

Can Investment-specific Technology Shocks Explain the Cross-section of Stock Returns?

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Abstract

In this paper we analyze the role of capital-embodied technological shocks in explaining properties of the cross section of stock returns. Our evidence suggests that, contrary to theoretical conjectures in the literature, investment-specific shock should demand a positive risk premium. We document that the magnitude of these shocks is too small to explain cross-sectional return patterns such as the value and momentum effect and that the pricing effect of investment specific shocks are different depending on the time period used in the analysis (pre vs. post 1963). Finally, we propose an alternative testing ground of the investment-specific shock channel by analyzing the relationship of firms' capital intensity and returns. The empirical evidence we gather seems to lend little support to the hypothesis that investment-specific shocks can explain cross sectional variations in stock returns.

JEL classification: E22; G12; O30

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1 Introduction

Capital-embodied technological shocks (Solow (1960)) have been invoked by macroeconomists as important determinants of economic growth and business cycle fluctuations. More recently, financial economists have stressed their potential role in explaining properties of asset prices in both the cross section and time series.¹ The qualitative and quantitative predictions of any theory that relies on these investment-specific shocks to explain asset prices depend on the sign and magnitude of the price of risk of the investment shock. The existing theoretical literature seems to disagree on whether this risk should demand a positive or a negative price. On one hand, Papanikolaou (2011) and Kogan and Papanikolaou (2012a) argue that a *negative* price of risk is needed to explain the value premium. On the other hand, Li (2011) assumes a *positive* price of risk in order to explain the momentum effect in the cross section. Because both value and momentum co-exist in the cross section of stock returns, it is impossible that both assumptions about the sign of the price of risk of investment-specific shocks are true at the same time.

The purpose of this paper is to provide a thorough empirical analysis of the effect of investment-specific shocks on the cross section of stock returns. Our goal is to resolve the inconsistency in the literature and advance our understanding on the pricing effect of investment-specific shocks. Such an analysis is important not only for our understanding on pricing implications of investment-specific shocks, but also has direct impact on our understanding of the existing literature that does not feature such shocks (e.g., qualitative and quantitative implications of models with only capital-disembodied shocks). In other words, it helps us better understand the source of firm heterogeneity and ultimately cross-sectional return properties.

¹For example, Papanikolaou (2011) introduces investment-specific technology shocks in a two-sector general equilibrium model and derives time series and cross sectional asset pricing implications. Garleanu, Panageas, and Yu (2011) and Garleanu, Kogan, and Panageas (2011) are recent examples of asset pricing models with embodied technological changes. We review the literature in Section 2.

We focus on two well-known cross-sectional return patterns: the value premium (higher B/M firms earn higher expected returns than lower B/M firms) and the momentum effect (past winners earn higher expected returns than past losers). We choose these effects for two reasons: (i) these are the most prominent and extensively studied return anomalies in the cross-section; (ii) previous work finds opposite signs for the price of risk of the investment-specific shocks based on these two patterns. To resolve the inconsistency, we focus on these same return patterns.

We use two measures of investment-specific shocks proposed by the existing literature. The first is a measure of investment shocks based on their effect on the price of capital goods relative to consumption goods. This measure captures shocks to the cost of investment in new capital as results of capital-embodied technological shocks. The second measure is implied by the theoretical model of Papanikolaou (2011), where investment shocks are proxied by the spread between the return of firms in the investment and consumption sectors (IMC).

We first infer the *sign* and *magnitude* of the price of risk for investment-specific shocks using these two measures from 1930 to 2010. Our analysis yields the following two main results. First, investment shocks are more likely to be pro-cyclical and therefore should carry a positive price of risk *if* it is a priced risk factor. For example, if the first measure is used, the time series of investment shocks is positively correlated with both GDP growth and consumption growth. On the other hand, the second measure of investment shocks is only slightly positively correlated with consumption growth but not with GDP growth. Second, the magnitude of investment shocks is too small to explain the large cross-sectional return dispersion generated by value and momentum. As reported in Papanikolaou (2011), if the measured riskiness (volatility) of the shock to the price of new capital is used, the general equilibrium model only generates negligible value premium and IMC return spread. This also applies to partial equilibrium models. That is, if the measured new

capital price is used as the proxy for investment shocks, then the existing models can only generate negligible value premium or momentum effect. If value premium and momentum are indeed driven by differences in firms' factor loadings on investment-specific shocks then we should expect significant variations in investment rates across BM and momentum portfolios. We find that the spread in investment rate across portfolios sorted in B/M or momentum is in the order of 10% per year, a number too small to generate a return spread comparable to the magnitude of the value premium or momentum effect.

Our analysis also generates new findings that guide our further investigation in two directions. First, we document that the statistical properties of existing measures of investment-specific shocks in recent sample periods significantly differ from those in earlier sample periods. For example, the correlation of the return-based measure of investment shocks (IMC) with the value factor (HML) switches from *positive* in 1930-1962 to *negative* in 1963-2010. Papanikolaou (2011) and Kogan and Papanikolaou (2012a) infer the price of risk for investment shocks based on the B/M effect and the IMC measure only using the period of 1963-2008. This suggests that the inference of the existing studies may be sample dependent. Therefore, we extend their analysis to an earlier sample of 1930 to 1962. We find that the risk loading difference between value-growth stock portfolios on investment shocks is negative for 1963-2008, but positive for 1930-1962. Since the value premium is positive for both periods, the earlier sample implies a positive price of risk for the investment shocks, opposite to what is implied by the later sample, which is negative. If we use the full sample of 1930-2010, then the evidence based on B/M indicates that the investment-specific shocks should demand a positive price rather than a negative price, which again is consistent with our direct time series analysis above.

Second, we find a low correlation between the time series of the two measures of investment shocks, suggesting that these measures contain different information. This finding may raise some concerns regarding the use of either measure as an empirical

quantification of investment shocks. To address this concern, we propose a new testing ground for the impact of investment shocks on cross-sectional returns that relies on the use of a firm's *capital intensity*—measured as a firm's fraction of capital goods (e.g., Property, Plant, and Equipment (PPE)) in their total assets (AT)—as a firm's characteristic that can help identify firms that are more or less exposed to investment specific shocks. The rationale for this choice is that all else equal, firms with higher capital intensity (PPE/AT ratio) should have higher exposure to investment shocks and demand either high or low returns depending on the sign of the price of risk for the investment shocks. The novelty of this approach is that it does not require any specific measure of investment shocks while, at the same time providing additional evidence on the pricing effect of investment shocks.

We first ignore the potential difference in growth opportunities and simply sort returns according to capital intensity (PPE/AT). We find negligible difference between high- and low- capital intensity portfolios. This finding suggests that, if firms with different capital intensity have similar growth opportunities, investment shocks are not a priced risk. We then explicitly account for the potential heterogeneity in growth opportunities across firms. Under the null hypothesis that investment shocks can explain the cross-sectional returns sorted by B/M and past performance (momentum), both B/M and past performance are good proxies of growth opportunities. In other words, to control for growth opportunities, we only need to control either B/M or past performance. This can be done by double sorting firms in capital intensity (PPE/AT) and B/M (or momentum). This provides two testable predictions. First, controlling for growth opportunities (proxied by B/M or momentum), there is a return spread between high and low capital intensity portfolios. Second, the return spread between high and low portfolios of B/M (or momentum) is stronger for high capital intensity firms. For the first prediction, we find that the result from simple sort, i.e., no clear return pattern across capital intensity portfolios, still holds

even after we control for growth opportunities. For the second prediction, we find that the return spread between high and low B/M firms is a v-shape in capital intensity. That is, the value spread is high for either high or low capital intensity firms. On the other hand, the momentum effect has no clear pattern and very noisy across capital intensity portfolios. Both results reject the hypothesis that investment shocks can explain the cross-sectional return patterns such as value and momentum effect.

