})][(1-\delta) + \delta A_{jt} S_t] \tag{21}$$

where $\hat{\pi} = \pi/Y$ and $\hat{v} = v/Y$. Since the firm value is linear in Y, the shock to economic growth contributes to the equity premium, but not to the risk premium in the cross section. The normalized firm value $\hat{v}$ is a function of four state variables: X_t, S_t, Z_{jt}, and A_{jt}. We also assume an exogenous leverage ratio ϕ, which encompass the effect of both financial and operating leverage.

3.3.1 Calibration and the optimal solution

We solve the problem numerically using value function iterations at a monthly frequency. We simulate the model 100 times with each sample representing 1,000 firms and 600 months. Table 10 reports the parameter values used in our benchmark calibration.

[Insert Table 10 Here]

Consistent with the literature on the real business cycles (e.g., Kydland and Prescott (1982), Cooper and Haltiwanger (2006)), we set the depreciation rate is 1% per month (or 12% per year), and risk-free rate is 0.25% per month (or 3% per year). We normalize $\bar{x} = 0$, and set $\rho_x = 0.98$, $\sigma_x = 0.04$, $\sigma_y = 0.027$ to approximately match the volatility of the aggregate market returns, the volatility of aggregate variable costs growth relative to aggregate sales growth, the volatility of aggregate sales-aggregate variable costs ratio, and the autocorrelations of the aggregate profitability and aggregate book-to-market ratio. We choose $\bar{s} = -0.146$, $\rho_s = 0.9685$, $\sigma_s = 0.026$ to match the mean, standard deviation, and autocorrelation of the aggregate investment rate of 11.4%, 1%, and 0.73, respectively. We set η, the elasticity of substitution between capital and intermediate inputs, to 0.3, $\rho_z = 0.97$, $\sigma_z = 0.075$, $\rho_a = 0.98$, $\sigma_a = 0.107$, and $\rho_{az} = 0.18$ to approximately match the cross-sectional distribution of GP/A, book-to-market ratios, gross profit margin across GP/A and BM quintile portfolios, the firm-level return volatility, as well as the volatility of firm-level variable costs growth relative to that of the firm-level sales growth. p_1 is set to 1.39 from our estimates in Section 4.1. We choose $p_0 = 2.1$ to match the level of aggregate GP/A, and the average ratio of aggregate sale to aggregate variable costs. We set $\gamma_x = 15$, $\gamma_y = 6.5$, and $\gamma_s = -10$ to match the equity premium and aggregate book-to-market ratio. These values are also in line with Kogan and Papanikolaou (2013, 2014). Finally, following Boldrin, Christiano, and Fisher (2001), we choose a leverage ratio ϕ of 1.67, potentially capturing both operating leverage and financial leverage. Table 11 compares the key moments from the simulated data and empirical data. The parameter values chosen match very well the key moments from the simulated data of the model and the actual data.

[Insert Table 11 Here]

Figure 1 plots the value functions of the calibrated model. The top row of Figure 1 plots the firm value (or the firm's market-to-book), the value of assets-in-place, the value of growth options, and gross profitability against the two aggregate state variables (x and s), while the bottom row plots these value functions against the two idiosyncratic state variables (z and a). We calculate the value of assets-in-place by eliminating future project arrivals using value function iterations. The value of growth options is the difference between the total firm value and the value of assets-in-place. Consistent with our intuition, total firm value increases with all four state variables, so both aggregate profitability shock (positively) and aggregate IST shock (negatively) contribute to the equity premium, given the signs of the prices of risk for these two aggregate risk factors. The value of assets-in-place increases with aggregate and idiosyncratic profitability, but its exposures to the aggregate and idiosyncratic IST shocks are much lower. On the other hand, the value of growth options is more sensitive to the aggregate and idiosyncratic investment shocks. Taken together, while the firm value (the market-to-book ratio) increases with both the idiosyncratic profitability and investment shocks, its sensitivity to the latter is higher, indicating that book-to-market differentials are mainly driven by cross-sectional dispersion in a. The difference in the exposure to the aggregate investment shocks between assets-in-place and growth options gives rise to a composition effect as in Kogan and Papanikolaou (2013, 2014).

[Insert Figure 1 Here]

The far right two panels show the gross profitability (GP/A) against these state variables. The gross profitability is a function of aggregate profitability x and idiosyncratic profitability z only. The strong positive relation between GP/A and z indicates that sorts on GP/A create cross-sectional dispersions in z and in the exposure to x. The non-monotonic relation between gross profitability and the aggregate profitability x is also interesting. At low levels of x, gross profitability increases with x, but when x is above some threshold, their relation becomes negative. Intuitively, revenues have an exposure to aggregate profitability of approximately one, whereas the exposure of the variable costs is greater than one since $p_1 > 1$, so variable costs provide a hedge to aggregate profitability shock. When x is low, the level of revenue is much higher than that of the variable cost. In this situation, the hedging effect is small and the exposure of gross profits to aggregate profitability shocks is positive (i.e., a positive GP/A-x relation). When x is high, on the other hand, the level of variable cost is comparable to that of revenues. In this case, the strong hedging effect from variable costs offsets the positive exposure of revenues, giving rise to a negative exposure of gross profits to aggregate profitability shock (i.e., a negative GP/A-x relation).

3.3.2 Implications for profitability premium and value premium

Tables 12 and 13 provide quantitative results on the portfolio analysis. Panel A of these two tables reports the characteristics of the GP/A and BM quintile portfolios. In our model, high (low) GP/A firms look like growth (value) firms. For instance, Table 12 Panel A shows that high GP/A firms have a logBM of -1.24, as compared to -0.93 for low GP/A firms. Similarly, Table 13 Panel A shows that value firms have a GP/A of 0.16, as compared to 0.31 for growth firms. Therefore, the model reproduces the empirical fact that gross profitability behaves like the other side of value. Panel A of Tables 12 also confirms that the cross-sectional variation in GP/A is mainly driven by the idiosyncratic profitability shock Z (GP/A increases in Z), whereas the variation in BM is driven by both A and Z (Panel A of Table 13). Compared with value firms, growth firms have higher A and Z because positive shocks to both A and Z increase the firm value. Panel A of Tables 12 and 13 also shows that high GP/A firms and growth firms have higher gross margin (GM) and intermediate input-capital ratio (EK) than low GP/A firms and value firms. Intuitively, following positive firm-specific profitability shocks, firms use more intermediate inputs, and because the substitution between capital and intermediate inputs (η) is inelastic, revenue increases more than input cost. As a result, both EK and GM increase with GP/A.

