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

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Abstract

In this paper we assess the role of capital-embodied technology shocks in explaining properties of the cross section of stock returns. Existing theories seem to disagree on the sign and magnitude of the price the market demands for bearing the risk of such shocks: while a *negative* price is necessary to justify the value premium or the cross-sectional predictability of returns by firm characteristics, a *positive* price is required to justify the existence of momentum profits. Our direct empirical analysis, conducted over the 1930–2010 period, finds weak support for the existence of a significant price of risk for investment-specific shocks and indicates, instead, that inferences based on commonly used proxies of investment-specific shocks are sensitive to the time period considered (pre vs. post 1963). Taking the magnitude of the value premium or the momentum profits as given we further infer that the empirically observed magnitude of these shocks appears to be too small to explain such phenomena. Finally, exploiting the fact that investment shocks manifest themselves through the creation of new capital stock, we propose novel cross-sectional tests that rely on firms' capital intensities to indirectly assess the impact of investment shocks on stock returns without measuring these shocks directly. The empirical evidence we gather lends mild support to the hypothesis that investment-specific shocks can explain a significant part of the cross sectional variations in stock returns.

JEL Classification Codes: E22; G12; O30

Keywords: Investment-specific shocks; Capital intensity; Cross-sectional returns

1 Introduction

Capital-embodied, or "investment-specific", technology shocks—i.e., technological innovations that materialize through the creation of new capital stock—have long been recognized by economists as important determinants of economic growth and business cycle fluctuations.[1] More recently, financial economists have stressed their potential role in explaining properties of asset prices in both the cross section and time series.[2] The qualitative and quantitative predictions of any theory that relies on investment-specific shocks to explain asset pricing properties crucially depend on the sign and magnitude of the price demanded by the risk associated to this type of shocks. The existing theoretical literature seems to disagree on whether this risk should demand a positive or a negative price. On the one hand, Papanikolaou (2011) and Kogan and Papanikolaou (2012a,b) argue that a *negative* price of risk is needed to explain phenomena such as the value premium and the cross sectional return predictability by firm characteristics. On the other hand, Li (2011) argues that a *positive* price of risk is necessary to explain the profitability of momentum strategies. 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 assess the magnitude of the channels through which investment specific shocks may impact the cross section of equity return. We accomplish this goal by taking as our test bank two well known cross sectional return patterns: the value premium—i.e., the fact that high book to market (B/M) firms earn higher returns than low B/M firms (see Fama and French (1993))—and the momentum effect—i.e., the fact that stocks with high past returns outperform stocks with low past returns (see Jegadeesh and Titman (1993)). As mentioned above, the current macro-finance

[1] The hypothesis that investment in new capital is necessary to improve productivity growth has its roots as far back as Smith's *Wealth of Nations* (Smith (1776)), in which its source is attributed to the division of labor. Smith's hypothesis was later refined and extended by Marx and Engels (1848), Schumpeter (1939), and Solow (1960), among others.

[2] For 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.

literature requires investment-specific shocks with prices of risk of opposite signs in order to rationalize the existence of these two return patterns. Our ultimate goal is to advance our understanding of the relationship between firms' heterogeneity, in the form of capital-embodied technological shocks, and cross-sectional return properties.

We conduct our study over a sample period ranging from 1930 to 2010 and base our empirical analysis on two measures of investment-specific technology shocks (IST shocks hereafter) that have been proposed by the existing macroeconomics and finance literature. The first, direct, measure (*Ishock*), proposed by Greenwood, Hercowitz, and Krusell (1997), is based on the price of capital goods relative to that of consumption goods and aims to capture shocks to the cost of investment in new capital. The second, indirect, measure (*IMC*), proposed by Papanikolaou (2011) is based on the stock return spread between investment and consumption good producers.

To shed initial light on the *sign* of the market price of risk for IST shocks, we begin by analyzing the cyclical behavior of the two proxies for IST shocks relative to aggregate macroeconomic variables, such as consumption and output growth over the 1930–2010 time period. According to basic asset pricing theory, asset risk premia are determined by the covariance of their return with the growth rate of the representative agent's marginal utility of consumption. As discussed in Papanikolaou (2011), shocks that lead to states with high marginal utility of consumption (i.e., low consumption growth states) are suggestive of a negative price of IST risk. We find that both measures of IST shocks exhibit positive correlation with consumption growth over the entire sample period, suggesting that, over the period analyzed, IST shocks are more likely to demand a positive market price of risk. Furthermore, direct cross sectional estimation based on portfolios sorted by loadings on IMC shows weak support for the existence of a significant price of risk for IST shocks.

To understand the *magnitude* of the pricing effect of IST shocks on the cross section of equity returns, we first develop a simple valuation model that helps us identify the following three channels through which IST shocks can affect cross sectional returns: (i) IST shocks volatility, (ii) cross-sectional dispersion in investment opportunities, and (iii) market price of risk for IST shocks. Specifically, larger volatility for IST shocks, larger cross-sectional dispersion in investment opportunities (i.e., larger dispersion in exposure to IST shocks), and larger market price of risk for IST shocks all lead to larger cross-sectional dispersion in stock returns. Based on this valuation framework, we show that the IST shocks in the data are too small in magnitude to explain well known cross-sectional return patterns. For example, we find that, in order for IST shocks to generate return spreads comparable to the observed value premium and momentum profits, the required volatility for IST shocks need to be about five times larger than what is observed in the data. We then compare the parameter inputs in the existing theoretical models with the corresponding values in the data and find that at least one of the above three channels helps the existing models to generate a large pricing impact of IST shocks on the cross section of stock returns.

Our analysis also generates new empirical facts that help sharpen our understanding of the effect of IST shocks on the cross section of stock returns. The first fact is that the statistical properties of existing measures of IST shocks in recent sample periods significantly differ from those in earlier sample periods. For example, the correlation of the IMC return with the value factor switches from *positive*, in the 1930–1962 period, to *negative*, in the 1963–2010 period. Because Papanikolaou (2011) and Kogan and Papanikolaou (2012a,b) infer the price of risk from the 1963–2008 period, this finding suggests that this inference may be sample dependent. We extend their analysis to the earlier sample from 1930 to 1962 and find that the difference between IST betas of value and growth portfolios is negative for the 1963–2008 sample period, as in their study, but *positive* for the 1930–1962 sample period. Since the value premium is positive in both sample periods, this implies that from the earlier sample one would infer a positive price of risk for the investment shocks, while from the more recent sample such inference would suggest a negative price of risk. Over the full 1930–2010 sample we find a positive spread between IST betas of value and growth firms. This suggests that the evidence based on B/M portfolios weighs in favor of a positive price of risk for IST shocks, in agreement with our earlier preliminary findings based on correlations between measures of IST shocks and measures of macroeconomic fluctuations.

The second fact we document is that return-based measures of IST shocks exhibit low correlation with measures based on the price of capital goods, indicating that these two measures capture potentially 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 to use a measure of *capital intensity*—defined as a firm's fraction of capital goods in their total assets—to capture a firm's degree of exposure to investment specific shocks. The rationale for this choice is that, because IST shocks are capital embodied, all else being equal, firms with higher capital intensity and/or firms with more growth opportunities should have higher exposure to investment shocks. Depending on whether the sign of the price of risk is positive or negative, these firms will demand, respectively, a higher or lower return than firms with low exposure to IST shocks. The novelty of this approach is that it bypasses the need to directly measure IST shocks while, at the same time, providing additional evidence on the pricing effect of these shocks.