The rest of the paper is organized as follows. Section 2 briefly reviews the related literature. Section 3 describes the data sources. Section 4 presents direct analysis on the sign and magnitude of the price of risk for investment shocks using two measures of these shocks. Section 5 provide an analysis comparing the inference of the price of risk for investment shocks for two complimentary sample periods. Section 6 analyzes the effect of investment shocks on returns for firms with different investment capital intensity without using any specific measure of these shocks. Section 7 discusses how to reconcile the conflicting findings in the existing literature. Finally, Section 8 concludes.

2 Related Literature

In macroeconomics, there are two types of technological innovations that are key drivers of economic growth and fluctuation. The first is *disembodied* (or neutral) technology shocks that affect the productivity of all firms. The second is *embodied* technology shocks that affect firm's productivity only through new equipment. So it is also called investment-specific shocks since it affects firms only when they invest in new equipment. While the first type is traditionally the focus of macroeconomic models, the second type gains more interest in the recent literature. For example, Greenwood et al. (1997, 2000) and Fisher (2006) show that investment-specific shocks can account for a large fraction of growth and variations in output. Justiniano et al. (2010) also study the effect of investment shocks

on business cycles.

Given the importance of investment-specific shocks in the macro economy, it is natural to explore their effect on asset prices. Christiano and Fisher (2003) is the first to explore the implications of investment shocks for asset prices at the aggregate (i.e., equity premium). Papanikolaou (2011) is one of the first to explore the implications of investment shocks for asset prices in the cross-section of stocks. He introduces investment shocks into otherwise standard two-sector general equilibrium model. The model also generates a new proxy for the investment shocks using only financial data and available at higher frequency. Kogan and Papanikolaou (2010) utilize this proxy to estimate firms' unobservable growth opportunities. In a follow up partial equilibrium study, Kogan and Papanikolaou (2012a) explore how the investment shocks can explain the value premium in the cross-section. Kogan and Papanikolaou (2012b) also use investment shocks to explain other return patterns in cross-section associated with firm characteristics, such as Tobin's Q, past investment, earnings-price ratios, market betas, and idiosyncratic volatility of stock returns.

Other studies using investment shocks to explain asset prices include Li (2011) and Yang (2011). Li (2011) propose a rational explanation of momentum effect in the cross-section by using the investment shocks as the key risk factor. Yang (2011) use investment shocks to explain the commodity basis spread, which refers to the fact that commodities with a low basis (i.e., commodity with a low ratio of futures price to spot price) tend to have higher expected return than futures contracts written on commodities with a high basis.

More broadly, this paper is related to a large literature that uses the heterogeneity in firm's investment behavior to explain the cross-sectional returns. The traditional source of risk in the literature is the neutral productivity shocks. See for example, Berk et al. (1999) and Zhang (2005). Motivated by the fact that models with only one single source

of risk cannot explain the failure of CAPM, recent study tries to incorporate additional source of risk besides the neutral technological shocks, and the investment-specific shocks are the natural alternatives. For example, Garleanu, Kogan, and Panageas (2011) study the “displacement risk” due to innovation in a general-equilibrium overlapping-generations economy. Garleanu, Panageas, and Yu (2011) study the asset pricing implications of technological growth in a model with “small,” disembodied productivity shocks and “large,” infrequent technological innovations, which are embodied into new capital vintages. For recent literature on firm investment and asset prices, see review in Kogan and Papanikolaou (2011).

3 Data Sources

This analysis utilizes both macro-economic and financial data. The macro-economic data include price level of capital goods relative to that of consumption goods as a measure of investment shocks and growth rates in GDP or consumption as a measure of macro-economic condition. The financial data include the standard CRSP and COMPUSTAT merged data.

Specifically, to capture the idea that technological shocks affect the firm’s investment directly through the cost of capital goods, we follow Greenwood et al. (1997) and define the investment-specific shock (*Ishock*) as the drop in logs of the price deflator of investment goods relative to that of non-durable consumption goods (both from National Income and Product Accounts (NIPA) at the Bureau of Economic Analysis (BEA)). That is, for year t , the investment shock (*Ishock*) is defined as

$$Ishock_t = \log \left(\frac{P_I}{P_C} \right)_{t-1} - \log \left(\frac{P_I}{P_C} \right)_t, \quad (1)$$

where P_I is the price deflator for equipment and software of gross private domestic

investment (row 11 of NIPA table 1.1.9), and P_C is the price deflator for nondurable consumption goods (row 5 of NIPA table 1.1.9).

In addition, we follow Papanikolaou (2011) and define the return of firms producing investment (capital) goods minus the return of firms producing consumption goods (IMC) as an alternative measure of investment-specific shock. To construct this measure, we classify firms into either investment or consumption sector depending on their contribution of final product to each sector. We follow the procedure of Gomes et al. (2009) and classify each Standard Industry Classification (SIC) code into either investment or consumption sector based on the 1987 benchmark input-output accounts.² To classify firms, we use their SIC code from Compustat if available and their SIC code from CRSP otherwise.

To assess the cyclicity of the investment-specific shocks, we also measure the macroeconomic conditions using the annual growth rates of real GDP (row 1 of NIPA table 1.1.1) and different consumption measures (NIPA table 1.1.1 contains personal consumption expenditures (PCE in row 2) and nondurable goods (NDG in row 5)). In addition, we also calculate the correlation of investment shocks with the standard return factors, such as Fama-French three factors, which are available from Kenneth French's website.

We collect monthly stock returns from CRSP and annual accounting data from COMPUSTAT. The sample includes U.S. common stocks (CRSP share code of 10 or 11). In subsample analysis, we also exclude financial stocks (siccd: 6000-6999). The sample covers from Jan. 1930 to Dec. 2010. Note that for analysis using COMPUSTAT data, we mainly focus on the subsample of 1963 to 2010 due to data availability.

We are interested particularly in two well-known cross-sectional return patterns: the

²Gomes et al. (2009) provide a one to one match between SIC code and different categories of final demand, such as consumption (further classified as durables, nondurables, and service), investment, net exporter (NX), and government expenditure (G). Each industry specified by a SIC code is classified into the category of final demand to which it has the highest contribution. Their classification is available from Motohiro Yogo's website. We do not need the detailed classification within the consumption sector and we allocate the NX or G to either the investment or consumption sector depending on their contribution to these two sectors.

value and momentum. To generate these patterns, we need measures of book-to-market (B/M) and past performance (past 12-month returns). The B/M is the book-to-market ratio of equity, where historical book equity is used if the COMPUSTAT book equity is missing.³ The market value is the firm's capitalization (i.e., price \times share outstanding). Momentum is measured by past 12-month compounded returns. We require a firm to have 12 valid monthly returns to compute momentum.

Another key variable is the capital intensity, measured by the ratio of Property, Plant, and Equipment (PPE) to total book assets (COMPUSTAT items `ppent/at`). This measure captures the importance of capital goods in the firm's production. For example, a low ratio of PPE to total assets implies that the firms need less capital goods in producing their final products. Other items in the total assets besides PPE include cash, inventories, intangibles, and other non-PPE assets.