[Insert Table 12 Here]

[Insert Table 13 Here]

Panel B of Tables 12 and 13 examines the value-weighted returns and asset pricing tests of the GP/A portfolios and BM portfolios.[12] For the asset pricing models, we consider the CAPM and a two-factor model with the market and the value premium factor (HML) as the risk factors.[13] The model generates a positive gross profitability premium of 3.13% per year and value premium of 3.4% per year with a correlation coefficient of −0.27 (untabulated) between the two factors. Thus, we are able to generate large profitability and value premia, with negative correlation between the corresponding factors, in a structural asset pricing model with production. None of the two premia are captured by the CAPM. For the gross profitability premium, even though the market beta increases slightly from low to high GP/A firms, the CAPM alpha remains 2.88% per year, which is 3.67 standard errors from zero. For the value premium, the CAPM beta goes in the wrong direction (a negative market beta), so that the abnormal return spread (4.50%) is even greater than the return spread (3.4%). Adding the value premium factor eliminates the abnormal return of the value premium as shown in Table 13 Panel B, but increases the abnormal return of the gross profitability premium even further as shown in Table 12 Panel B. The two-factor model alpha controlling for HML becomes 3.79% per year, which is greater than both the average return and CAPM alpha of the Hi-Lo GP/A portfolio. Therefore, while the model reproduces a coexistence

[12] To save space, we only report the value-weighted portfolio returns. The results for the equal-weighted returns are very similar.

[13] We use the two-factor model in the simulation to draw parallel to the Fama and French three-factor model in the empirical analysis. We do not include a separate size premium factor as we did in the empirical analysis (Tables 1 and 2) because our theoretical model is a three-factor model and we lack one additional risk factor compared to the data. In the empirical analysis, the gross profitability premium is unable to be captured by the Fama and French three-factor model, so a total of four factors are needed to capture the size, value, and gross profitability premiums in the data.

of the profitability premium and the value premium, these two premiums are negatively correlated with each other.

To understand the drivers of the profitability premium and the value premium in our investment-based model, Panel C of Tables 12 and 13 reports the exposures of the GP/A and BM portfolios to the aggregate profitability shock, aggregate growth (Y) shock, and aggregate investment (S) shock. The exposures to the aggregate growth shock is approximately 1.68 for all GP/A and BM portfolios. Therefore, while the aggregate growth shock contributes to the overall equity premium, it does not drive the average stock returns in the cross section. High GP/A firms have higher exposures to the aggregate profitability shock than low GP/A firms, with a difference in $\beta(X)$ of 0.13 (t-statistic = 8.49). So consistent with our earlier discussion, the aggregate profitability shock is the main underlying risk factor for the positive gross profitability premium. In addition, due to the positive correlation between firm-specific profitability shocks and firm-specific investment shocks, profitable firms also have higher exposure to the aggregate investment shocks than less profitable firms, with a difference in $\beta(S)$ of 0.06 (t-statistic = 2.59).

For the value premium, value firms have an exposure to S shocks of 0.38, much lower than that of growth firms (0.95), and their difference is more than 20 standard errors from zero. On the other hand, the exposure to X shocks is hump-shaped, with a slightly higher $\beta(X)$ for growth firms than value firms. Therefore, the asset composition and the exposure to the aggregate investment shocks are the major sources of the positive value premium in our model. Furthermore, the opposite signs in the risk exposures to aggregate profitability and investment shocks between the gross profitability premium and value premium generate a strong negative correlation between these two premiums.

The prediction of our model on the negative correlation between the gross profitability premium and the value premium is also novel and stands out from the existing studies on these cross-sectional phenomena. Most analyses focus on one phenomenon while ignoring the other (e.g., Wang and Yu (2015), Lam, Wang, and Wei (2014), Zhang (2005), Carlson, Fisher, and Giammarino (2004)). One exception is Kogan and Papanikolaou (2013). In their model, both the value premium and gross profitability premium are driven by the asset composition and heterogeneous exposures to the aggregate investment shocks. Specifically, more profitable firms derive much of their values from assets-in-place than growth options, and hence their exposure to the aggregate investment shocks is lower than less profitable firms. Since the aggregate investment shock is also driving the different risk premiums between value and growth firms, the value premium and the gross profitability premium in their model are positively correlated. Different from their model, high GP/A firms in our model have low BM, instead of high BM, than low GP/A firms, so profitable firms look a lot like growth firms, not value firms. In addition, the sources of the GP/A and value premiums are different in our model. While the value premium is due to the heterogeneous exposure to the aggregate investment shock, the gross profitability premium is driven by different exposures to the aggregate profitability shock. Thus, our model breaks the positive correlation between the profitability premium and the value premium.

To further illustrate the mechanism of the model to generate the gross profitability premium and the value premium that is negatively correlated with the profitability premium, we report the returns and risk exposures of the portfolios sorted by the underlying firm-specific state variables Z and A in Table 14. Because of the channel we discussed in Section 3.1, sorting on Z creates a larger return spread of 3.56% per year than the gross profitability premium of 3.13%, as reported in Panel A. The majority of the premium is due to the exposure to the aggregate profitability shock: $\beta(X)$ for the Hi-Lo Z portfolio is 0.14 (t-stat = 9.36). Furthermore, because of the positive correlation between Z and A shocks, this premium also loads positively on the aggregate investment shock, $\beta(S)$.

[Insert Table 14 Here]

Similarly, Panel B reports the results for the portfolios sorted by firm-specific investment opportunity A. High A stocks have an average return of 6.12% per year, which is 4.77% lower than that of the low A stocks, and the findings on the exposures of these portfolios on the aggregate risk factors indicate that the aggregate investment shock is the dominant source of this risk premium. In addition, this premium is 40% higher than that of the value premium, indicating that book-to-market sorts contain information about Z, which "contaminates" and offsets the negative relation between A and risk premium in the book-to-market sorts.

4 Conclusion

We explore a novel economic channel for heterogeneity in cash flow risk among firms. The hedging effect due to highly procyclical value of intermediate inputs generates differential exposures to aggregate profitability shocks, which correlate with firm profitability. Less profitable firms benefit more from this hedging effect, and thus exhibit lower cash flow risk, and lower average returns.

We develop a dynamic model, in which the profitability premium coexists with the value premium. The two effects are generated by different economic channels. The value spread reflects in large cross-sectional differences in firm growth opportunities, and thus their heterogeneous exposures to the aggregate investment-specific shocks. The profitability spread is driven primarily by the aggregate profitability shocks. Our model is able to reproduce the negative correlation between the value factor and the gross profitability factor in returns.

Operating leverage has been explored extensively in the prior literature as a mechanism for generating the value premium in the cross-section of stock returns. It is also well known that the logic of operating leverage leads to counterfactual implications for the relation between firm profitability and average returns. In this paper we show that impact of production costs on firm cash flow risk is more nuanced than suggested by the operating leverage channel alone, and variable costs give rise to a first-order hedging effect on firm cash flows. Additional research is needed to better understand the dynamics of firm costs, particularly in relation to the input-output structure of the economy, and cross-sectional differences in production technologies and market power. Our analysis suggests that this would yield useful insights into the properties of stock returns and firm dynamics.