Under the null hypothesis that investment shocks can explain the cross-sectional returns of portfolios sorted by B/M and past performance (momentum), we formulate the following two conjectures. First, controlling for growth opportunities, we should observe a return spread between high and low capital intensity portfolios. The sign of this spread corresponds to the sign of the price of risk for IST shocks. Second, the value premium and momentum profits should be stronger for high capital intensity firms than for low capital intensity firms. Tests of the first conjecture reveal no significant return spread between high and low capital intensity portfolios. Tests of the second conjecture reveal a value premium that is U-shaped in capital intensity and momentum profits that are uncorrelated with capital intensity. Both results reject the null hypothesis that investment shocks can explain value and momentum effects and are consistent both with our earlier findings based on cross-sectional tests as well as with our indirect inference.

The literature on IST shocks also highlights important differences in the preference structure of the representative household needed to rationalize time series and cross-sectional return patterns in equilibrium. On the one hand, in the general equilibrium model of Papanikolaou (2011), a representative household with recursive preference and an elasticity of inter-temporal substitution (EIS) less than 1 is required for the investment shocks to explain the value premium in the cross-section. On the other hand, an EIS larger than one seems to be a necessary requirement to explain observed level of time series moments of the equity risk premium and risk-free rate (see, e.g., Bansal and Yaron (2004) and several others). This observation emphasizes the challenging task to reconcile time series and cross sectional evidence under a unified framework for a given set of household preferences.

This paper makes three contributions to the literature on cross sectional asset pricing. First, we provide a thorough empirical analysis of the investment-specific shock channel. The long sample period (1930–2010) considered in this paper offers an "out-of-sample" analysis that complements existing studies focused mainly on relatively recent data (post 1963). Second, we provide a novel cross-sectional test of the pricing effect of IST shocks that does not rely on a specific measure of these shocks. This is especially important given that IST shocks are not directly observable and proxies for these shocks may contain information other than IST shocks. Finally, we clarify the source of conflicting inferences in the existing literature regarding the pricing impact of IST shocks.

The rest of the paper is organized as follows. Section 2 briefly reviews the related literature. Section 3 describes the data sources. Sections 4 and 5 present both direct and indirect analysis on the sign and magnitude of the price of risk for IST shocks. Section 6 extends existing empirical studies by introducing our new empirical tests based on firms' capital intensity. Section 7 concludes.

2 Related literature

Macroeconomists distinguish between two types of technological innovations as key drivers of economic growth and fluctuation: *disembodied* (or neutral) technology shocks, that affect the productivity of all firms uniformly, and *embodied* technology shocks (IST shocks), that affect firm's productivity only through new equipment. Since the work of Solow (1960), IST shocks have become an important feature of the macroeconomic literature. Representative works in this area are Greenwood, Hercowitz, and Krusell (1997, 2000) and Fisher (2006), who show that IST shocks can account for a large fraction of growth and variations in output, and Justiniano, Primiceri, and Tambalotti (2010) who study the effect of investment shocks on business cycles.

Christiano and Fisher (2003) is the first paper to explore the implications of IST shocks for asset prices at the aggregate level, i.e., the equity premium, while Papanikolaou (2011) is the first to study the implications of these shocks for asset prices in the cross-section of stocks. Papanikolaou (2011) introduces IST shocks in a two-sector general equilibrium model and shows how financial data can be used to measure IST shocks at a higher frequency. Papanikolaou's (2011) insight of using financial market data to measure IST shocks started an active and growing literature in financial economics that aims at linking IST shocks to asset prices. For example, Kogan and Papanikolaou (2010) utilize this proxy to estimate firms' unobservable growth opportunities. In a partial equilibrium setting, Kogan and Papanikolaou (2012a,b) explore how IST shocks can explain the value premium as well as other return patterns in the cross-section that are associated with firm characteristics, such as Tobin's Q, past investment, earnings-price ratios, market betas, and idiosyncratic volatility of stock returns. Li (2011) proposes a rational explanation of the momentum effect in the cross-section by using investment shocks as the key risk factor. Yang (2011) uses investment shocks to explain the commodity basis spread, which refers to the fact that future contracts written on 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.

We contribute to this literature by providing both direct and indirect assessments of the magnitude of the effects of IST shocks on the cross section of equity returns. By analyzing the implication of this mechanism from several viewpoints, we hope to offer a better understanding of the importance of capital embodied shocks for the study of cross sectional asset prices.

More broadly, our paper is related to a large literature that uses heterogeneity in firms' investment decisions to explain cross-sectional returns. Neutral productivity shocks have been used extensively in the investment-based asset pricing literature pioneered by Berk, Green, and Naik (1999).[3] Recent studies that introduce sources of risk in addition to neutral productivity shocks are the works of Garleanu, Kogan, and Panageas (2011) who study the role of "displacement risk" due to innovation in a general-equilibrium overlapping-generations economy, and Garleanu, Panageas, and Yu (2011) who study the asset pricing implications of technological growth in a model with "small," disembodied, productivity shocks, and "large," infrequent, technological innovations embodied into new capital vintages. Kogan and Papanikolaou (2011) provide an excellent survey of the recent literature on firms' economic activity and asset prices.

3 Data and variable definitions

Our empirical analysis relies on two measures of IST shocks: a direct measure, based on the price of capital goods relative to that of consumption goods, and an indirect measure, based on the stock return spread of investment and consumption good producers. The first measure is constructed from macroeconomic data from the National Income and Product Accounts (NIPA) database at the Bureau of Economic Analysis (BEA), while the second is obtained from financial market data available from the CRSP and Compustat databases.

To construct the direct measure of IST shocks, we follow Greenwood, Hercowitz, and Krusell (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. Specifically, for year t, the Ishock is defined as

$$\text{Ishock}_t = \ln\left(\frac{P_I}{P_C}\right)_{t-1} - \ln\left(\frac{P_I}{P_C}\right)_t, \tag{1}$$

[3]The investment based asset pricing literature is too vast to be reviewed here. Significant contributions to this literature include Gomes, Kogan, and Zhang (2003), Carlson, Fisher, and Giammarino (2004), Zhang (2005), Liu, Whited, and Zhang (2009).

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). A positive Ishock means a reduction in the relative price of equipment.

Table 1, panel A, reports summary statistics for the Ishock measure. The annual mean and standard deviation over the entire sample period (1930–2010) are 1.02% and 3.59%, respectively. Interestingly, over the earlier subsample (1930–1962), the mean Ishock is negative, −0.60%, with a higher standard deviation of 4.26%, while for the later subsample (1963–2010), the mean is higher, 2.12%, with a lower standard deviation of 2.56%.

The indirect measure of IST shocks is the difference between the returns of firms producing investment (capital) goods and the return of firms producing consumption goods (IMC return), first proposed by Papanikolaou (2011). The rationale for using IMC returns as a measure of IST shocks rests on the fact that firms producing investment goods (investment firms) and consumption goods (consumption firms) have the same loadings on the neutral productivity shock, but different loadings on IST shocks. Therefore, the return difference between investment and consumption firms loads only on IST shocks and can therefore be used as a proxy for these shocks that relies only on financial data.

To construct the IMC measure, we classify firms as belonging to either the investment or consumption sectors depending on the contribution of their final product to each sector. We rely on the procedure outlined in Gomes, Kogan, and Yogo (2009) and classify each Standard Industry Classification (SIC) code into either investment or consumption sector based on the 1987 benchmark input-output accounts.[4] To classify firms, we use their SIC code from Compustat, if available, and their SIC code from CRSP, otherwise.