In forming portfolios, firms are sorted at the end of June according to the sorting variables. For example, the B/M used for sorting is the book equity for the fiscal year ending in $t-1$ divided by the market value at the end of December $t-1$. Similarly, the PPE/AT ratio used for sorting is PPE divided by total assets both for the fiscal year ending in $t-1$. On the other hand, the momentum sorting at the end of June t uses the returns from July $t-1$ to June t . For IMC portfolios, the sector classification is based on the SIC code from COMPUSTAT for the fiscal year ending in $t-1$ if not missing and SIC code from CRSP for June of year t otherwise. The portfolio classification is then assigned to firms in the next 12 months, from July t to June $t+1$. We calculate the value-weighted returns using the lagged market value as weight for each portfolio, and then compound the monthly portfolio returns from January t to December t to generate the annual returns of each portfolio for year t . Following the literature, we use the breakpoints of NYSE stocks only in portfolio sorting.

³The historical book equity data are downloaded from Ken French's website. The book equity is calculated as in Davis et al. (2000).

4 Analysis: Two Measures of Investment Shocks

In this section, we provide analysis on the *sign* and *magnitude* of the price of risk for the investment-specific shocks using the two alternative measures described above.

Table 1 reports summary statistics for the two measures of investment-specific shocks. For the first measure based on relative price of capital goods (Ishock), the mean and standard deviation for the full sample (1930-2010) are 0.44% and 1.56%, respectively. Note that, for the earlier subsample (1930-1962), Ishock is negative (-0.26%) with higher standard deviation (1.85%). In contrast, for the later subsample (1963-2010), the mean is higher (0.92%) but the standard deviation is lower (1.11%). When the second measure based on the return difference between firms in the investment and consumption goods sectors (IMC) is used, the mean and standard deviation for the full sample (1930-2010) are 0.70% and 13.88%, respectively. Note that, for the earlier subsample (1930-1962), IMC is positive (1.82%) with a high standard deviation (13.99%). In contrast, for the later subsample (1963-2010), the mean is negative (-0.06%) and the standard deviation is also high (13.90%). Comparing the two measures, both measures show a large change across the two periods and IMC return is much more volatile.

4.1 The Sign of the Price of Risk for Investment Shocks

To determine the sign of the price of risk for the investment shocks, we first look at the cyclical behavior of investment shocks relative to macro-economic fluctuations. For macro-economic conditions, we use both GDP growth and consumption growth. We also calculate the correlation of investment shocks with other well-known return factors, such Fama-French 3-factors. The time series correlations are reported in Table 2. Finally, we try to understand the sign and economic meaning of portfolio factor loadings on the investment shocks. The factor loadings of different portfolios from existing studies are

reproduced in Table 3 for discussion. We use two measures of investment shocks, namely, Ishock and IMC, in the next two subsections, respectively.

A. Investment Shocks – Measured by Ishock

Correlation with GDP growth

The correlation between the Ishock and the growth rate of GDP is positive for both the full sample and subsamples. Since Ishock measures the drop in the relative price of capital goods to consumption goods, this implies that the relative price of capital goods is high (i.e., investment shock is negative) in low GDP growth state. That is, the capital good price is countercyclical relative to GDP growth.⁴ Therefore, the investment shock is *pro-cyclical* relative to GDP growth.

Correlation with consumption growth

In traditional asset pricing models, assets are priced according to the correlation of their payoffs with the marginal utility of consumption. Assets with higher payoffs in states with higher marginal utility worth more and require lower expected returns. In other words, shocks that lead to payoffs that are positively correlated with marginal utility (i.e., negatively correlated with consumption growth) can hedge the consumption risk and therefore carry a negative price of risk. So, the correlation between a shock and the consumption growth is informative about the sign of the price of the risk.

Using the growth rate of nondurable consumption goods as a measure of consumption growth (same result for personal consumption expenditure), the correlation with Ishock is positive and large (above 0.3) in earlier subsample (1930-1962), and positive but small (close to zero) in later subsample (1963-2010), and positive in the full sample (1930-2010). This indicates that Ishock is positive when the growth in consumption is high. In other

⁴This is consistent with the findings in Christiano and Fisher (2003), Fisher (2006), and Greenwood et al. (2000).

words, the investment shock is *pro-cyclical* relative to consumption growth. Therefore, the correlation suggests that Ishock should carry a *positive* price of risk.

Correlation with other return factors

If the investment shocks can explain the cross-sectional return patterns such as the value premium and the momentum effect, then they should be highly correlated with the empirically successful return factors constructed from these cross-section patterns, such as Fama-French's high-minus-low (HML) value factor and the momentum factor. We find that the correlations between Ishock and Fama-French 3-factors (market excess return (MKT), SMB, and HML) are positive in the earlier subsample (1930-1962), but negative in the later subsample (1963-2010). For example, the correlation of Ishock with HML changes from 0.44 in 1930-1962 to -0.10 in 1963-2010. This indicates that Ishock is less likely to be able to explain the associated return patterns (e.g., size and B/M sorted portfolio returns in the cross-section) for both subsamples. In other words, it seems that Ishock can *at best* explain the value premium (which can be well explained by the HML factor) for only a subsample, but not for both periods. Finally, Ishock is positively correlated (with insignificant low magnitude) with the momentum factor.

Factor loadings of portfolios: the sign and economic meaning

In Kogan and Papanikolaou (2012a) the beta of stock returns of each firm (therefore also portfolios) in the consumption goods sector with respect to the investment specific shock is proportional to the weight of growth opportunities in the firm value. So this implies the betas should be all positive. Do the data support this prediction?

Papanikolaou (2011) reports (in his Table 6 and reproduced here in Table 3) the risk exposure of B/M portfolios for the sample of 1963-2008 is all negative when the price of investment goods (Ishock) is used as a measure of investment shock. A negative loading of portfolio on Ishock implies that a positive investment shock (i.e., a drop in the price

of investment goods) is a bad news for stock prices. This is counter-intuitive, but is consistent with the finding that Ishock is negatively correlated with the market factor during the later subsample in Table 2. On the other hand, Li (2011) reports that the momentum portfolio loadings on Ishock change from negative for losers to positive for winners. In other words, a positive shock to the price of investment goods is good news for winners but bad news for losers. However, intuitively, a positive investment shock should be good news for all firms.⁵

To quickly summarize, investment shocks, measured as the drop in the price of investment goods relative to consumption goods (Ishock), are *pro-cyclical* with respect to both GDP growth and consumption growth. The correlation is stronger in the earlier period and becomes weak in the recent period. In addition, the correlation between investment shocks and Fama-French's value risk factor (HML) changes sign from positive in earlier period to negative in later period. On the other hand, the correlation between investment shocks and the momentum factor is only slightly positive.

B. Investment Shocks – Measured by IMC

In Papanikolaou (2011), firms producing investment goods (investment firms) and consumption goods (consumption firms) have the same loadings on the productivity shock but have different loadings on the investment-specific shocks. Therefore, the return difference between investment and consumption firms loads only on the investment-specific shocks. Motivated by this theoretical implication, he advocates the return difference between the two sectors (IMC) as a proxy for investment-specific shocks using only financial data. Since IMC is (excess) return traded in the market, its sign will provide a direct

⁵It can be argued that a drop in capital good price is bad news for firms selling their existing capital (i.e., the price of existing assets also drops with the new capital price). However, as reported by Li (2011), the losers' portfolios have large positive investment rather than disinvestment.

implication for the sign of price of risk for the investment-specific shocks.⁶

Let's first look at the IMC returns. For value-weighted portfolios, the return spread in IMC is positive for the full sample (0.70% per year for 1930-2010) and earlier sample (1.82% per year for 1930-1962), but is negative for the later sample (-0.06% per year for 1963-2010).⁷ Note that dropping two years (2009 and 2010) or adding one year (1962) changes the magnitude dramatically: value-weighted return spread is -0.81% per year in 1963-2008 and is -0.97% per year in 1962-2008.⁸

Therefore, IMC seems to earn a positive return rather than a negative return in the full sample. This implies that the price of risk for IMC is more likely to be positive. The fact that the IMC return changes sign over the two periods calls for caution when interpreting results using only the later sample.