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Appendix

Firm's problem chooses intermediate inputs to maximize firm operating profits:

$$\begin{aligned}\pi &= \max_E\{O - PE\} \\ &= \max_E\{X[(ZE)^{\frac{\eta-1}{\eta}} + K^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}} - PE\}.\end{aligned} \tag{A.1}$$

where O is firm's revenues. The first-order condition implies that:

$$P = XZ^{\frac{\eta-1}{\eta}}E^{\frac{-1}{\eta}} \times [(ZE)^{\frac{\eta-1}{\eta}} + K^{\frac{\eta-1}{\eta}}]^{\frac{1}{\eta-1}}, \tag{A.2}$$

so intermediate inputs share is:

$$ES \equiv \frac{PE}{O} = \frac{(ZE)^{\frac{\eta-1}{\eta}}}{(ZE)^{\frac{\eta-1}{\eta}} + K^{\frac{\eta-1}{\eta}}}. \tag{A.3}$$

Empirically, this measures the ratio of variable cost and revenue. In addition, firm's gross profitability equals:

$$\begin{aligned}\text{GP/A} &= X\left[\left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}} + 1\right]^{\frac{1}{\eta-1}} \\ &= X\left(\frac{O}{\pi}\right)^{\frac{1}{\eta-1}},\end{aligned} \tag{A.4}$$

where the second equality follows from Eqn (A.3). O/π is the inverse of a firm's gross profit margin, so the relation between GP/A and gross margin can be used to estimate η empirically.

Taking the partial derivative of the logarithm of both sides of Equation A.2 with respect to $\log X$, we have:

$$\frac{\partial \log E}{\partial \log X} = \eta\left(1 - \frac{\partial \log P}{\partial \log X}\right)\left[1 + \left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}}\right]. \tag{A.5}$$

Taking the partial derivative of the logarithm of both sides of Equation A.2 with respect to

$\log Z$, we have:

$$\frac{\partial \log E}{\partial \log Z} = \eta \left[1 + \left(\frac{ZE}{K} \right)^{\frac{\eta-1}{\eta}} \right] - 1. \tag{A.6}$$

Therefore, the exposure of firm's gross profit with respect to X, or β_X, is:

$$\begin{aligned} \beta_X \equiv \frac{\partial \log \pi}{\partial \log X} &= 1 + \frac{1}{\eta} \frac{(ZE)^{\frac{\eta-1}{\eta}}}{(ZE)^{\frac{\eta-1}{\eta}} + K^{\frac{\eta-1}{\eta}}} \times \frac{\partial \log E}{\partial \log X} \\ &= 1 + \left(1 - \frac{\partial \log P}{\partial \log X} \right) \left(\frac{ZE}{K} \right)^{\frac{\eta-1}{\eta}}. \end{aligned} \tag{A.7}$$

Taking the partial derivative of β_X with respect to $\log Z$:

$$\begin{aligned} \frac{\partial \beta_X}{\partial \log Z} &= \left(\frac{\eta - 1}{\eta} \right) \left(1 - \frac{\partial \log P}{\partial \log X} \right) \left(\frac{ZE}{K} \right)^{\frac{\eta-1}{\eta}} \left(1 + \frac{\partial \log E}{\partial \log Z} \right) \\ &= (\eta - 1) \left(1 - \frac{\partial \log P}{\partial \log X} \right) \left(\frac{ZE}{K} \right)^{\frac{\eta-1}{\eta}} \left[1 + \left(\frac{ZE}{K} \right)^{\frac{\eta-1}{\eta}} \right]. \end{aligned} \tag{A.8}$$

The last two terms are always positive, so a positive gross profitability premium requires:

1. $\eta > 1$ and $\frac{\partial \log P}{\partial \log X} < 1$; or
2. $\eta < 1$ and $\frac{\partial \log P}{\partial \log X} > 1$.

It can be quickly shown that:

$$\frac{\partial \log O}{\partial \log Z} = \eta \left(\frac{ZE}{K} \right)^{\frac{\eta-1}{\eta}}, \tag{A.9}$$

and

$$\frac{\partial \log O}{\partial \log X} = 1 + \eta \left(\frac{ZE}{K} \right)^{\frac{\eta-1}{\eta}} \left(1 - \frac{\partial \log P}{\partial \log X} \right). \tag{A.10}$$

Comparing Equation (A.10) with Equation (A.7), we have the following identity:

$$\frac{\partial \log O}{\partial \log X} - 1 = \eta \left(\frac{\partial \log \pi}{\partial \log X} - 1 \right) \tag{A.11}$$

Table 1: Gross profitability portfolios

This table reports the characteristics and returns of quintile value-weighted portfolios sorted by gross profitability (GP/A). Panel A reports the average characteristics of GP/A portfolios, including gross profitability (GP/A), log book-to-market (logBM), log market cap (logSize), momentum (Mom), market-based financial leverage (FLev), operating leverage (OLev), Tobin's Q (Q), cash holdings (CH), R&D intensity (R&D), investment rate (IK), and gross profit margin (GM). Panel B reports the mean, standard deviation, CAPM test result, and Fama-French three-factor model test result of the quintile GP/A portfolios. The sample is 196307-201412. Newey-West *t*-stats given in parentheses control for heteroscedasticity and autocorrelation.

Panel A: Portfolio characteristics

Portfolio	GP/A	logBM	logSize	Mom	FLev	OLev	Q	CH	RD	IK	GM
Lo	0.09	-0.28	4.58	0.02	0.33	0.73	1.68	0.21	0.42	0.09	0.19
2	0.22	-0.19	4.71	0.05	0.22	1.78	1.08	0.10	0.03	0.11	0.25
3	0.34	-0.31	4.51	0.06	0.16	2.29	1.55	0.15	0.05	0.11	0.29
4	0.47	-0.49	4.46	0.07	0.12	2.82	2.09	0.20	0.09	0.12	0.36
Hi	0.72	-0.71	4.38	0.08	0.07	3.76	2.60	0.25	0.11	0.14	0.44