Specifically, to construct IMC portfolios, the sector classification is based on the SIC code from Compustat for the fiscal year ending in year $t-1$, if not missing, and on the SIC

[4]Gomes, Kogan, and Yogo (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 NX and G to either the investment or consumption sector depending on whether they contribute more to the investment or consumption sector.

code from CRSP for June of year t, otherwise. The portfolio classification is then assigned to firms in the next 12 months, from July of year t to June of year $t+1$. We calculate the value-weighted returns for each portfolio using the lagged market value as weight, and then compound the monthly portfolio returns from January of year t to December of year t to generate the annual returns of each portfolio for year t.

Table 1, panel B, reports summary statistics for the IMC measure, computed using value-weighted portfolios. The annual mean and standard deviation of the IMC return over the entire sample period (1930–2010) are 0.70% and 13.88%, respectively. Over the earlier subsample (1930–1962), the IMC mean is positive, 1.82%, with a high standard deviation of 13.99%, while over the later subsample (1963–2010) the IMC mean is negative, −0.06%, with a similarly high standard deviation of 13.90%.[5] Note that dropping two years (2009 and 2010) or adding one year (1962) changes the magnitude dramatically: the value-weighted return spread is −0.81% per year in the 1963–2008 period, compared to −0.06% in 1963–2010, and is −0.97% per year in the 1962–2008 period.[6] Similar to the Ishock measure, the IMC measure exhibits different statistical properties over the two subsamples considered, but, unlike Ishock, IMC is much more volatile.

Since IMC is the excess return of a portfolio traded in the market, its sign provides a direct implication for the sign of the price of risk for IST shocks. In fact, if IST shocks were fully spanned by the IMC return, then the risk premium for the investment shock would simply be the average IMC return. From the summary statistics reported in Table 1, the sign of the average IMC return seems to be sensitive to the sample period. This fact calls for caution when interpreting results using only the later sample, as we will discuss at length in Section 4.

[5]For equally weighted portfolios (not reported in Table 1), the return spread in IMC is always positive for both the full sample and the two subsamples. The sample average is 1.42% for the 1930–1962 period, 1.98% for the 1963–2010 period, and 1.75% for 1930–2010 period.

[6]Papanikolaou (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.

We measure economy-wide macroeconomic conditions using the annual growth rates of real GDP (row 1 of NIPA Table 1.1.1) and different consumption measures.[7] Monthly stock returns are from CRSP and annual accounting data are 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 period ranges from January 1930 to December 2010. For analysis using Compustat data, we mainly focus on the subsample period between 1963 and 2010 due to data availability.

In our empirical analysis we focus on two cross-sectional return patterns: the value premium and the profitability of momentum strategies. 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.[8] The market value is the firm's capitalization (i.e., price$\times$share outstanding). Momentum is measured by past 12-month compounded returns. To compute momentum profits, we require a firm to have at least 12 non-missing monthly returns.

4 The sign of the price of risk for investment shocks

To understand the mechanism through which IST shocks affect returns it is important to have a clear picture of what the data say about: (i) the sign of the price of risk of IST shocks and (ii) the amount of exposure (beta) of an asset or portfolio to such shocks. In this section, we use the two alternative measures of IST shocks discussed above to infer the sign of the price of risk associated to such shocks. Our analysis consists of three parts. In the first part, Section 4.1, we infer the sign of the IST price of risk by studying the cyclical behavior of IST shock measures. In the second part, Section 4.2, we look at the sign and economic meaning of the loadings of portfolios on IST shocks. This also helps us infer the sign for the price of risk for IST shocks. In the last part, Section 4.3, we perform

[7] NIPA Table 1.1.1 contains personal consumption expenditures (PCE in row 2) and nondurable goods (NDG in row 5).

[8] The historical book equity data are downloaded from Ken French's website. The book equity is calculated as in Davis, Fama, and French (2000).

formal cross sectional analyses to estimate the market price of risk for IST shocks by Fama-MacBeth regressions based on IMC-beta and book-to-market sorted portfolios.

4.1 Cyclical behavior of investment specific shocks

To determine the sign of the price of risk for IST shocks, we first look at the cyclical behavior of measures of these shocks with respect to measures of macroeconomic fluctuations as well as commonly use return factors. The time series correlations are reported in Table 2.

4.1.1 IST shocks and consumption growth

In representative agent models, equilibrium assets' risk premia are determined by the correlation of their payoffs with the agent's marginal utility of consumption. Assets with higher payoffs in states with higher marginal utility are 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. Hence, the correlation between shocks and consumption growth is a useful gauge for the sign of the price of risk for IST shocks.

In Table 2 we use both the growth rate of nondurable consumption goods (NDG) and the personal consumption expenditure (PCE) as alternative measures of consumption growth. The correlation between Ishock and NDG growth (Panel A) is positive and large (0.33) in the 1930–1962 subsample, positive but small (0.01) in the 1963–2010 subsample, and positive (0.24) in the entire 1930–2010 sample period. Correlations with PCE growth exhibit similar properties. These findings indicates that Ishock is positive (i.e., relative price of capital good is low) when the growth in consumption is high, or, equivalently, marginal utility is low. The correlation between IMC and consumption growth (Panel B)—computed using either personal consumption expenditure (PCE) or nondurable goods (NDG)—is positive in all periods considered. Correlation levels are low with PCE, and slightly stronger with NDG.

It is worth comparing the correlation levels from our analysis with those of existing studies. For example, Papanikolaou (2011) reports in his Table 2 that the correlation between growth of investment goods prices ($\dot{p}_I$) and consumption growth ($\dot{c}$) is 0.44 for the period of 1951–2008. Our value for the correlation between Ishock and NDG growth for the same period is -0.14. Since Ishock is the negative of growth in investment good prices, the sign of our correlation coefficient is consistent with that in Papanikolaou (2011), although smaller in magnitude. This also demonstrates that the correlation between the growth in investment goods price and consumption is time varying and sample dependent.

In summary, both the Ishock and IMC measures are *pro-cyclical* relative to consumption growth, suggesting that investment shocks lead to low marginal utility of consumption states and hence, possibly, carry a positive price of risk.

4.1.2 IST shocks and GDP growth

Table 2, Panel A shows that the correlation between the Ishock and the growth rate of GDP is positive for both the full sample (1930–2010) and subsamples (1930–1962 and 1963–2010). 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 low (i.e., investment shock is positive) in high GDP growth states. That is, the capital good price is countercyclical relative to GDP growth. Therefore, the investment shock is *pro-cyclical* (and the price of investment goods is counter-cyclical) relative to GDP growth.

Papanikolaou (2011) reports in his Table 2 a correlation of 0.24 between growth in investment goods price ($\dot{p}_I$) and GDP growth ($\dot{y}$) for the period 1951–2008. In contrast, our calculation for the same time period yields a correlation of -0.05. Our finding that the price of investment goods is counter-cyclical relative to GDP is consistent with the results reported in Greenwood, Hercowitz, and Krusell (1997, 2000), Christiano and Fisher (2003), and Fisher (2006).

Unlike Ishock, IMC does not show any significant cyclical behavior relative to GDP growth. The correlation between IMC and GDP growth (Panel B) is -0.06 for the 1930–1962 period, 0.02 for the 1963–2010 period, and -0.02 for 1930–2010 period.

4.1.3 IST shocks and return factors

As noted above, the correlation between IST shock measures and macroeconomic indicators show large difference across time periods. In this section, we further investigate this issue by looking at the correlations of IST shocks with well-known risk factors. The idea is that if IST shocks can explain 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-sectional patterns. We obtain commonly used financial market factors, such as the market (MKT), the size (SMB), book-to-market (HML), and momentum (MOM) factors from Kenneth French's website. Table 2, Panel A shows that the correlations between Ishock and Fama-French 3-factors (MKT, SMB, and HML) are positive in the 1930–1962 subsample but negative in the 1963–2010 subsample. For example, the correlation of Ishock with HML changes from 0.44 in the 1930–1962 period to −0.10 in the 1963–2010 period. These findings indicate that it is unlikely that Ishock can explain cross sectional return patterns such as size and value premia in *both* subsamples. Finally, the correlation between Ishock and momentum is positive and insignificant in the earlier sample and positive and significant in both the later sample and in the full sample. This is broadly consistent with Li (2011), who uses IST shocks proxied by Ishock to explain the momentum effect in the cross section.