Since IMC proxies for the investment shock, we can infer the correlation of investment shocks with other time series by using IMC returns.

Correlation with GDP growth

As reported in Table 2, IMC is basically uncorrelated with GDP growth. The correlation is -0.06 for 1930-1962, 0.02 for 1963-2010, and -0.02 for 1930-2010. In other words, IMC does not show any significant cyclical behavior relative to GDP growth.

Correlation with consumption growth

The correlation with consumption growth, using either personal consumption expenditure (PCE) or nondurable goods (NDG), is always positive. But the correlation level is low with PCE, and is slightly stronger with NDG. So it suggests that investment shocks are

⁶If we require the investment-specific shocks to explain perfectly the IMC return, then the risk premium for the investment shock should be the average IMC return.

⁷For equal-weighted portfolios (not reported in Table 1), the return spread in IMC is always positive for either the full sample or the subsamples. The sample average is 1.42% for 1930-1962, 1.98% for 1963-2010, and 1.75% for 1930-2010.

⁸Papanikolaou (2011) reports in his Table 3 that IMC return is -1.41% for 1962-2008. But Kogan and Papanikolaou (2012a) reports in their Table 3 that IMC return is -1.9% for 1963-2008. Our results have the same sign but slightly smaller spread in returns.

pro-cyclic relative to consumption growth even though the level of correlation is low.

Correlation with other return factors

IMC is positively correlated with market excess return (MKT) and SMB. The correlation between IMC and HML flips sign from earlier subsample to later subsample: it is positive (0.38) in 1930-1962, but negative (-0.48) in 1963-2010. The correlation between IMC and momentum factor is -0.41 in 1930-1962, and 0.15 in 1963-2010. This indicates that IMC shows different correlations in two periods with either HML or momentum. This calls for particular caution when using IMC to explain the value premium in the later subsample. In addition, IMC is only slightly positively correlated with Ishock in 1930-1962. The correlation becomes negative (-0.02) in 1963-2010. The two are uncorrelated in the full sample.⁹

Factor loadings of portfolios: the sign and economic meaning

Papanikolaou (2011) reports in his Table 6 the risk exposure of B/M portfolios is mostly positive (with only two small negatives) if the IMC is used as an alternative measure of investment shock. Kogan and Papanikolaou (2012a) report all positive risk exposures. This is in sharp contrast to the all negative risk exposure of these same portfolios to Ishock. This implies that IMC contains quite different information from the price of investment goods (Ishock). What really drives IMC spread is an important research topic that we leave for future exploration.

To quickly summarize, investment shocks, proxied by the return difference between firms in investment and consumption sectors (IMC), do not show any cyclical behavior with respect to GDP growth but are pro-cyclical relative to consumption growth. IMC is positively correlated with market factor (MKT) and SMB. On the other hand, the correlation between investment shocks and value risk factor (HML) changes sign from positive

⁹Kogan and Papanikolaou (2012a) reports that IMC and Ishock are positively correlated with a correlation of 0.223 in 1963-2008. Our calculation gives a correlation of only 0.06 during the same period. Note that adding two more years (2009 and 2010), the correlation becomes negative (-0.02).

in earlier period to negative in later period. Similarly, IMC is negatively correlated with the momentum factor in the earlier subsample, but uncorrelated in the later subsample. In addition, the risk loadings of B/M portfolios on IMC are mainly positive, contrast to the negative loadings on *Ishock*.

4.2 The Magnitude of the Price of Risk for Investment Shocks

In this section, we try to extract the information from prior research regarding the magnitude of the price of risk for the investment shocks. Specifically, we will compare the price of risk implied by the general equilibrium (GE) model of Papanikolaou (2011) using the measured investment shocks from the data with the calibrated price of risk for the investment shocks in the literature under a partial equilibrium (PE). Finally, as an alternative, we take the difference in firm's investment rates in the data as given and provide a simple calculation for the required magnitude of investment shocks such that the cross-sectional returns can be explained.

A. Implied Price of Risk for Investment Shocks in General Equilibrium

Investment shocks: Ishock

Let's first look at the implied risk premium in the GE model when using the investment goods price as a measure of investment shocks with extra quality adjustment. In the calibration section, Papanikolaou (2011) explores different values for the standard deviation of investment shock. In the data, it is roughly 3.5% (if quality adjusted price is used, otherwise, it is only about 1.5% or lower as we report in Table 1). In his Table 3, different parameter values for investment shock are used in calibration. If the volatility of investment shock is low (Alternate 1: 4.5%), the model generates only a tiny risk premiums for market (0.3%), IMC (-0.1%), value-growth (0.18%); and the corresponding return volatilities are also much lower than the data.

According to his model (under realistic value for the standard deviation for the investment shock of 4.5%), the IMC return is only -0.1%, with standard deviation of 2%. So the GE implied price of risk for investment shock is $-0.1/2=-0.05$. If lower standard deviation of the investment shock is used in the calibration, then the price of risk should be even lower than -0.05.

Investment shocks: IMC

Papanikolaou (2011) reports that in the data IMC return is -1.41% with a standard deviation of 10.96%. So if the investment-specific shocks price the IMC portfolio perfectly, then the price of risk for the investment-specific shock should be $-1.41/10.96=-0.13$. The model generates IMC return of -0.68% with standard deviation of 5.8%, which implies a price of risk of $-0.68/5.8=-0.12$. This high value of price of risk in the model (i.e., the benchmark model relative to Alternate 1 in Table 3 of Papanikolaou (2011)) is a result of assuming a high volatility of the investment shock (by adding extra volatility to the capital good price).

B. Calibrated Price of Risk for Investment Shocks in Partial Equilibrium

In Kogan and Papanikolaou (2012a), if the risk premium for investment shock is set at the average return of IMC, then the price of risk should be $-0.019/0.112=-0.17$. But the calibrated value is -0.35, more than 2 times larger. In Kogan and Papanikolaou (2012b), the calibrated price of risk for investment shock is -0.57, so even bigger. In Yang (2011), the calibrated price of risk is -12!

In Li (2011) the empirical standard deviation of I shock is 1.55%, so setting it to 20% significantly magnifies the importance of investment shocks in the cross-section. The price of risk for the investment shock is $20 \times 0.2=4$!

C. Required Magnitude of Investment Shocks

Now, let's step out of any theoretical details featured in the existing models. Instead, let's have some very simple calculations to get an idea regarding the economic importance (i.e., in terms of magnitude) of investment shocks on cross-sectional return patterns.

If the cross-sectional return difference is indeed driven by the difference in their loadings on investment-specific shocks, then it should manifest in the investment rate (i.e., growth opportunities) directly. However, the investment rate difference across portfolios sorted by variable of interest is relatively small. For example, B/M portfolios generate investment difference of only 4%. To generate return difference of order 5%, it requires that investment shocks can generate investment cost difference in the order of 125%, which is highly unrealistic. A similar argument holds for momentum portfolios: it is highly unrealistic that an investment difference of only 10% generates return difference of magnitude of 8%.

Even if different firms have different loadings on investment cost, the raw level of investment rate of portfolios is in the order of 20%. This translates into a required shock to generate cost difference of 25% to produce a return difference of 5%. If investment goods (e.g., PPE) only account 50% of the firm's total book assets, then the required difference in cost is 50%. This is still unreasonably high comparing to the data.

The only possible way to reduce the required magnitude of investment shocks but still produce the observed magnitude of return spread is by introducing extreme discount factors: that is, discount cash flows in different states very differently. This translates into extreme discount factors (such as an extreme price of risk). This provides an intuitive explanation of why the calibrated price of risk for investment shocks in the existing literature is so large in magnitude.