Panel B: Portfolio returns and Fama-French 3-factor model test

	Lo	2	3	4	Hi	Hi-Lo
Mean	4.83	5.34	6.89	6.03	8.51	3.69
Std	15.38	16.01	16.39	17.02	15.88	10.52
α	-0.79	-0.55	0.71	-0.33	2.81	3.60
	(-0.91)	(-0.58)	(1.07)	(-0.40)	(2.81)	(2.21)
MKT	0.92	0.97	1.01	1.04	0.94	0.01
	(46.36)	(36.92)	(51.62)	(50.88)	(36.22)	(0.35)
$R^2(\%)$	85.68	86.81	91.37	89.63	82.93	0.04
α	-1.96	-1.56	0.64	1.11	4.41	6.37
	(-2.46)	(-1.82)	(0.90)	(1.55)	(4.98)	(4.56)
MKT	0.96	1.03	1.00	1.00	0.89	-0.06
	(52.81)	(45.96)	(47.28)	(59.50)	(35.89)	(-1.67)
HML	0.21	0.21	-0.01	-0.25	-0.28	-0.48
	(5.89)	(5.69)	(-0.25)	(-6.66)	(-5.56)	(-6.71)
SMB	0.02	-0.09	0.07	-0.03	-0.05	-0.07
	(0.75)	(-2.65)	(2.73)	(-1.11)	(-1.50)	(-1.32)
$R^2(\%)$	87.26	88.95	91.59	91.54	85.58	18.45

Table 2: Book-to-market portfolios

This table reports the characteristics and returns of quintile value-weighted portfolios sorted by the book-to-market equity ratio (BM). Panel A reports the average characteristics of BM portfolios, including gross profitability (GP/A), log book-to-market (logBM), log market cap (logSize), momentum (Mom), market-based financial leverage (FLev), operating leverage (OLev), Tobin's Q (Q), cash holdings (CH), R&D intensity (R&D), investment rate (IK), and gross profit margin (GM). Panel B reports the mean, standard deviation, CAPM test result, and Fama-French three-factor model test result of the quintile BM portfolios. The sample is 196307-201412. Newey-West t-stats given in parentheses control for heteroscedasticity and autocorrelation.

Panel A: Portfolio characteristics

Portfolio	GP/A	logBM	logSize	Mom	FLev	OLev	Q	CH	RD	IK	GM
Lo	0.43	-1.52	5.20	0.04	0.06	2.16	7.30	0.43	0.22	0.18	0.41
2	0.37	-0.80	5.20	0.05	0.15	2.36	2.79	0.22	0.09	0.14	0.36
3	0.34	-0.39	4.90	0.06	0.22	2.44	1.56	0.15	0.06	0.12	0.32
4	0.30	-0.02	4.37	0.07	0.30	2.55	0.95	0.11	0.05	0.10	0.29
Hi	0.27	0.49	3.42	0.07	0.43	2.74	0.48	0.09	0.03	0.08	0.26

Panel B: Portfolio returns and Fama-French 3-factor model test

	Lo	2	3	4	Hi	Hi-Lo
Mean	5.20	6.01	7.03	8.73	10.64	5.43
Std	17.14	15.63	15.19	15.43	17.82	13.58
α	-1.18	0.07	1.50	3.31	4.73	5.91
	(-1.26)	(0.10)	(1.78)	(2.95)	(3.23)	(2.74)
MKT	1.05	0.98	0.91	0.89	0.97	-0.08
	(48.34)	(53.66)	(37.16)	(26.27)	(22.28)	(-1.31)
R^2(%)	89.01	92.96	85.22	79.13	70.55	0.79
α	1.48	0.13	0.29	0.23	0.27	-1.20
	(2.61)	(0.20)	(0.37)	(0.31)	(0.27)	(-1.05)
MKT	1.00	0.97	0.94	0.95	1.02	0.03
	(72.73)	(56.93)	(44.36)	(47.51)	(39.39)	(0.90)
HML	-0.45	-0.02	0.22	0.53	0.72	1.17
	(-16.37)	(-0.48)	(4.29)	(11.05)	(14.44)	(20.95)
SMB	-0.13	0.02	0.01	0.13	0.33	0.46
	(-5.56)	(0.83)	(0.17)	(5.32)	(9.70)	(12.61)
R^2(%)	95.11	92.99	87.07	89.36	86.56	70.32

Table 3: The cyclicality of gross output, intermediate input, and value added

This table reports the cyclicality of gross output (GO), intermediate input (II), and value added (VA). The price index (P), quantity index (Q), and total value (V) of gross output, intermediate input, and value added are from GDP-by-industry account at Bureau of Economic Analysis (BEA). The price indexes and total values are further deflated by Consumer Price Index. Panel A reports the mean and standard deviation of their growth rates in percentages. Panel B reports the elasticity of P(II) with respect to P(GO), $\beta^{\text{P}}_{\text{GO}}(\text{II})$, and the elasticity of V(II) and V(VA) with respect to V(GO), $\beta^{\text{V}}_{\text{GO)}}(\text{II})$ and $\beta^{\text{V}}_{\text{GO)}}(\text{VA})$, respectively, which are estimated from univariate regressions. The Newey-West *t*-statistics control heteroscedasticity and autocorrelation. The data are annual from 1947 to 2014.

Panel A: Summary statistics

	ΔlogP(GO)	ΔlogP(II)	ΔlogQ(GO)	ΔlogQ(II)	ΔlogV(GO)	ΔlogV(II)	ΔlogV(VA)
Mean (%)	-0.09	-0.1	3.07	3.03	2.81	2.7	2.89
Std (%)	1.49	2.23	2.81	3.86	2.9	4.21	2.52

Panel B: Elasticity of intermediate input and value added

	$\beta^{\text{P}}_{\text{GO}}(\text{II})$	$\beta^{\text{V}}_{\text{GO)}}(\text{II})$	$\beta^{\text{V}}_{\text{GO}}(\text{VA})$
Est.	1.33	1.34	0.74
t-stat	(9.3)	(12.73)	(9.72)

Table 4: Elasticity of substitution between capital and intermediate inputs

This table presents the estimate for the elasticity of substitution (η) between capital and intermediate inputs using the firm-level Fama-MacBeth regressions:

$$\log \mathrm{GM}_{it} = a_t + (1-\eta_t) \times \log \mathrm{GP/A}_{it} + \epsilon_{it}$$

where GM is gross margin (gross profits divided by sales), and GP/A is gross profitability (gross profits divided by total asset). In Panel A, we report the estimated η at the portfolio level using gross profitability and book-to-market decile portfolios. In Panel B, we report the estimated η at the firm level within each of 14 industries from the GDP-by-industry, Bureau of Economic Analysis. The Newey-West t-statistics control heteroscedasticity and autocorrelation. The data are annual from 1947 to 2014.