Panel B shows that the IMC return is positively correlated with the market and size factors for both periods. Interestingly, the correlation between IMC and HML changes sign from the earlier to the later subsample: it is positive (0.38) in 1930–1962, but negative (−0.48) in 1963–2010. The correlation between IMC and the momentum factor, MOM, is positive (0.14) in 1930–1962, and negative (−0.13) in 1963–2010. Hence, IMC exhibits different correlation structures in the two subperiods with respect to both HML and MOM. 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 the 1930–1962 period. The correlation becomes negative (−0.02) in the 1963–2010 period.[9] The two measures are uncorrelated in the full sample, a fact that we will explore further in Section 6.

4.2 Factor loadings of portfolios: sign and economic meaning

An alternative, indirect, way to address the issue of inferring the size of the price of risk for IST shocks is to analyze the factor loadings (betas) of firms and portfolios with respect to this type of shocks. Combining this information with the evidence on firms' return will provide us with an independent assessment of whether the data support the existence of a positive or negative price for IST shocks.

A useful starting point for this analysis is the two-factor partial equilbrium model of Kogan and Papanikolaou (2012a), in which it is shown that a firm's stock return beta with respect to IST shocks is proportional (and positively related) to the fraction of firm value accounted for by growth opportunities. Because the present value of growth opportunities is a non-negative quantity, this implies that one should observe positive values for firms' IST betas.

Panel A of Table 3, reproduced from Table 6 in Papanikolaou (2011) reports the risk exposure to IST shocks of B/M portfolios for the 1963–2008 sample period. When IST shocks are measured via the Ishock measure, the IST betas are negative for all B/M portfolios. A negative loading on Ishock implies that a positive investment shock (i.e., a drop in the price of investment goods) is bad news for stock prices.This finding is somewhat counter-intuitive given the argument in Kogan and Papanikolaou (2012a). From panel A of Table 3, high B/M portfolios have lower Ishock beta (-3.35) than low B/M portfolios (-2.36). Hence, the existence of a value premium implies a negative price of Ishock risk.

When IMC is used as a measure of IST shocks, Panel A of Table 3 shows that, with the exception of the seventh and eighth deciles, IMC betas are all positive. Similarly, Kogan and Papanikolaou (2012b) report positive IMC betas for Tobin's Q portfolios (see their Table 3). The sign of IMC betas are in clear contrast with the negative signs observed for

[9] Kogan and Papanikolaou (2012a) reports that IMC and Ishock are positively correlated with a correlation of 0.223 in 1963-2008. We find a correlation of only 0.06 during the same period. Note that adding two more years (2009 and 2010), changes the correlation from 0.06 to -0.02.

Ishock betas, suggesting that IMC return contains information that is potentially quite different from the price of investment goods.

Panel B of Table 3, reproduced from Table 9 in Li (2011), reports Ishock betas for momentum portfolios. These betas are negative for losers and 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. This finding is somewhat puzzling in light of the fact that a positive investment shock should be, at worst, neutral news for all firms, and more likely good news for most firms in the cross section.[10] Given the patterns of Ishock betas in Panel B of Table 3, the existence of momentum profits in the cross section implies a positive price for Ishock risk.

In summary, these results suggest caution in inferring properties of IST shocks on the basis of only differences (not levels) in the portfolio loadings on these shocks and indicate that the two commonly used measures of IST shocks can potentially contain different and unrelated information. In the next section, we provide a formal cross-sectional analysis to directly estimate the risk premium of IST shocks.

4.3 Cross-sectional tests

We estimate the risk premium for IST shocks by using two different sets of testing assets: IMC-beta sorted portfolios (Section 4.3.1) and book-to-market sorted portfolios (Section 4.3.2).

4.3.1 IMC-beta sorted portfolios

A natural set of assets to use in order to estimate the risk premium of IST shocks is the set of portfolios sorted by the sensitivity of stocks to these shocks. Under the null hypothesis that IST shocks are priced in the cross-section, portfolios sorted by the loadings on these shocks will generate a large dispersions in both returns and betas, thus making them suitable for cross sectional tests.

[10]It 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.

Since the IMC return is based on financial data and is available at high frequency, following Papanikolaou (2011), we use IMC-beta sorted portfolios as our testing assets. Specifically, at the end of June in year t, we sort stocks into IMC-beta portfolios and assign the portfolio ranking to firms from July t to June $t+1$. The firm level pre-ranking IMC-beta is estimated by using weekly stock returns and IMC returns (both in logs) from July $t-1$ to June t. We require stocks to have at least 50 non-missing weekly returns within the estimating period of one year. Once the portfolios are formed, we calculate annual returns (from January to December) and estimate the corresponding post-ranking betas relative to Ishock and IMC for each portfolio. Therefore, for each of the ten portfolios we have a time series of annual returns and a time-invariant post-ranking loading on Ishock (Ishock-beta) and IMC (IMC-beta). We estimate the risk premium for IST shocks via traditional Fama-MacBeth cross-sectional regressions. That is, for each year, we run a cross-sectional regression of portfolio returns on the portfolios' IST betas. The estimated IST risk premium is the time series average of the cross-sectional estimates. The t-statistics for the IST risk premium are corrected for autocorrelation using Newey-West with two lags.

Table 4 reports the results for three time periods. For the earlier sample period (1930–1962) in Panel A, the IMC-beta sorted portfolios have a non-monotonic pattern in return. The differences in returns between decile 10 and 1 is -1.5% while the difference between decile 9 and 2 is 2.2%. Even though the IMC betas are generally increasing with the portfolio ranking, there is no clear pattern in Ishock betas for the ten portfolios. The Fama-MacBeth estimation of the risk premia are positive (1.08% for Ishock and 0.83% for IMC), but insignificant (t-statistics are 0.62 for Ishock and 0.35 for IMC).

For the later sample period (1963–2010) in Panel B, the IMC-beta sorted portfolios show slightly increasing but non-monotonic return patterns in pre-ranking IMC-beta. For example, the return increases from 5.8% for the low IMC-beta portfolio to 8.1% for the 6th decile, and then decreases to 6.7% for the high IMC-beta portfolio. The portfolio loadings on Ishock are all negative without clear pattern. The portfolio IMC betas increase from -0.13 to 1.10, consistent with the fact that these are IMC-beta sorted portfolios. The

Fama-MacBeth estimates of the risk premium are both insignificant: 0.75% ($t = 0.28$) for Ishock, and -0.21% ($t = -0.09$) for IMC.

Panel C reports the results for the full sample period (1930–2010). The patterns are similar to the previous ones. First, there is no clear patterns in returns across the ten portfolios. Second, the Ishock betas are all positive without clear pattern, similar to that of the earlier period. Third, the IMC betas are increasing. Finally, none of the risk premia is significant. For example, the Fama-MacBeth estimation of the risk premium is -0.34% ($t = -0.19$) for Ishock and 0.08% ($t = 0.04$) for IMC.