5 Robustness Analysis: The Case of Two Periods

The analysis above generates two main findings of the paper: (i) the investment-specific shocks are likely to demand a positive price of risk, and (ii) the magnitude of these shocks are too small to explain the large cross-sectional return dispersions such as value and momentum. In addition, the analysis also uncovers two important issues. First, there likely is a structural break of the pricing effect of investment shocks. Second, the two measures of investment shocks contain different information. To address the first issue of potential structural break, in this section we provide a robustness analysis by breaking the full sample into two. We address the second issue in the next section.

Separating the full sample into two serves two purposes. First, we would like to document the empirical facts across these two sample periods, especially the potential structural break of the pricing effect of the investment shocks. Second, such an analysis also helps us better understand the results from existing studies. For example, the sign of the price of risk for the investment shocks as in the theoretical model of Papanikolaou (2011) depends on the model parameters, such as risk aversion and elasticity of intertemporal substitution (EIS). To explain the value premium in the recent sample (e.g., post-1963 sample), the model can generate the required sign (negative) for the price of investment shocks by choosing an EIS of smaller than one. Note, however, under an EIS of greater than one, the model may generate a positive price of risk for investment shocks.¹⁰ In addition, the model-based measure of investment shocks (i.e., IMC) may empirically capture other information besides the investment shocks. Therefore, it is important that we provide additional analysis by using an earlier sample that is complimentary to the sample used in the previous studies.

¹⁰More precisely, Papanikolaou (2011) finds that an EIS smaller than the inverse of the coefficient of risk aversion guarantees a negative risk premium for the investment shocks. However, for higher EIS, the sign of the risk premium of the investment shocks is ambiguous and can be positive. This is in stark contrast to Bansal and Yaron (2004), which features an EIS of larger than one in a long-run risk model to explain the equity premium.

We provide such an out-of-sample analysis to Papanikolaou (2011) and Kogan and Papanikolaou (2012a) by using an earlier sample of 1930-1962, during which B/M measure is still available. They use IMC as a measure of investment shocks and infer the price of risk for these shocks from the cross-section of B/M sorted portfolios for the sample period of 1963-2008. We follow their procedure. Specifically, we sort stocks into B/M decile portfolios at the end of every June. The portfolio ranking is assign to the firms in the next 12 months. Then for each B/M portfolio, we calculate the value weighted returns for each month, and then compound the monthly returns within a calendar year to construct our annul return measure. We then use this annual return time series to estimate the risk loadings of each portfolio on investment shocks, proxied by both Ishock and IMC. To be consistent with Kogan and Papanikolaou (2012a), we use only non-financial firms in the consumption sector in constructing the B/M portfolios. The results are qualitatively the same if we use all firms or non-financial firms.

Table 4 shows the results for different sample periods. Let's first look at the 1963-2010 sample. The return spread between value and growth portfolios is 5.7% per year. The univariate betas on investment shocks are decreasing from growth to value portfolios. The betas for the high-minus-low portfolio are -4.02 (Ishock Beta) and -0.14 (IMC Beta). A positive value premium and negative loadings on investment shocks imply a negative price of risk for these shocks. This is consistent with and confirms the findings in Papanikolaou (2011) and Kogan and Papanikolaou (2012a).

We then look at the earlier sample of 1930-1962. The return spread between value and growth portfolios is 8.9% per year, which is higher than that of the later sample. Note that the univariate betas are increasing from growth to value portfolios. Specifically, the betas for the high-minus-low portfolio are 7.26 (Ishock Beta) and 1.46 (IMC Beta). Given that the value premium is still positive during this period, positive loadings on investment shocks imply a positive price of risk for these shocks. This is exactly the opposite to the

inference from the later sample.

The result using the full sample of 1930-2010 is qualitatively similar to the earlier sample. That is, the value premium and univariate betas of high-minus-low B/M portfolio on investment shocks are all positive. This indicates that despite of the shorter time period the earlier sample has a stronger effect on the full sample. Therefore, the full sample also implies a positive price of risk for investment shocks.

To summarize our analysis in this section, we find that the inference on the price of risk for investment shocks changes sign from positive in the earlier or full sample to negative for the later sample. Therefore, we need to exert caution in interpreting the mechanism proposed to explain the data only in the later sample.

6 Robustness Analysis: Heterogeneity in Capital Intensity

As discussed above, our earlier analysis reveals that the two measures of investment shocks are not correlated and therefore contain different information. In this section, we provide a novel cross-sectional analysis that is independent of any empirical measure of investment shocks. Specifically, we test the pricing effect of investment shocks by taking into account their heterogeneous impact on firms with different capital intensity. In other words, we use the heterogeneity in capital intensity as a new testing dimension to eliminate the necessity of choosing specific measure of investment shocks.

The idea is as follows. For two firms with different capital intensity (proxied by PPE/AT ratio), all else equal, the investment shocks are more important for high capital intensity firms as these firms need to invest more in capital (PPE) to generate a given growth in total assets (equivalently in total sales). For example, if two firms have capital intensity of 40% and 80% respectively, then they have to invest in PPE of 40% and 80%

of their total assets respectively in order to double their total assets or sales. Therefore, high capital intensity firms have higher exposure to investment shocks if all firms have the same total growth opportunities (in assets or sales). If the price of investment shocks is negative (positive), high capital intensity firms should have lower (higher) returns. This leads to our first prediction based on capital intensity:

Prediction 1 *All else equal, investment shocks are more important for firms with higher capital intensity. Therefore, we should observe a capital intensity premium with the same sign as the price of risk for investment shocks.*

Note, however, two firms with different capital intensity may also have different total growth opportunities (in total assets or sales). For example, if two firms have capital intensity of 40% and 80% respectively, and total growth opportunities of 100% and 50% respectively, then they invest a same fraction of their total assets (40%) in PPE. Therefore, it is important to control for growth opportunities when assessing the impact of investment shocks on the cross-section of stock returns. The null hypothesis that the investment shocks can explain the value or momentum through firm's investment in new capital provides a natural way of controlling for growth opportunities. Since the investment shocks affect stock prices through their impact on the cost of firm's investment in new capital goods (PPE), firms with different growth opportunities will have different exposure to investment shocks. If investment shocks generate return patterns such as value and momentum, then firms sorted in these characteristics (B/M and past performance) should have different total growth opportunities. In other words, firm characteristics such as B/M ratio and past performance are natural proxies of firm's total growth opportunities under the null hypothesis.

We then have the following new prediction regarding the return spread across firms with different capital intensity.

Prediction 2 *We should observe a capital intensity premium after controlling for growth opportunities (proxied by B/M or momentum). The premium has the same sign as the price of risk for the investment shocks.*

Similar, we have the following prediction regarding the existing return patterns in the cross section.

Prediction 3 *If the assumed sign of the price of risk for investment shocks is correct, then the value or momentum effect for firms with higher capital intensity should be stronger than that of firms with lower capital intensity.*

If high capital intensity firms have stronger return pattern than low capital intensity firms, then the assumed price of risk has the *correct* sign. And the difference will provide information regarding the magnitude of the price of risk for the investment shock. If there is no difference, the investment shock is *not* priced! If the pattern is weaker, then the assumed price of risk has the *wrong* sign, and again, the difference will provide information regarding the magnitude of the price of risk for the investment shock.

Since the capital intensity is constructed by using accounting data on capital investment (PPE) and total assets (AT), we focus the analysis in this section to the later sample of 1963-2010 due to data availability.

6.1 Simple Sorting

To test the first prediction, we use simple sorting in this section. We first confirm the standard B/M and momentum effect in our sample. Then we test our first prediction by sorting firms in capital intensity.