Panel A: Estimates based on 10 GP/A and 10 BM portfolios

Portfolios	η	std. err.
10 GP/A	0.612	0.031
10 BM	0.371	0.035
10 GP/A + 10 BM	0.573	0.025

Panel B: Estimates for 14 industries

Industry	η	std. err.
Agriculture, forestry, fishing, and hunting	0.738	0.037
Arts, entertainment, recreation, accommodation, and food services	0.708	0.032
Construction	0.751	0.037
Educational services, health care, and social assistance	0.510	0.026
Finance, insurance, real estate, rental, and leasing	0.878	0.027
Information	0.642	0.008
Manufacturing	0.534	0.020
Mining	0.690	0.031
Other services, except government	0.733	0.032
Professional and business services	0.607	0.023
Retail trade	0.624	0.021
Transportation and warehousing	0.696	0.046
Utilities	0.743	0.067
Wholesale trade	0.627	0.035

Table 5: Cash flow elasticities at aggregate, firm, and portfolio levels

This table reports the cash flow elasticities at aggregate, firm, and portfolio levels. In Panel A1, we report the mean and standard deviation of aggregate-level sales growth (ΔlogASale) and aggregate-level gross profits growth (ΔlogAGP). In Panel A2, we estimate the elasticity of AGP with respect to ASale by running the time series regression: $\Delta \text{logAGP} = a + b \times \Delta \text{logASale}$. In Panel B1, we report the mean and standard deviation of the firm-level sales growth (ΔlogSale) and firm-level gross profits growth (ΔlogGP). In Panel B2, we report the elasticity of GP with respect to Sale by running Fama-MacBeth regressions $\Delta \text{logGP}_{it} = a_t + b_t \times \Delta \text{logSale}_{it}$ and report the time series average of b_t. In Panel C, we report the elasticity of gross profits with respect to sales ($\beta_{\text{Sale}}(\text{GP})$), elasticity of operating profits with respect to gross profits ($\beta_{\text{GP}}(\text{OP})$), and elasticity of operating profits with respect to sales ($\beta_{\text{Sale}}(\text{OP})$) for GP/A portfolios. These elasticities are estimated from univariate time series regressions. For instance, $\beta_{\text{Sale}}(\text{GP})$ is estimated from regressing portfolio ΔlogGP onto portfolio ΔlogSale for each of these GP/A portfolios. The Newey-West t-statistics in Panels A2, B2, and C control heteroscedasticity and autocorrelation. The sample is annual from 1964 to 2014.

Panel A: Sales growth and gross profits growth at the aggregate level

Panel A1

Summary	ΔlogASale	ΔlogAGP
Mean (%)	3.16	3.31
Std (%)	5.75	4.99

Panel A2

$\beta_{\text{ASale}}(\text{AGP})$	
Est.	0.75
t-stat	(14.27)

Panel B: Sales growth and gross profits growth at the firm level

Panel B1

Summary	ΔlogSale	ΔlogGP
Mean (%)	7.49	7.06
Std (%)	21.07	26.73

Panel B2

$\beta_{\text{Sale}}(\text{GP})$	
Est.	1.14
t-stat	(17.73)

Panel C: Cash flow elasticities of GP/A portfolios

GP/A Port	Lo	2	3	4	Hi
$\beta_{\text{Sale}}(\text{GP})$	0.40	0.96	0.95	1.06	1.06
	(2.44)	(13.03)	(11.34)	(23.89)	(18.78)
$\beta_{\text{GP}}(\text{OP})$	1.33	1.36	1.53	1.63	1.37
	(7.44)	(41.04)	(32.25)	(23.16)	(26.35)
$\beta_{\text{Sale}}(\text{OP})$	0.34	1.27	1.41	1.61	1.42
	(1.85)	(13.29)	(10.41)	(12.94)	(18.49)

Table 6: Cross-industry evidence

This table examines the relation between the cyclicality of input and output prices and the gross profitability premium across industries. 14 industries from the GDP-by-industry accounts from Bureau of Economic Analysis are considered. In Panel A, we report the cyclicality of input prices (β_{II}), of output prices (β_{GO}), their difference ($\beta_{\mathrm{GO}}-\beta_{\mathrm{II}}$), the gross profitability premium, and the gross profitability premium conditional on the book-to-market. The industry input (output) price cyclicality is estimated from the time series regression of industry input (output) price growth on the aggregate output price growth. The gross profitability premium is from the Fama-MacBeth regression of returns on gross profitability within a particular industry, with or without controlling for book-to-market. Panel B reports the result from the cross sectional regressions of the gross profitability premium (with or without controlling for book-to-market) on β_{GO} and $\beta_{\mathrm{GO}} - \beta_{\mathrm{II}}$. The Newey-West t-statistics in Panel B control heteroscedasticity and autocorrelation. The data are annual from 1947 to 2014.

Panel A: Price elasticities and gross profitability premium for different industries

Industry	β_{II}	β_{GO}	$\beta_{\mathrm{GO}} - \beta_{\mathrm{II}}$	GP/A Prm.	GP/A Prm. Cont. BM
Agriculture, forestry, fishing, and hunting	1.50	1.38	-0.12	0.96	1.13
Arts, entertainment, recreation, accommodation, and food services	1.03	0.61	-0.41	1.41	1.77
Construction	1.09	1.01	-0.08	0.45	0.83
Educational services, health care, and social assistance	0.95	0.68	-0.28	0.04	0.53
Finance, insurance, real estate, rental, and leasing	0.74	0.50	-0.24	0.65	0.70
Information	0.76	0.46	-0.31	0.63	0.86
Manufacturing	1.52	1.33	-0.20	0.82	1.29
Mining	1.59	3.43	1.84	0.87	1.62
Other services, except government	0.90	0.71	-0.20	-0.91	-0.17
Professional and business services	0.73	0.74	0.01	1.08	1.39
Retail trade	0.92	0.89	-0.03	0.41	0.49
Transportation and warehousing	1.25	0.92	-0.34	0.86	1.67
Utilities	2.63	1.41	-1.22	1.76	2.86
Wholesale trade	0.83	0.72	-0.11	0.57	0.84

Panel B: Relation between gross profitability premium and price elasticity across industries

GP/A Prm.	Int	β_{GO}	$\beta_{\mathrm{GO}} - \beta_{\mathrm{II}}$
Coef	-0.08	0.64	-0.72
t-stat	(-0.20)	(2.05)	(-1.94)

GP/A Prm. C/BM	Int	β_{GO}	$\beta_{\mathrm{GO}} - \beta_{\mathrm{II}}$
Coef	-0.13	1.07	-1.12
t-stat	(-0.37)	(3.76)	(-3.35)

Table 7: Exposure of gross profitability premium to aggregate profitability shocks
This table reports the exposures of the quintile GP/A portfolios to the aggregate profitability shock. We use the aggregate utilization-adjusted total factor productivity shock (dTFP) from Basu, Fernald, and Kimball (2006) and Fernald (2014) as our measure of aggregate profitability shock. Panel A reports the cash flow betas, which are estimated in the following annual regressions:

$$\Delta \text{logGP}_t^i = a^i + \beta^i \times \text{dTFP}_t + \epsilon_t^i,$$

where ΔlogGP_t^i is the growth rate of gross profits of the GP/A quintile i in year t. We also report the betas for sales and costs of goods sold to TFP shocks. Den Haan-Levin VARHAC t-statistics given in parentheses control for heteroscedasticity and autocorrelation. Panel B reports the stock return exposure of the GP/A quintiles to the market and dTFP from the time-series regressions. We consider a 2-factor model, with the market and dTFP as the risk factors, and a 4-factor model, with the market factor, the value premium factor, the size premium factor, and dTFP as the risk factors. To save space, we only report the dTFP beta. Newey-West t-statistics given in parentheses control for heteroscedasticity and autocorrelation. The sample is from 1964 to 2014.