In summary, using IMC-beta portfolios, we do not find significant risk premia for the IST shocks by using either Ishock or IMC measures. Therefore, our empirical evidence based on IMC-beta sorted portfolios does not provide a clear inference on the sign (as well as magnitude) of the price of risk for IST shocks. However, it is important to emphasize that these results are obtained by using testing assets constructed from IMC-beta and are hence affected by the quality of the IST shock measure. In fact, if the the IMC return is a noisy measure of IST shocks, then the above procedure would have less power in detecting significant risk premium for IST shocks. We try to address this potential issue in the next section by using B/M sorted portfolios as alternative testing assets.

4.3.2 Book-to-market sorted portfolios

As suggested by the low correlation between IMC and Ishock documented in Table 2, the IMC return may capture information potentially unrelated to investment shocks. Furthermore, these measures exhibit different statistical properties across the two subsamples, as discussed in Subsection 4.1. In this section we use book-to-market sorted portfolio as alternative testing assets to estimate the risk premium for IST shocks and extend the analysis of existing studies to a longer sample period.

Papanikolaou (2011) and Kogan and Papanikolaou (2012a) 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 1963–2008 sample period. We provide an out-of-sample analysis of their work by extending their analysis to the 1930–1962 period. Specifically, we sort stocks into B/M decile portfolios at the end of June of every year.[11] For each B/M portfolio, we calculate the value weighted return in each month, and then compound the monthly returns within a calendar year to construct our annual return measure. We 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 only non-financial firms.

Table 5 shows the results for the 1930–1962 period (panel A), the 1963–2010 period (panel B), and for the entire 1930–2010 period (panel C). Over 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 -1.74 (Ishock beta) and -0.14 (IMC beta). A positive value premium and negative spread in IST loadings between value and growth, imply a negative price of risk for these shocks, thus confirming the conjecture of Papanikolaou (2011) and Kogan and Papanikolaou (2012a).

Let us now turn to the earlier sample period of 1930–1962. As Panel A shows, in this period the return spread between value and growth portfolios is 8.9% per year, higher than in the 1963–2010 period. The univariate IST shock betas are now *increasing* from growth to value portfolios: the spred in betas between high and low B/M portfolios are 3.15 (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 conclusion from that obtained from the later sample.

The results from the full sample of 1930-2010 (panel C) are qualitatively similar to those of the earlier sample. That is, the value premium and univariate betas of high-

[11]The B/M used for sorting in year t is the book equity for the fiscal year ending in year $t-1$ divided by the market value at the end of December of year $t-1$. The portfolio rankings are then assigned to firms from July t to June $t+1$.

minus-low B/M portfolio on investment shocks are all positive, hence implying a positive price of risk for investment shocks.

Direct estimation (not reported) from Fama-MacBeth regressions using all ten book-to-market sorted portfolios confirms the above findings. For the earlier sample period (1930–1962), the risk premium is 2.2% ($t = 1.53$) based on Ishock and 5.2% ($t = 1.53$) based on IMC. For the later period (1963–2010), the risk premium is -2.1% ($t = -2.2$) based on Ishock and -14% ($t = -2.2$) based on IMC. Similar to the earlier period, the risk premium for the full sample is 2.6% ($t = 2.0$) based on Ishock and 8.7% ($t = 2.3$) based on IMC.

In summary, inference from B/M-sorted portfolios indicates that the price of risk for IST shocks changes sign from positive, in the earlier sample, to negative, for the later sample. This suggests some caution when basing the interpretation of the economic mechanism underlying IST shocks on data coming only from the later sample.

5 The magnitude of the price of risk for investment shocks

Even though, as the evidence gathered above indicates, the question of whether IST shocks carry a positive or negative price of risk cannot be reliably answered with the data at our disposal, an equally important question concerns the *magnitude* of this price. This is perhaps a more fundamental question because it speaks directly to the economic plausibility of the mechanism that links IST shocks to asset prices, through the creation of new capital stock.

We address this question in two ways. First, in Section 5.1, we provide a simple reduced form valuation model to highlight the potential channels through which IST shocks can affect the cross-sectional dispersion in returns. Taking as given the magnitude of cross sectional patterns in stock returns, i.e., value and momentum, we can infer the required magnitude of the IST shocks to explain these patterns. Comparisons of the inferred IST shocks to the observed ones provide a direct way to assess the plausibility the IST shock in explaining cross sectional return patterns. Second, in Section 5.2, we compare the price of risk for IST shocks implied by the general equilibrium (GE) model of Papanikolaou (2011) with the calibrated price of risk used in existing partial equilibrium (PE) models. Because PE models calibrate the price of risk to match empirically observed patterns in stock return, in order for this mechanism to be economically sound, the calibrated value should be of the same order of magnitude as the value inferred from a GE model. We rely on the channels identified from our simple valuation model to better understand the key mechanisms through which the pricing impact of IST shocks can be enhanced in existing calibration exercises.

5.1 Inferring the magnitude of investment shocks

Let us consider a simple, reduced form, valuation model involving investment shocks and different investment opportunities across firms. The market value of a firm is the sum of discounted expected net cash flows (D_t),

$$P_0 = \sum_{t=1}^{\infty} \frac{D_t}{(1+r)^t} = \frac{D_1}{1+r} + \frac{P_1}{1+r}, \tag{2}$$

where, for simplicity, we assume a constant risk adjusted discount rate r. Instead of considering firms' investment directly, we assume that the impact of investment shocks on the price of firms' new investment can be incorporated into firms' net cash flows D_t. All else being equal, a positive investment shock decreases the price of new capital goods and therefore decreases the cost of investment. This leads to an increase in the firms' net cash flows after investment.

Under the above assumptions, the *expected* net cash flow at date 1 is the gross cash flow minus the expected cost of investment: $D_1 = C_1 - I_1$. However, in the presence of IST shocks, the cost of installing capital $\tilde{I}_1$ is stochastic. Suppose $\tilde{I}_1 = (1-\epsilon)I_1$ where ϵ is a zero mean random shock. A positive (negative) values of ϵ represents a percentage drop (increase) in the price of new capital. Hence the *realized* net cash flow is

$\tilde{D}_1 = C_1 - (1-\epsilon)I_1 = D_1 + I_1\epsilon$, yielding the following realized return at date 1:

$$\tilde{r} = \frac{\tilde{D}_1 + P_1}{P_0} - 1 = r + \frac{I_1}{P_0}\epsilon. \tag{3}$$

Equation (3) captures, in a reduced form, the connection between IST shocks, ϵ, and returns.

Let us now consider two firms, i and j. For simplicity, assume that these two firms differ only in their date 1 investment and are identical from date 2 onwards. Then the return difference between firms i and j at date 1 can be written as

$$\tilde{r}_i - \tilde{r}_j = \left(\frac{I_i}{P_{0i}} - \frac{I_j}{P_{0j}}\right)\epsilon. \tag{4}$$

Note that, because ϵ is a zero-mean shock, equation (4) cannot be used directly to infer return difference across firms due to IST shocks. Equation (4) can however be used to infer the magnitude of the *volatility* in the cross-sectional return difference attributable to investment shocks. For illustrative purposes, we will then translate the inferred volatilty into an inferred return difference by taking as given the Sharpe ratio of the return difference.[12] The volatility of the return difference is given by

$$\sigma(\tilde{r}_i - \tilde{r}_j) = \left(\frac{I_i}{P_{0i}} - \frac{I_j}{P_{0j}}\right)\sigma(\epsilon). \tag{5}$$

Denoting by SR denote the Sharpe ratio for the return difference, the expected return difference across firm can be written as

$$E(\tilde{r}_i - \tilde{r}_j) = SR \times \sigma(\tilde{r}_i - \tilde{r}_j) = SR \times \left(\frac{I_i}{P_{0i}} - \frac{I_j}{P_{0j}}\right)\sigma(\epsilon). \tag{6}$$

Equation (6) highlights the three channels through which IST shocks can impact the cross-section of stock returns. First, all else being equal, larger investment shocks (i.e., higher $\sigma(\epsilon)$) have larger impact on the return difference. Second, a higher dispersion

[12] To formally derive the expected return difference, one would need a model of the stochastic discount factor, which is beyond the purpose we set out to accomplish in the simple valuation model of this section.

in investment opportunities across firms (i.e., higher spreads $I_i/P_{0i} - I_j/P_{0j}$) generates a larger cross-sectional return dispersions. Finally, higher values of the Sharpe ratio, SR, of the return difference increase the pricing impact of investment shocks. If cross sectional return differences are uniquely determined by IST shocks, then a high Sharpe ratio corresponds to a high price of risk for investment shocks.