A. Simple Sort on B/M and Momentum

Table 5 reports the returns for B/M sorted deciles. The return spread between high- and low-B/M deciles is 7.4% (t=2.46) for all firms, 6.9% (t=2.43) for non-financial firms, and 5.7% (t=1.91) for non-financial and consumption firms (i.e., non-financial firms in the consumption sector).

Table 6 reports the returns for momentum sorted deciles. The return spread between high and low past 12-month return deciles is 10.2% (t=3.38) for all firms, 8.3% (t=2.58) for non-financial firms, and 7.4% (t=2.33) for non-financial and consumption firms.

These results are consistent with the prior literature that the cross-section of stock returns shows a significant positive value and momentum premium.

B. Simple Sort on Capital Intensity

Table 7 report returns for capital intensity (PPE/AT ratio) sorted deciles. Note that returns across these portfolios are relative flat and the return difference between high and low capital intensity portfolios is insignificant and close to zero. This is true for all the three samples of firms that we consider. So the data fail to show any significant capital intensity premium. This result rejects Prediction 1.

6.2 Double Sorting

If firms have similar total growth opportunities across capital intensity portfolios, then the above result indicates that investment shocks have no significant impact on expected returns. In other words, investment shocks are not priced in the cross-section of stock returns sorted by capital intensity. One potential concern is that these portfolios may have different growth opportunities, which makes the inference more difficult. In this section, we control for growth opportunities by double sorting firms in capital intensity and B/M (or momentum).

A. Double Sort Firms on B/M and Capital Intensity

Table 8 reports capital intensity premium (the return spread between high and low capital intensity quintiles) for firms with different B/M ratios using independent double sort. Comparing to the simple sort in Table 7, the capital intensity premium is all negative for a given B/M ratio quintile. Although the sign is consistent with a negative price of risk for investment shocks, none of the return spread is statistically significant. Note that the capital intensity premium is relatively stronger for firms with medium B/M ratios, rather than for high B/M firms as the existing theory would suggest. This rejects Prediction 2 when B/M is used to control for growth opportunities.

Table 9 reports value premium (the return spread between high and low B/M quintiles) for firms with different capital intensity (PPE/AT ratio) using independent double sort. Note first that the value spread is non-monotonic in capital intensity. For the sample using all firms, value premium is high for both low and high capital intensity firms, but low for firms with moderate capital intensity ratios. In other words, the value premium shows a v-shape cross capital intensity quintiles. This pattern holds for subsamples using either only non-financial firms or only non-financial and consumption firms. In the case of non-financial and consumption firms, value premium is high for capital intensity quintiles 1, 4, and 5. The middle quintiles 2 and 3 have much lower (and insignificant) value premium. This suggests that the value premium is less likely driven by the investment shocks. This rejects Prediction 3 for the value premium.

B. Double Sort Firms on Momentum and Capital Intensity

Table 10 reports capital intensity premium (the return spread between high and low capital intensity quintiles) for firms with different past 12-month returns using independent double sort. Comparing to the simple sorting in Table 7, the capital intensity premium is positive in momentum quintiles 1 (low) and 2, but negative in momentum quintiles 3

and 4 and 5 (high). Although the sign for the two quintiles with low past performance is consistent with a positive price of risk for investment shocks, the sign for the three quintiles with high past performance is consistent with a negative price of risk for investment shocks. The mixed inference on the sign of price of risk for investment shocks indicates that investment shocks are less likely the driving force of momentum effect in the cross-section. This rejects Prediction 2 when past performance is used to control for growth opportunities.

Table 11 reports momentum premium (the return spread between past winners and losers quintiles) for firms with different capital intensity (PPE/AT ratio) using independent double sort. Note that the momentum spread is also non-monotonic in capital intensity. For the sample using all firms, value premium is high for capital intensity quintiles 1, 2, and 4, but low for firms in capital intensity quintiles 3 and 5. It is worth pointing out that the momentum premium even turns negative for firms with highest capital intensity. This pattern holds for subsamples using either only non-financial firms or only non-financial and consumption firms. This suggests that the momentum premium is also less likely to be driven by the investment shocks. This rejects Prediction 3 for the momentum premium.

To summarize the analysis in this section, the empirical evidence finds little support for the hypothesis that investment shocks can explain the value and momentum effect. This finding is based on the later sample of 1930-2010 and is independent of any specific measure of investment shocks.

7 Discussions

From the above analysis, the take away message is that the investment-specific shock seem too small in magnitude to explain the well-known return patterns in the cross-

section. In addition, we also find a structural break for the two periods (separated by year 1963) in terms of inference on the sign of the price of risk for investment shocks. More important, contrary to the existing literature, our analysis of firms with heterogeneous capital intensity (PPE/AT ratio) finds little support for the hypothesis that investment shocks can explain the cross-sectional return patterns such as value and momentum effect.

As we mentioned in the Introduction, Papanikolaou (2011) and Kogan and Papanikolaou (2012a) argue that a positive price of risk for investment shocks can explain the value premium. On the other hand, Li (2011) finds that a positive price of risk for investment shocks can explain the momentum premium. In this section, we try to reconcile the inconsistency between these studies as well as between theirs and ours.

Let's first look at the case of Li (2011), who measures investment-specific shocks directly using the relative price of capital goods (Ishock). From results reported in his paper, the assumed volatility of investment shock in the model is 10 times larger than observed in the data, and the calibrated price of risk is too high. Put it in other way, if his model assumes comparable volatility of investment shocks to the data, and the price of risk for the investment shock is set to the empirical estimate of 2.67% per unit of beta in the data (in his model: 80%), then it will generate insignificant (if any) momentum effect. In other words, the results of Li (2011) are generated by unrealistic and inflated input for the investment specific shocks. Put it differently, the model of Li (2011) can generate a positive but insignificant price of risk for the investment shock under reasonable model parameters. This is broadly consistent with our findings.

Now, let's turn to papers in the same line as Kogan and Papanikolaou (2012a), which use mainly the model implied proxy of investment-specific shocks (IMC). As we discussed already, IMC contains different information from the conventional measure of investment shocks based on relative price of capital goods. Therefore, there is an additional layer between the empirical analysis and the theoretic model, which makes inference especially

difficult. So even if we find empirical relationship of returns with the proxy IMC, it does not necessarily validate the theory. For example, we find the inference from the earlier sample is exactly the opposite to that from the latter sample. In addition, our analysis without using any specific measure of investment shocks indicates that even the inference from the later sample may be misguided. Equally important, if the price of risk is set at a reasonable level that is consistent with the direct empirical evidence, then the model of Kogan and Papanikolaou (2012a) will not be able to generate significant value premium in the cross-section. This is also broadly consistent with our findings.

We would like to point out that it is interesting to extend the analysis to other cross-sectional return patterns, such as these included in Kogan and Papanikolaou (2012b). We will leave that to future research.

8 Conclusion

This paper finds that the price of risk for the investment-specific shocks is more likely to be positive in the long sample, *if* it is a priced factor. But investment shocks are too small to explain the large cross-sectional return patterns. In addition, there is a structural break for the two periods separated around 1963 for the sign of the price of risk for the investment shocks. This makes it especially difficult to use a single story to explain the effect of investment shocks on the cross-sectional returns for both periods.

In terms of magnitude, we find that the risk premium related to investment shocks is really small, if there is any. A novel empirical test which takes into account the heterogeneity in firm's capital intensity without specifying any explicit measure of investment shocks does not detect any significant risk premium for these shocks. That is, our analysis fails to identify any statistically significant risk premium related to the investment-specific shocks in the cross-sectional returns.