Panel A: Cash flow betas to TFP shocks

GP/A Port	Lo	2	3	4	Hi	Hi-Lo
β_{TFP}(GP)	-0.93	-0.04	-0.23	-0.60	0.50	1.43
	(-1.73)	(-0.04)	(-0.32)	(-1.06)	(1.61)	(4.01)
β_{TFP}(Sale)	-0.46	-0.02	-0.62	-0.63	0.38	0.84
	(-0.56)	(-0.02)	(-0.65)	(-1.20)	(1.51)	(0.87)
β_{TFP}(COGS)	-0.33	0.00	-0.81	-0.68	0.31	0.64
	(-0.34)	(0.00)	(-0.74)	(-1.25)	(1.29)	(0.77)

Panel B: Stock return betas to TFP shocks

GP/A Port	Lo	2	3	4	Hi	Hi-Lo
β_{TFP}(ret) from	-1.07	-0.64	-0.94	0.75	0.66	1.73
2-factor model	(-2.08)	(-2.28)	(-1.91)	(1.87)	(1.32)	(1.90)
β_{TFP}(ret) from	-1.26	-0.80	-0.99	1.13	1.24	2.49
4-factor model	(-2.89)	(-2.90)	(-2.13)	(3.04)	(2.33)	(2.80)

Table 8: Pricing of aggregate profitability shocks

This table reports the pricing of the aggregate profitability shock. We use the aggregate utilization-adjusted total factor productivity shock (dTFP) from Basu, Fernald, and Kimball (2006) and Fernald (2014) as our measure of aggregate profitability shock. Panel A1 reports the regression coefficients of K-year GDP growth (GDPG), aggregate durable consumption growth (DurG), aggregate nondurable consumption growth (NDuG), aggregate service growth (SerG), and aggregate fixed investment growth (InvG) on K-year dTFP, where K = 3 or 5 years. As a comparison, we also report the result when the gross profitability premium is used as measure of the aggregate profitability shock in Panel A2. dTFP and GP/A premium are standardized to have a unit standard deviation. Den Haan-Levin VARHAC t-statistics given in parentheses control for heteroscedasticity and autocorrelation. In Panel B, we use Fama and French 17 and 30 industry portfolios to test the pricing of dTFP in GMM stochastic discount factor (SDF) tests. We consider a two-factor model with the market and dTFP as the risk factors. We also report the results for CAPM for comparison. We normalize the intercept of the SDF to one and report the mean absolute errors (MAE), the p-value associated with over-identification test, the price of risk (b) from the first-stage GMM estimations. The sample is annual from 1964 to 2014.

Panel A: Response of macroeconomic variables

Panel A1: Agg prof shock proxy: dTFP					
	GDPG	DurG	NDuG	SerG	InvG
K = 3	1.60	4.95	1.81	1.88	2.69
	(1.99)	(2.21)	(2.87)	(2.98)	(0.53)
K = 5	4.72	13.03	4.36	3.75	7.94
	(3.25)	(16.11)	(5.64)	(8.52)	(0.11)
Panel A2: Agg prof shock proxy: GP/A premium					
K = 3	1.35	5.53	1.65	1.32	2.78
	(1.91)	(2.88)	(4.69)	(2.2)	(0.99)
K = 5	3.66	9.74	3.64	2.23	9.14
	(6.26)	(3.53)	(3.51)	(1.31)	(2.3)

Panel B: GMM-SDF tests

Portfolios	FF17	FF30
Model: CAPM		
MAE	1.35	1.50
p-value	0.94	1.00
b(MKT)	2.21	2.33
	(3.28)	(2.62)
Model: MKT + dTFP		
MAE	0.94	1.13
p-value	0.82	0.99
b(MKT)	0.75	0.93
	(0.89)	(0.98)
b(dTFP)	36.50	31.91
	(2.72)	(3.54)

Table 9: Operating leverage and gross profitability premium

This table reports the average excess returns (Panel A), CAPM alphas (Panel B), and Fama-French three-three factor model alphas (Panel C) of 5-by-5 portfolios double-sorted on operating leverage (OL) and gross profitability (GP/A). We only include stocks with positive GP/A and OL. The sample is annual from 1964 to 2014. The Newey-West t-statistics control heteroscedasticity and autocorrelation.

Panel A: Average excess returns

	Lo	2	GP/A	4	Hi	Hi-Lo	Ave Hi-Lo
Lo	4.35	5.51	6.46	7.10	6.60	2.25	
	(1.42)	(2.21)	(2.64)	(3.15)	(2.44)	(0.92)	
2	5.04	6.55	6.74	7.33	7.66	2.62	
	(1.71)	(2.51)	(2.54)	(2.87)	(2.93)	(1.12)	
OL	7.45	5.88	6.85	5.33	8.03	0.58	
	(2.44)	(1.96)	(2.62)	(2.08)	(3.37)	(0.27)	
4	6.64	8.47	9.02	8.03	9.76	3.13	
	(1.84)	(2.71)	(3.19)	(3.17)	(4.16)	(1.22)	
Hi	8.58	7.92	7.55	10.37	10.71	2.13	2.14
	(2.15)	(1.95)	(2.03)	(2.65)	(3.83)	(0.76)	(1.25)

Panel B: CAPM alphas

	Lo	2	GP/A	4	Hi	Hi-Lo	Ave Hi-Lo
Lo	-2.85	-0.22	0.95	1.56	0.34	3.19	
	(-1.70)	(-0.14)	(0.62)	(1.28)	(0.21)	(1.29)	
2	-2.09	0.20	0.13	1.00	1.96	4.05	
	(-1.49)	(0.17)	(0.11)	(0.89)	(1.37)	(1.73)	
OL	0.17	-1.09	0.17	-0.87	2.35	2.18	
	(0.12)	(-0.74)	(0.14)	(-0.79)	(1.83)	(1.06)	
4	-1.62	1.05	2.25	2.08	4.20	5.83	
	(-0.88)	(0.65)	(1.59)	(1.51)	(3.32)	(2.46)	
Hi	-0.03	-0.65	-0.75	2.73	4.59	4.62	4.97
	(-0.01)	(-0.27)	(-0.36)	(1.17)	(2.84)	(1.73)	(2.49)