In the data, the annual standard deviation for the investment shocks, $\sigma(\epsilon)$, is about 3.5% (see Table 1). Assuming a cross-sectional dispersion of investment relative to firm value ($I_i/P_{0i} - I_j/P_{0j}$) of 50%, then the inferred volatility of return difference is $50\% \times 3.5\% = 1.75\%$. Assuming a Sharpe ratio SR for the return difference of 0.5, we obtain an inferred expected return difference of $0.5 \times 1.75\% = 0.88\%$.[13]

To assess the plausibility of the above values, let us consider the investment rate difference in the data across portfolios sorted by variable such as B/M or momentum. The difference of investment rates between high and low B/M portfolios is in the order of 10% in the year following portfolio formation (Table 4 in Kogan and Papanikolaou (2012a) reports an investment rate difference of only 4% for IMC-beta sorted portfolios). According to equation (6) this can generate return difference of $0.5\times10\%\times3.5\% = 0.175\%$. In other words, to generate the observed return difference of about 5% between high and low B/M portfolios, one would need a volatility of investment shocks (in terms of percentage price movement in the capital goods) in the order of $5\%/(0.5 \times 10\%) = 100\%$ annually, which is inconsistent with what we observe in the data. Similarly, for momentum portfolios, the difference between investment rates of winners and losers is about 10% (see Figure 2 in Li (2011)). According to equation (6) this difference in investment rates can generate a return difference of $0.5 \times 10\% \times 3.5\% = 0.175\%$. This implies that to generate a return difference comparable to the magnitude of momentum profits, about 8%, one would need a volatility of investment shocks in the order of $8\%/(0.5 \times 10\%) = 160\%$ per year, again inconsistent with what we see in the data.

[13] Our choice of a Sharpe ratio of 0.5 is higher than most of the values that we observed in the equity market. For example, using annual data from 1927–2010, the Sharpe ratios for market, size and value factors are, respectively, 0.39, 0.25 and 0.38. The momentum factor has a high Sharpe ratio of 0.53 for the same time period. However, this factor is constructed by re-balancing portfolios every month, which is too high a frequency for IST shocks. Hence, by choosing a Sharpe ratio of 0.5 we introduce a bias in favor of finding larger effect of IST shocks.

In the above calculations, we assumed for simplicity that firms differ in their investment only for the year following the portfolio formation. In the data, the investment difference across portfolios can persist for more than one year (usually 3 to 5 years), although it diminishes over time quickly. Even accounting for longer-lived investment differences, the above argument is still qualitatively true. For example, if we assume an investment difference across portfolios sorted by either B/M or momentum of 50% in the years after sorting, a value considerably larger than what is observed in the data (see for example, Figure 2 in Li (2011)), the implied return difference would be in the order of 1%. To generate return differences of 5% for B/M and 8% for momentum, the volatility of investment shocks $\sigma(\epsilon)$ in equation (6) should be in the order of $5\%/(0.5 \times 50\%) = 20\%$ and $8\%/(0.5 \times 50\%) = 32\%$, respectively. Both values are much larger than what is observed in the data (about 3.5% in Table 1), even if we account for volatility in the shocks to marginal efficiency in investment (about 5.0%, see Justiniano, Primiceri, and Tambalotti (2011)).

5.2 Implied price of risk from general and partial equilibrium models

In this section, we further analyze the magnitude of the pricing effect of IST shocks on cross-sectional returns by comparing the calibrations used in existing partial and general equilibrium studies. Intuitively, because partial equilibrium models have more degrees of freedom in matching the data, comparing the calibrations in these models to those inferred from a general equilibrium setting provides a way to assess whether the IST channel is empirically plausible.

Let us first consider the implied risk premium in the GE model of Papanikolaou (2011). The benchmark model considered contains two types of IST shocks: a productivity shock to the investment sector and a shock to the marginal efficiency of investments. If one ignores the second shock and calibrates the volatility of the productivity shock to the investment sector closer to empirically observed values (4.5%), then, as Papanikolaou (2011) acknowledges, the model has difficulty in matching asset pricing moments (see

Table 3, "Alternate 1" column in Papanikolaou (2011)). Specifically, the model generates a market risk premium of 0.3% with 7.32% volatility (compared to 4.89% and 17.92% in the data), a IMC spread of −0.1% with 2% volatility (−1.41% and 10.96% in the data), and a value-growth spread of 0.18% with 5.78% volatility (6.15% and 19.12% in the data). The implied price of risk for IST shocks in the model can be obtained from the IMC spread and is equal to $-0.1/2 = -0.05$. If IST shocks price the IMC portfolio perfectly then the price of risk for the IST shocks should be equal to the empirical Sharpe ratio of the IMC portfolio, i.e., $-1.41/10.96 = -0.13$. If one includes also the second type of IST shock, i.e., shocks to the marginal efficiency of investment, then the GE model can generate asset pricing moments comparable to what is observed in the data. In his benchmark calibration, Papanikolaou (2011) chooses a volatility of 3.5% for the productivity shock and of 13.5% for the shock to the marginal efficiency of investments. With these values (see column "Benchmark" in his Table 3), the model generates IMC return of −0.68% with 5.8% volatility (−1.41% and 10.96% in the data), implying a price of risk of $-0.68/5.8 = -0.12$, indeed very close to the Sharpe ratio of the IMC portfolio (−0.13) in the data.

The calibrations used in PE models, however, do not seem to coincide with the values inferred from the GE model. In Kogan and Papanikolaou (2012a), for example, setting the risk premium for investment shock to the average return of IMC, implies a price of risk of $-0.019/0.112 = -0.17$. But, the calibrated value is set to −0.35, more than twice larger (in absolute value). In Kogan and Papanikolaou (2012b), the calibrated price of risk for investment shock is set to −0.57, more than three times larger (in absolute value). In Yang (2011), the calibrated price of risk is −12, i.e., about 70 times larger (in absolute value). In Li (2011), the calibrated price of risk is 4, a value more than 23 times larger (in absolute value) and of opposite sign to that of the IMC Sharpe ratio.[14] Furthermore, the volatility of Ishock in his calibration is set to 20%. Given an empirically observed

[14]Note that the price of risk for IST shocks in Li (2011) is equal to $\gamma_q \times \sigma^q = 20 \times 0.2 = 4$ based on values reported in his Table 7 and on the specification of the pricing kernel in his equation (20).

Ishock volatility of 3.59% (see Table 1), these calibrated values significantly magnify the importance of IST shocks in the cross section.

The three channels emerging from our simple valuation model (see equation (6)) can help us better understand the mechanisms in the existing literature on IST shocks and stock returns. In fact, existing theoretical models generate large return dispersions in the cross-section using some or all of these three channels. For example, in the benchmark calibration of Papanikolaou (2011), the volatility of IST shocks is much higher than that implied by the data.[15] In the Kogan and Papanikolaou (2012a) model, in addition to the large price of risk for IST shocks discussed above, there is also a larger dispersion in investment rate than that observed in data.[16] Finally, as we discussed above, in Li (2011) both the price of risk and the volatility of IST shocks are much larger than the values observed in the data.