Our findings challenge the small but growing literature that uses investment-specific shocks as the main source of risk to explain cross-sectional return patterns. It also calls for further study on the sources of firm heterogeneity related to investment that generates cross-sectional return patterns.

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Table 1: Summary Statistics.

This table reports summary statistics for the two measures of investment-specific shocks for different sample periods. Ishock is based on the relative price of capital goods to consumption goods. IMC is the return spread between firms in investment and consumption goods sectors. Both measures are in annual frequency. The reported statistics are mean, standard deviation (stdev), standard error of the mean (stderr), minimum (min), median (med), and maximum (max).

Sample Period	mean	stdev	stderr	min	med	max
Panel A: Ishock						
1930-1962:	-0.0026	0.0185	0.0032	-0.0447	-0.0026	0.0465
1963-2010:	0.0092	0.0111	0.0016	-0.0275	0.0091	0.0303
1930-2010:	0.0044	0.0156	0.0017	-0.0447	0.0065	0.0465
Panel B: IMC						
1930-1962:	0.0182	0.1399	0.0244	-0.1285	0.0046	0.6224
1963-2010:	-0.0006	0.1390	0.0201	-0.2361	-0.0129	0.4483
1930-2010:	0.0070	0.1388	0.0154	-0.2361	0.0032	0.6224

Table 2: Correlation of Investment Shocks with other Time Series.

This table reports correlation of investment-specific investment shocks with growth rates of output and consumption and return factors for different sample periods. It also reports the correlation between the two alternative measures of investment shocks. All measures are in annual frequency. Panel A and B report results for Ishock and IMC, respectively. GDP is the real gross domestic product, PCE is personal consumption expenditures, NDG is the nondurable goods. The return factors include Fama-French 3-factors (MKT, SMB, HML) and the momentum factor (MOM). Note that the momentum portfolios (quintiles) are formed at the end of June in year t by using the returns from July t-1 to June t. The breakpoints are based on NYSE stocks. The portfolio ranks are then assigned to firms in July t to June t+1. The momentum factor is constructed as the annual return difference between winners (top quintile) and losers (bottom quintile). To ensure all the measures are contemporaneous, all the annual return factors correspond to a calendar year (i.e., from Jan. to Dec.). Numbers in bold font are significant at 10% level, and numbers in italic-bold font are significant at 5% level.

Sample Period	Output Growth	Consumption Growth		Return Factors				Investment Shocks
	GDP	PCE	NDG	MKT	SMB	HML	MOM	Ishock
Panel A: Ishock								
1930-1962:	<i>0.64</i>	0.33	0.32	<i>0.40</i>	<i>0.41</i>	<i>0.44</i>	0.07	1.00
1963-2010:	0.21	0.01	0.04	<i>-0.37</i>	<i>-0.27</i>	-0.10	0.13	1.00
1930-2010:	<i>0.46</i>	<i>0.24</i>	0.22	0.05	0.06	0.19	0.17	1.00
Panel B: IMC								
1930-1962:	-0.06	0.07	0.13	<i>0.62</i>	<i>0.53</i>	<i>0.38</i>	<i>-0.41</i>	0.06
1963-2010:	0.02	0.04	0.14	<i>0.28</i>	<i>0.29</i>	<i>-0.48</i>	0.15	-0.02
1930-2010:	-0.02	0.05	0.12	<i>0.44</i>	<i>0.39</i>	-0.12	-0.13	-0.01

Table 3: Portfolio Factor Loadings (betas) on Investment Shocks.

The results in this table are reproduced from existing studies. Panel A is from Table 6 in Papanikolaou (2011) for the annual sample of 1963-2008. Panel B is from Table 9 in Li (2011) for the annual sample of 1930-2009. Note that Δz^I corresponds to *Ishock* in this paper. R_{IMC} is the return spreads for IMC (investment minus consumption).

	Low	2	3	4	5	6	7	8	9	High	High-Low
Panel A: B/M portfolios											
Δz^I	-2.36	-2.14	-2.41	-2.60	-2.47	-3.38	-3.05	-3.30	-3.62	-3.35	-0.99
R_{IMC}	0.38	0.23	0.23	0.23	0.05	0.06	-0.00	-0.05	0.02	0.19	-0.19
Panel B: Momentum portfolios											
<i>Ishock</i>	-2.97	-1.60	-1.77	-1.34	-0.17	-0.23	0.47	1.01	0.97	1.58	4.54

Table 4: Returns and Risk Exposures of B/M Portfolios on Investment Shocks.

This table reports returns and risk exposures for B/M sorted deciles for three different sample periods. Our sample includes non-financial firms in the consumption sector following Kogan and Papanikolaou (2012a). The portfolios are formed at the end of June in year t by using book equity for the fiscal year-end in year $t-1$, market equity in December $t-1$. The ranking uses NYSE breakpoints. The portfolios are then held from July t to June $t+1$. The annual returns are based on portfolio returns in a calendar year (i.e., Jan. to Dec.). The table reports the average excess returns (in percentage) relative to risk-free rate (Mean) and univariate betas relative to *Ishock* and IMC returns. It also reports the spread between high and low deciles and its corresponding t-statistics.

B/M Portfolio	Low	2	3	4	5	6	7	8	9	High	High-Low	t-stat
Panel A: 1930-1962												
Mean Return:	9.0	9.4	8.8	10.1	10.2	13.8	14.1	13.1	12.8	17.8	8.9	1.48
Ishock Beta:	4.44	2.61	3.78	7.50	6.68	9.14	6.61	7.73	7.58	11.70	7.26	2.37
IMC Beta:	0.81	0.55	0.78	1.23	1.07	1.70	1.10	1.27	1.37	2.27	1.46	4.11
Panel B: 1963-2010												
Mean Return:	5.6	5.5	7.8	6.1	6.0	8.3	8.9	9.1	10.1	11.3	5.7	1.91
Ishock Beta:	-6.10	-6.17	-5.21	-5.14	-5.76	-6.70	-8.07	-9.36	-10.01	-10.12	-4.02	-1.51
IMC Beta:	0.13	0.05	0.03	-0.02	0.15	0.12	-0.10	0.03	-0.05	-0.02	-0.14	-0.65
Panel C: 1930-2010												
Mean Return:	7.0	7.1	8.2	7.7	7.7	10.5	11.0	10.7	11.2	14.0	7.0	2.33
Ishock Beta:	0.80	-0.31	0.98	2.73	2.06	3.02	1.22	1.60	1.49	3.31	2.51	1.31
IMC Beta:	0.40	0.25	0.32	0.49	0.52	0.76	0.39	0.53	0.53	0.92	0.52	2.46

Table 5: BM Sorted Portfolios.

This table reports returns (in percentage) for B/M sorted deciles for the period of 1963-2010. The portfolios are formed at the end of June in year t by using book equity for the fiscal year-end in year $t-1$, market equity in December $t-1$. The ranking uses NYSE breakpoints. The portfolios are then held from July t to June $t+1$. The annual returns are based on portfolio returns in a calendar year (i.e., Jan. to Dec.). The table reports three samples of firms: all firms, non-financial firms, and non-financial consumption firms. It also reports the return spread between high and low deciles and its corresponding t -statistics.

	Low	2	3	4	5	6	7	8	9	High	High -Low	t- stat
All firms:	10.2	11.5	11.6	11.6	12.1	13.3	14.0	14.2	15.4	17.6	7.4	2.46
Non-financial firms:	10.3	11.5	11.9	11.4	12.1	13.9	13.9	14.3	15.5	17.2	6.9	2.43
Non-financial, consumption firms:	11.1	11.0	13.3	11.6	11.4	13.8	14.3	14.5	15.6	16.7	5.7	1.91

Table 6: Momentum Sorted Portfolios.