Panel C: Fama-French three-factor model alphas

	Lo	2	GP/A	4	Hi	Hi-Lo	Ave Hi-Lo
Lo	-3.51	-0.71	0.57	1.31	1.38	4.88	
	(-2.08)	(-0.48)	(0.40)	(1.12)	(0.88)	(1.97)	
2	-3.49	-0.38	-0.17	1.25	3.00	6.48	
	(-2.74)	(-0.33)	(-0.14)	(1.15)	(2.21)	(3.05)	
OL	-0.74	-1.98	-0.05	-0.69	3.54	4.28	
	(-0.63)	(-1.40)	(-0.04)	(-0.66)	(2.97)	(2.43)	
4	-2.92	-0.37	1.82	2.39	4.55	7.46	
	(-1.85)	(-0.24)	(1.36)	(1.78)	(3.68)	(3.61)	
Hi	-2.14	-2.81	-2.08	2.09	3.49	5.63	5.75
	(-1.23)	(-1.41)	(-1.11)	(0.85)	(2.34)	(2.29)	(4.16)

Table 10: Parameter values

This table reports the parameter values used for the numerical analysis. The model is solved and simulated at a monthly frequency.

Parameter	Description	Value
γ_x	Price of risk for aggregate profitability shocks	15
γ_y	Price of risk for aggregate growth shocks	6.5
γ_s	Price of risk for aggregate investment shocks	-10
η	Elasticity of substitution between capital and intermediate inputs	0.3
δ	Depreciation rate	0.01
r_f	Risk-free rate	0.0025
$\bar{x}$	Unconditional aggregate profitability	0
ρ_x	Persistence of aggregate profitability shocks	0.98
σ_x	Conditional volatility of aggregate profitability shocks	0.04
σ_y	Conditional volatility of aggregate growth shocks	0.027
$\bar{s}$	Unconditional aggregate investment opportunity	-0.146
ρ_s	Persistence of aggregate investment shocks	0.9685
σ_s	Conditional volatility of aggregate investment shocks	0.026
$\bar{z}$	Unconditional idiosyncratic profitability	1.1
ρ_z	Persistence of idiosyncratic profitability shocks	0.97
σ_z	Conditional volatility of idiosyncratic profitability shocks	0.075
ρ_a	Persistence of idiosyncratic investment shocks	0.98
σ_a	Conditional volatility of idiosyncratic investment shocks	0.107
ρ_{az}	Correlation between idiosyncratic profitability and investment shocks	0.18
p_0	Logarithm of the level of intermediate inputs price	0.588
p_1	Cyclicality of intermediate inputs price w.r.t. aggregate profitability shock	1.39
ϕ	Leverage ratio	1.67

Table 11: Moments

This table reports the moments of interest from model simulation. The model is solved at a monthly frequency. 100 samples are simulated with each sample representing 600 months and 1,000 firms. Cross sample means of these moments are reported.

Moment	Data	Model
Average annual aggregate GP/A	0.24	0.25
AR(1) of aggregate annual GP/A	0.87	0.92
Average book-to-market ratio	0.53	0.44
AR(1) of aggregate book-to-market	0.89	0.89
Average annual aggregate investment rate	11.4%	11.1%
Standard deviation of annual aggregate investment rate	1%	1%
AR(1) of annual aggregate investment rate	0.73	0.72
Average aggregate sales - aggregate variable costs ratio	1.44	1.50
Volatility of aggregate sales - aggregate variable costs ratio	0.05	0.05
Volatility of aggregate variable costs growth/volatility of aggregate sales growth	1.12	1.15
Correlation between aggregate sales growth and aggregate variable costs growth	0.99	0.99
Volatility of firm-level variable costs growth/Volatility of firm-level sales growth	0.99	0.91
Value-weighted annual market premium	6.47%	8.87%
Value-weighted annual market volatility	16.96%	18.33%
Equal-weighted annual market premium	10.9%	9.42%
Equal-weighted annual market volatility	26.03%	18.13%
Volatility of monthly firm-level stock returns	12.6%	10.9%

Table 12: GP/A portfolios: Model

Panel A of this table reports the characteristics, including the gross profitability (GP/A), log book-to-market ratio (logBM), idiosyncratic profitability (Z), idiosyncratic investment opportunity (A), gross profit margin (GM), and intermediate input-capital ratio (EK) of the GP/A quintile portfolios. Panel B reports the mean and standard deviation the value-weighted returns, and the asset pricing test results based on CAPM and a two-factor model with market (MKT) and the value premium factor (HML) as the risk factors. Panel C reports the risk factor exposures of the GP/A portfolios to the aggregate profitability shock $\beta(X)$, aggregate growth shock $\beta(Y)$, and aggregate investment shock $\beta(S)$. The portfolio returns, standard deviations, and the abnormal returns are annualized. The model is simulated for 100 samples, with each sample representing 1,000 firms and 600 months. The Newey-West t-statistics control heteroscedasticity and autocorrelation.

Panel A: Portfolio characteristics

	GP/A	logBM	Z	A	GM	EK
Lo	0.05	-0.93	0.71	-0.36	0.09	0.33
2	0.16	-1.02	0.95	-0.28	0.23	0.57
3	0.24	-1.09	1.10	-0.23	0.30	0.69
4	0.33	-1.14	1.25	-0.18	0.37	0.79
Hi	0.47	-1.24	1.49	-0.10	0.47	0.95

Panel B: Portfolio returns and asset pricing tests

	Lo	2	3	4	Hi	Hi-Lo
Mean	6.87	7.74	8.39	9.09	10.00	3.13
Std	16.95	17.08	17.15	17.23	17.45	5.59
α	-1.52	-0.72	-0.11	0.56	1.36	2.88
	(-3.15)	(-1.51)	(-0.23)	(1.15)	(2.77)	(3.67)
MKT	0.99	0.99	1.00	1.00	1.01	0.03
	(117.18)	(119.79)	(122.44)	(119.73)	(120.19)	(2.15)
R^2(%)	95.86	96.03	96.11	96.01	96.01	0.96
α	-2.00	-0.92	-0.17	0.68	1.79	3.79
	(-4.11)	(-1.89)	(-0.35)	(1.34)	(3.58)	(4.84)
MKT	1.00	1.00	1.00	1.00	1.00	0.00
	(116.67)	(116.40)	(117.42)	(114.71)	(116.24)	(0.22)
HML	0.11	0.05	0.01	-0.03	-0.10	-0.20
	(4.87)	(2.15)	(0.59)	(-1.20)	(-4.19)	(-5.61)
R^2(%)	96.08	96.07	96.12	96.03	96.18	7.82

Panel C: Risk exposures

	Lo	2	3	4	Hi	Hi-Lo
$\beta(X)$	0.05	0.09	0.11	0.14	0.18	0.13
	(4.99)	(7.94)	(10.12)	(12.39)	(15.67)	(8.49)
$\beta(Y)$	1.68	1.68	1.68	1.68	1.68	0.00
	(107.99)	(103.09)	(101.96)	(98.46)	(96.55)	(0.17)
$\beta(S)$	0.62	0.64	0.65	0.66	0.69	0.06
	(39.01)	(37.99)	(37.73)	(37.39)	(38.12)	(2.59)