To summarize, our analysis indicates that the observed magnitude of IST shocks is too small to explain the large cross-sectional return patterns such as value and momentum effects. In addition, we also find that existing models seem to overstate the pricing impact of IST shocks by choosing parameter values significantly larger than those observed in the data.

6 Assessing the investment shock channel: the role of capital intensity

Our main conclusion from the above analysis is that IST shocks are too small in magnitude to explain large cross-sectional return dispersions of the magnitude of the value premium and momentum profits. In addition, our analysis reveals that the two measures of investment shocks used empirically (Ishock and IMC) exhibit low correlation and hence

[15]Specifically, the calibrated volatility of IST shocks in Papanikolaou (2011) is 3.5% for the productivity shock plus 13.5% for the shock to the marginal efficiency of investments. Although the volatility of the productivity shock is close to the volatility of Ishock in our Table 1, the volatility of the shock to the marginal efficiency of investments is much higher than the value of about 5% reported by Justiniano, Primiceri, and Tambalotti (2011).

[16]In Table 4 of Kogan and Papanikolaou (2012a), the model generates a difference of 7% in investment rate between high and low IMC-beta portfolios, while it is only about 4% in the data.

seem to capture different information. In this section, we address this measurement issue by providing a novel cross-sectional analysis that is independent of any empirical proxy of investment shocks. We propose to use heterogeneity in firms' capital intensity as a testing dimension that eliminates the need to choose a specific 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.

The idea is as follows. We define a firm's *capital intensity* as the ratio of Property, Plant, and Equipment (PPE) over total assets (AT). Consider two firms with different capital intensity, PPE/AT. All else being equal, IST shocks are more important for high capital intensity firms. In fact because IST shocks are embodied into new capital, the high capital intensity firm has to invest more in capital (PPE) to generate the same growth in total asset (or, equivalently, in total sales) as the low intensity firm. For example, suppose two firms have capital intensity of 40% and 80% respectively, and common growth rate in total assets of g%. Then the first firm has to invest $(40 \times g)\%$ of its asset in PPE in order to achieve a growth g in asset, while the PPE investment for the second firm is $(80 \times g)\%$ of its asset. Therefore, if all firms have the same total growth opportunities (in assets or sales), high capital intensity firms have higher exposure to investment shocks. If the price of investment shocks is negative (positive), high capital intensity firms should have lower (higher) returns. This leads to the following prediction based on capital intensity.

Prediction 1a. *All else being equal, investment shocks are more important for firms with higher capital intensity. Hence, we should observe a return spread between high and low capital intensity. The return spread between high and low capital intensity firms should have the same sign as that of the price of risk for investment shocks.*

Note, however, that two firms with different capital intensity may also have different total growth opportunities (in total assets or sales). For example, if the two firms in the example above have total growth opportunities $g = 100\%$ and $g = 50\%$ respectively, then they would invest the same fraction, $(40 \times 1)\% = (80 \times 0.5)\%$ of their total assets in PPE.

Therefore, when assessing the impact of investment shocks on the cross-section of stock returns it is important to control for growth opportunities.

The null hypothesis that the investment shocks can explain value premium or momentum profits through firm's investment in new capital stock provides a natural way of controlling for growth opportunities. In fact, if IST 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 portfolio sorted by these characteristics (B/M and past performance) should have different total growth opportunities. In other words, under the null hypothesis that IST shocks can explain value premium and/or momentum profits, firm characteristics such as B/M ratio and past performance are natural proxies of firm's total growth opportunities.[17] This leads to our second prediction regarding the return spread across firms with different capital intensity.

Prediction 1b. *Under the null hypothesis that IST shocks can explain the value premium and momentum profits in the cross section of equity returns, we should observe a return spread between high and low capital intensity firms after controlling for growth opportunities (proxied by B/M or momentum). The return spread has the same sign as the price of risk for the investment shocks.*

Sorting firms by capital intensity will also provide us with an intuitive way of assessing the plausibility of the IST shock channel in explaining cross-sectional returns. In fact, if this channel is at play, return patterns such as value and momentum should be stronger for high capital intensity firms than for low capital intensity firms. Furthermore, the difference in the strengths of these return patterns across capital intensity will provide information on the magnitude of the price of risk for IST shocks. This leads to our third prediction regarding existing return patterns in the cross section.

[17]This is consistent, for example, with Kogan and Papanikolaou (2012a) who use market-to-book ratio is as a proxy for growth opportunities in the testing of their theoretical model.

Prediction 2. *Under the assumption that IST shocks can explain cross-sectional returns, the value and momentum effects should be stronger for firms with higher capital intensity than for firms with lower capital intensity.*

A key variable we use in our empirical analysis is the capital intensity of a firm. We measure it as the ratio of Property, Plant, and Equipment (PPE, Compustat item ppent) to total book assets (AT, Compustat item 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 final products. Other items in the total assets, besides PPE, include cash, inventories, intangibles, and other non-PPE assets. Because IST shocks are embodied in new capital, we expect firms with higher intensity to be more exposed to this type of shocks. To form portfolios, the PPE/AT ratio used for sorting at the end of June in year t is PPE divided by total assets both for the fiscal year ending in $t-1$. The portfolios are then held for the next 12 months, from July t to June $t+1$. Since the capital intensity is constructed from accounting data on capital investment (PPE) and total assets (AT), we focus the analysis in the remainder of this section to the later sample from 1963 to 2010 due to data availability.

To test Prediction 1a we first confirm the standard B/M and momentum effect in our sample and then sort firms according to their capital intensity. Table 6 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 7 reports the returns for momentum sorted deciles.[18] 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 confirm the findings in the existing literature.

Table 8 reports returns for decile portfolios sorted on capital intensity (PPE/AT ratio). Returns are relatively flat across portfolios with a difference between high and low capital

[18]The momentum sorting at the end of June of year t uses the returns from July of year $t-1$ to June of year t. The portfolios are then held from July t to June $t+1$.

intensity that is insignificant and close to zero. This is true for all the three samples of firms that we consider. There does not seem to be any significant spread in return that is attributable to capital intensity, contrary to Prediction 1a.

Because the above results are based on simple one-dimensional sorts, they implicitly assume that firms have similar growth opportunities across capital intensity portfolios. One potential concern is that these portfolios are likely to have different growth opportunities, thus making the inference more difficult. To control for growth opportunities we double sort firms by capital intensity and B/M (or momentum).

Table 9 reports the capital intensity spread (i.e., the return spread between high and low capital intensity quintiles) for firms with different B/M ratios. We sort firms by B/M and, independently, by PPT/AT. Compared to the simple sort in Table 8, the capital intensity spread is always negative for all B/M ratio quintiles. This is consistent with a negative price of risk for investment shocks. However, none of the return spreads is statistically significant, and hence Prediction 1b is rejected when using B/M to control for growth opportunities. In addition, note that the capital intensity spread is relatively stronger for firms with medium B/M ratios, rather than for low B/M firms as the existing theories would suggest.

Table 10 is the "dual" of Table 9 and 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 containing all firms, the value premium is U-shaped across capital intensity quintiles: large for firms with low and high capital intensity ratios and small for firms with moderate capital intensity ratios. 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, the value premium is high for capital intensity quintiles 1, 4, and 5 and much lower (and statistically insignificant) for the second and third quintiles. This indicates that the xvalue premium is less likely driven by the investment shocks, in contradiction to Prediction 2.