This table reports returns (in percentage) for momentum sorted deciles for the period of 1963-2010. The portfolios are formed at the end of June in year t by using compounded returns from July $t-1$ to June t . The ranking uses NYSE breakpoints. The portfolios are then held from July t to June $t+1$. The annual returns are based on portfolio returns in a calendar year (i.e., Jan. to Dec.). The table reports three samples of firms: all firms, non-financial firms, and non-financial consumption firms. It also reports the return spread between high and low deciles and its corresponding t -statistics.

	Low	2	3	4	5	6	7	8	9	High	High -Low	t- stat
All firms:	7.0	10.4	11.2	11.5	11.2	11.4	11.4	13.0	14.5	17.1	10.2	3.38
Non-financial firms:	9.1	10.6	11.4	12.2	10.5	12.0	11.4	12.3	14.2	17.4	8.3	2.58
Non-financial, consumption firms:	9.7	11.2	11.7	12.3	11.1	11.7	11.8	11.8	14.1	17.1	7.4	2.33

Table 7: PPE/AT Sorted Portfolios.

This table reports returns (in percentage) for PPE/TA sorted deciles for the period of 1963-2010. The portfolios are formed at the end of June in year t by using property, plant, and equipment-net total (PPENT) and book assets-total (AT) for the fiscal year-end in year $t-1$. The ranking uses NYSE breakpoints. The portfolios are then held from July t to June $t+1$. The annual returns are based on portfolio returns in a calendar year (i.e., Jan. to Dec.). The table reports three samples of firms: all firms, non-financial firms, and non-financial consumption firms. It also reports the return spread between high and low deciles and its corresponding t -statistics.

	Low	2	3	4	5	6	7	8	9	High	High -Low	t- stat
All firms:	11.3	12.4	12.2	13.2	12.1	11.5	12.3	11.5	11.6	12.1	0.8	0.31
Non-financial firms:	11.5	12.1	13.6	13.4	11.8	11.2	11.5	11.8	11.7	12.0	0.4	0.13
Non-financial, consumption firms:	11.5	13.2	14.0	12.4	12.7	12.3	12.2	12.4	11.3	11.3	-0.3	-0.08

Table 8: PPE/AT Premium for Firms with Different B/M Ratio.

This table reports PPE/AT premium (return spread between high PPE/AT quintile and low PPE/AT quintile) for firms with different B/M ratio for the period of 1963-2010. Firms are double sorted independently into B/M quintiles and PPE/AT quintiles. The portfolios are formed at the end of June in year t by using book equity, market equity, property, plant, and equipment-net total (PPENT), and book assets-total (AT) all for the fiscal year-end in year $t-1$. The ranking uses NYSE breakpoints. The portfolios are then held from July t to June $t+1$. The annual returns (in percentage) are based on portfolio returns in a calendar year (i.e., Jan. to Dec.). The table reports three samples of firms: all firms, non-financial firms, and non-financial consumption firms. It also reports the t -statistics for PPE/AT premium.

Samples	B/M Ranking	Low	2	3	4	High
All firms:	HML(PPE/AT) Return	-0.4	-1.4	-2.5	-0.1	-1.6
	t-stat	-0.21	-0.57	-1.01	-0.02	-0.54
Non-financial firms:	HML(PPE/AT) Return	-0.8	-0.5	-2.4	-0.4	-2.6
	t-stat	-0.32	-0.19	-0.91	-0.12	-0.81
Non-financial consumption firms:	HML(PPE/AT) Return	-2.6	-3.4	-4.7	-1.0	-1.4
	t-stat	-0.99	-1.04	-1.67	-0.23	-0.40

Table 9: Value Premium for Firms with Different PPE/AT Ratio.

This table reports value premium (return spread between high B/M quintile and low B/M quintile) for firms with different PPE/AT ratio for the period of 1963-2010. Firms are double sorted independently into B/M quintiles and PPE/AT quintiles. The portfolios are formed at the end of June in year t by using book equity, market equity, property, plant, and equipment-net total (PPENT), and book assets-total (AT) all for the fiscal year-end in year $t-1$. The ranking uses NYSE breakpoints. The portfolios are then held from July t to June $t+1$. The annual returns (in percentage) are based on portfolio returns in a calendar year (i.e., Jan. to Dec.). The table reports three samples of firms: all firms, non-financial firms, and non-financial consumption firms. It also reports the t-statistics for value premium.

Samples	PPE/AT Ranking	Low	2	3	4	High
All firms:	HML(B/M) Return	8.7	12.1	4.7	4.4	7.5
	t-stat	2.53	3.00	1.60	1.71	2.95
Non-financial firms:	HML(B/M) Return	8.7	10.6	3.1	6.0	6.8
	t-stat	2.92	2.38	1.00	2.16	2.42
Non-financial consumption firms:	HML(B/M) Return	7.0	2.7	2.4	7.1	8.4
	t-stat	2.24	0.75	0.78	2.47	2.85

Table 10: PPE/AT Premium for Firms with Different Past Returns.

This table reports PPE/AT premium (return spread between high PPE/AT quintile and low PPE/AT quintile) for firms with different past returns (momentum) for the period of 1963-2010. Firms are double sorted independently into momentum quintiles and PPE/AT quintiles. The portfolios are formed at the end of June in year t by using property, plant, and equipment-net total (PPENT), and book assets-total (AT) for the fiscal year-end in year $t-1$, and compounded return from July $t-1$ to June t as a measure of past performance. The ranking uses NYSE breakpoints. The portfolios are then held from July t to June $t+1$. The annual returns are based on portfolio returns in a calendar year (i.e., Jan. to Dec.). The table reports three samples of firms: all firms, non-financial firms, and non-financial consumption firms. It also reports the t-statistics for PPE/AT premium.

Samples	Momentum Ranking	Low	2	3	4	High
All firms:	HML(PPE/AT) Return	6.9	1.8	-2.7	-2.3	-2.4
	t-stat	2.37	0.73	-1.19	-0.99	-0.82
Non-financial firms:	HML(PPE/AT) Return	6.7	3.3	-2.8	-2.3	-2.2
	t-stat	1.95	1.44	-0.96	-0.89	-0.69
Non-financial consumption firms:	HML(PPE/AT) Return	9.8	1.0	-0.9	-5.9	-3.4
	t-stat	3.02	0.37	-0.31	-2.30	-1.00

Table 11: Momentum Premium for Firms with Different PPE/AT Ratio.

This table reports momentum premium (return spread between high past return quintile and low past return quintile) for firms with different PPE/AT ratio for the period of 1963-2010. Firms are double sorted independently into momentum quintiles and PPE/AT quintiles. The portfolios are formed at the end of June in year t by using property, plant, and equipment-net total (PPENT), and book assets-total (AT) for the fiscal year-end in year $t-1$, and compounded return from July $t-1$ to June t as a measure of past performance. The ranking uses NYSE breakpoints. The portfolios are then held from July t to June $t+1$. The annual returns (in percentage) are based on portfolio returns in a calendar year (i.e., Jan. to Dec.). The table reports three samples of firms: all firms, non-financial firms, and non-financial consumption firms. It also reports the t-statistics for momentum premium.

Samples	PPE/AT Ranking	Low	2	3	4	High
All firms:	HML(Momentum) Return	7.8	10.1	2.5	6.2	-1.5
	t-stat	2.71	3.57	0.69	1.94	-0.49
Non-financial firms:	HML(Momentum) Return	9.0	7.4	3.8	6.1	0.0
	t-stat	2.88	2.59	1.02	2.00	0.01
Non-financial consumption firms:	HML(Momentum) Return	9.8	5.7	2.8	5.8	-3.2
	t-stat	3.00	2.05	0.60	1.73	-0.92