Table 13: Book-to-market portfolios: Model

Panel A of this table reports the characteristics, including the gross profitability (GP/A), log book-to-market ratio (logBM), idiosyncratic profitability (Z), idiosyncratic investment opportunity (A), gross profit margin (GM), and intermediate input-capital ratio (EK) of the book-to-market (BM) quintile portfolios. Panel B reports the mean and standard deviation the value-weighted returns, and the asset pricing test results based on CAPM and a two-factor model with market (MKT) and the value premium factor (HML) as the risk factors. Panel C reports the risk factor exposures of the BM portfolios to the aggregate profitability shock $\beta(X)$, aggregate growth shock $\beta(Y)$, and aggregate investment shock $\beta(S)$. The portfolio returns, standard deviations, and the abnormal returns are annualized. The model is simulated for 100 samples, with each sample representing 1,000 firms and 600 months. The Newey-West t-statistics control heteroscedasticity and autocorrelation.

Panel A: Portfolio characteristics

	GP/A	logBM	Z	A	GM	EK
Lo	0.31	-1.56	1.24	0.52	0.35	0.77
2	0.29	-1.21	1.19	0.04	0.33	0.74
3	0.26	-1.05	1.13	-0.24	0.31	0.69
4	0.23	-0.90	1.05	-0.52	0.28	0.64
Hi	0.16	-0.70	0.89	-0.94	0.21	0.50

Panel B: Portfolio returns and asset pricing tests

	Lo	2	3	4	Hi	Hi-Lo
Mean	6.45	8.78	9.42	9.89	9.86	3.40
Std	18.46	17.01	16.67	16.42	16.18	7.32
α	-2.64	0.31	1.12	1.73	1.86	4.50
	(-4.50)	(0.76)	(2.80)	(4.07)	(3.90)	(4.59)
MKT	1.07	1.00	0.97	0.96	0.94	-0.13
	(105.63)	(144.85)	(140.35)	(129.89)	(114.20)	(-7.58)
$R^2(\%)$	94.88	97.20	97.05	96.58	95.58	8.94
α	-0.12	-0.26	0.17	0.48	-0.12	0.00
	(-0.56)	(-0.68)	(0.48)	(1.43)	(-0.56)	
MKT	1.00	1.01	1.00	0.99	1.00	0.00
	(273.52)	(147.47)	(162.71)	(167.33)	(273.52)	
HML	-0.56	0.13	0.21	0.28	0.44	1.00
	(-61.14)	(7.46)	(14.06)	(19.39)	(48.00)	
$R^2(\%)$	99.39	97.48	97.85	98.00	99.20	100

Panel C: Risk exposures

	Lo	2	3	4	Hi	Hi-Lo
$\beta(X)$	0.12	0.13	0.13	0.12	0.09	-0.02
	(8.41)	(14.66)	(16.63)	(17.26)	(14.84)	(-1.62)
$\beta(Y)$	1.68	1.68	1.68	1.68	1.68	0.00
	(80.60	(126.62)	(145.28)	(159.42)	(179.85)	(0.21)
$\beta(S)$	0.95	0.65	0.55	0.47	0.38	-0.57
	(44.07)	(47.71)	(45.94)	(44.00)	(39.89)	(-24.46)

Table 14: Portfolios sorted by Z and A: Model

Panel A of this table reports the mean and standard deviation the value-weighted returns, and the asset pricing test results based on CAPM, and the risk factor exposures to the aggregate profitability shock $\beta(X)$, aggregate growth shock $\beta(Y)$, and aggregate investment shock $\beta(S)$ of portfolios sorted by firm-specific profitability Z and portfolio sorted by firm-specific investment opportunity A. The portfolio returns, standard deviations, and the abnormal returns are annualized. The model is simulated for 100 samples, with each sample representing 1,000 firms and 600 months. The Newey-West t-statistics control heteroscedasticity and autocorrelation.

Panel A: Portfolios sorted by Z

	Lo	2	3	4	Hi	Hi-Lo
Mean	6.61	7.78	8.30	9.14	10.17	3.56
Std	16.94	17.08	17.16	17.24	17.45	5.67
α	-1.77	-0.67	-0.20	0.59	1.53	3.30
	(-3.61)	(-1.39)	(-0.41)	(1.24)	(3.10)	(4.14)
MKT	0.98	0.99	1.00	1.00	1.01	0.03
	(116.24)	(118.72)	(119.98)	(122.10)	(120.34)	(2.27)
R^2(%)	95.76	95.88	96.06	96.09	96.00	1.01
$\beta(X)$	0.05	0.08	0.11	0.14	0.19	0.14
	(4.44)	(7.27)	(10.00)	(12.69)	(16.57)	(9.36)
$\beta(Y)$	1.68	1.68	1.68	1.68	1.68	0.01
	(108.32)	(102.40)	(100.55)	(99.57)	(97.49)	(0.23)
$\beta(S)$	0.62	0.64	0.65	0.66	0.68	0.06
	(39.11)	(37.82)	(37.49)	(37.69)	(38.24)	(2.52)

Panel B: Portfolios sorted by A

	Lo	2	3	4	Hi	Hi-Lo
Mean	10.89	10.08	9.29	8.55	6.12	-4.77
Std	16.17	16.42	16.66	17.03	18.48	7.46
α	2.90	1.92	0.99	0.06	-2.98	-5.87
	(5.98)	(4.51)	(2.49)	(0.14)	(-5.02)	(-5.87)
MKT	0.94	0.96	0.97	1.00	1.07	0.13
	(112.06)	(130.50)	(140.52)	(144.43)	(104.12)	(7.49)
R^2(%)	95.44	96.57	97.10	97.19	94.76	8.80
$\beta(X)$	0.13	0.13	0.12	0.12	0.11	-0.02
	(21.25)	(18.59)	(16.25)	(13.30)	(7.82)	(-1.06)
$\beta(Y)$	1.68	1.68	1.68	1.68	1.68	-0.01
	(189.65)	(163.46)	(145.73)	(125.46)	(80.20)	(-0.27)
$\beta(S)$	0.36	0.46	0.55	0.66	0.96	0.60
	(39.94)	(44.63)	(46.84)	(47.67)	(44.20)	(25.75)

Figure 1: Value functions

This figure plot the value function of the total firm value (Value), the value of assets-in-place (VAP), the value of growth opportunities (VGO), and gross profitability against aggregate profitability shocks (x), aggregate investment shocks (s), idiosyncratic profitability shocks (z), and idiosyncratic investment shocks (a).