Table 11 and 12 repeat the analysis for the case of momentum. Specifically, Table 11 reports capital intensity spread (the return spread between high and low capital intensity quintiles) for firms with different past 12-month returns. We construct portfolio using independent double sort. Compared to the simple sorts in Table 8, the capital intensity spread 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 unlikely to be the driving force of the momentum effect in the cross-section. This rejects Prediction 1b, when past performance is used to control for growth opportunities.

Table 12, the "dual" of Table 11, reports momentum profits (the return spread between past winners and losers quintiles) for firms with different capital intensity (PPE/AT ratio) using independent double sort. As observed for the value premium, momentum profits are also non-monotonic in capital intensity. For the sample using all firms, momentum profits are 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 momentum profits turn 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, suggesting that the momentum profits are also less likely to be driven by the investment shocks, thus contradicting Prediction 2.

In summary, the empirical evidence in this section provides little support to the hypothesis that IST shocks can explain cross sectional return phenomena such as the value premium and the profitability of momentum strategies. This finding is based on the later sample of 1963–2010 and is independent of any specific measure of investment shocks.

7 Conclusion

In this paper we assess the plausibility of the economic mechanism through which capital-embodied investment specific shock affect the cross section of equity returns.

From our analysis we obtain three main findings: (1) under the assumption that investment specific shocks are priced, the price of risk for such shocks is more likely to be positive over the 1930–2010 sample; (2) investment shocks are too small to be able to explain the large cross-sectional return patterns; and (3) the sign of the market price of risk depends on the estimation sample period (pre- vs. post 1963), thus questioning the validities of existing theories that are based on later sample estimation and calibrations.

We propose a novel set of empirical tests that account for the heterogeneity in firm's capital intensity without specifying any explicit measure of investment shocks. Our tests fail to detect any statistically significant risk premium in cross sectional returns attributable to investment-specific shocks.

Our findings, while challenging the growing literature that uses investment-specific shocks as the main source of risk to explain cross-sectional return patterns, also call for further efforts in understanding how heterogeneity in firms' investment decisions can generate cross sectional return patterns of the magnitude observed in the data.

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, as defined in equation (1). IMC is the return spread between firms in investment and consumption goods sectors. Both measures are in annual frequency. The reported statistics (in percentage) 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:	-0.60	4.26	0.74	-10.30	-0.60	10.71
1963-2010:	2.12	2.56	0.37	-6.34	2.09	6.97
1930-2010:	1.02	3.59	0.40	-10.30	1.49	10.71
Panel B: IMC						
1930-1962:	1.82	13.99	2.44	-12.85	0.46	62.24
1963-2010:	-0.06	13.90	2.01	-23.61	-1.29	44.83
1930-2010:	0.70	13.88	1.54	-23.61	0.32	62.24

Table 2: Cyclical behavior of IST shocks

This table reports correlation of investment-specific investment shocks with growth rates of consumption and output 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. Panels 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), which are all downloaded from Ken French's website. To ensure all the measures are contemporaneous, all the annual return factors correspond to a calendar year (i.e., from January to December). * and ** denote significance at the 10% and 5% levels, respectively.

Sample Period	Consumption Growth		Output Growth	Return Factors				Investment Shocks
	PCE	NDG	GDP	MKT	SMB	HML	MOM	Ishock
Panel A: Ishock								
1930-1962:	0.33*	0.32*	0.64**	0.40**	0.41**	0.44**	0.15	1.00
1963-2010:	0.01	0.04	0.21	-0.37**	-0.27*	-0.10	0.40**	1.00
1930-2010:	0.24**	0.22*	0.46**	0.05	0.06	0.19*	0.23**	1.00
Panel B: IMC								
1930-1962:	0.07	0.13	-0.06	0.62**	0.53**	0.38**	0.14	0.06
1963-2010:	0.04	0.14	0.02	0.28*	0.29**	-0.48**	-0.13	-0.02
1930-2010:	0.05	0.12*	-0.02	0.44**	0.39**	-0.12	-0.05	-0.01

Table 3: Portfolio factor loadings (betas) on IST 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											
$Ishock$	-2.97	-1.60	-1.77	-1.34	-0.17	-0.23	0.47	1.01	0.97	1.58	4.54

Table 4: IMC-beta sorted portfolios and cross-sectional regressions

This table reports returns and risk exposures for IMC-beta sorted deciles for three different sample periods. It also reports the estimated IST risk premium from Fama-MacBeth cross-sectional regressions. 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 according to the pre-ranking IMC-beta based on weekly returns from July $t-1$ to June t. The portfolio 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., January to December). The table reports the average excess returns (in percentage) relative to risk-free rate (Mean return) and univariate betas relative to Ishock and IMC returns. It also reports the Fama-MacBeth cross-sectional estimation of the IST risk premium (in percentage) based on both Ishock and IMC. The t-statistics for the IST risk premium are Newey-West adjusted with a lag length of 2.

IMC-beta Portfolios	Low	2	3	4	5	6	7	8	9	High	Risk Premium	t-stat
Panel A: 1930-1962												
Mean return:	10.6	10.1	10.2	10.8	10.3	9.6	12.6	11.7	12.3	9.1		
Ishock beta:	3.01	2.96	2.69	1.96	2.09	2.46	2.70	2.64	3.09	2.35	1.08	0.62
IMC beta:	0.57	0.87	0.85	0.87	0.60	0.84	1.01	1.24	1.74	1.55	0.83	0.35
Panel B: 1963-2010												
Mean return:	5.8	7.0	7.6	8.0	7.4	8.1	7.5	6.9	7.4	6.7		
Ishock beta:	-2.75	-2.26	-2.39	-2.49	-2.30	-2.64	-2.88	-3.10	-2.85	-3.20	0.75	0.28
IMC beta:	-0.13	-0.09	-0.19	-0.17	-0.04	0.26	0.40	0.34	0.56	1.10	-0.21	-0.09
Panel C: 1930-2010												
Mean return:	7.8	8.3	8.7	9.2	8.6	8.7	9.6	8.9	9.4	7.7		
Ishock beta:	0.62	0.83	0.67	0.22	0.34	0.52	0.40	0.31	0.64	0.24	-0.34	-0.19
IMC beta:	0.16	0.31	0.24	0.26	0.23	0.50	0.66	0.72	1.05	1.28	0.08	0.04

Table 5: Returns and risk exposures of B/M portfolios on IST 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., January to December). The table reports the average excess returns (in percentage) relative to risk-free rate (Mean return) 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 Portfolios	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:	1.98	1.19	1.70	3.31	2.96	4.02	2.93	3.41	3.35	5.14	3.15	2.37
IMC beta:	0.83	0.57	0.80	1.25	1.09	1.71	1.12	1.29	1.39	2.29	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:	-2.62	-2.65	-2.24	-2.21	-2.47	-2.88	-3.48	-4.04	-4.32	-4.37	-1.74	-1.51
IMC beta:	0.20	0.12	0.10	0.05	0.22	0.19	-0.03	0.10	0.02	0.06	-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:	0.16	-0.32	0.24	1.00	0.71	1.12	0.34	0.51	0.46	1.25	1.09	1.31
IMC beta:	0.46	0.31	0.38	0.55	0.58	0.82	0.45	0.59	0.58	0.98	0.52	2.46

Table 6: B/M 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., January to December). 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 7: 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., January to December). 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 8: 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., January to December). 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 9: PPE/AT premium for firms with different B/M ratio

This table reports PPE/AT spread (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., January to December). 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 spread.

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 10: 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., January to December). 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 11: PPE/AT premium for firms with different past returns

This table reports PPE/AT spread (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., January to December). 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 spread.

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 12: Momentum profits for firms with different PPE/AT ratio

This table reports momentum profits (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., January to December). 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 profits.

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

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