Capital Utilization, Market Power, and the Pricing of Investment Shocks

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Abstract

Capital utilization and market power crucially affect asset prices in an economy exposed to investment shocks, i.e., capital-embodied technology shocks that improve real investment opportunities. We embed these two mechanisms in a standard general equilibrium model and show that (i) the flexibility in capital utilization affects mainly the price of risk for investment shocks, and (ii) the degree of market power affects mainly the exposure of equity returns to investment shocks. We further show that, together with persistent variations in technology growth and recursive preferences, flexible capital utilization and high market power are quantitatively important for matching the observed equity risk premium.

JEL Classification Codes: E22; G12; O30
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1 Introduction

In this paper we argue that two fundamental economic mechanisms: capital utilization and market power, have important implications for the pricing of assets in financial markets. Intuitively, since flexibility in capital utilization affects how firms adjust output in response to technology changes, and the degree of market power affects how firms benefit from technology improvements, these mechanisms should also affect firms’ market values. Both mechanisms have been widely studied and featured prominently in many macroeconomic models. For example, the theory of business cycles relies on variable capital utilization for understanding comovement across macroeconomic aggregates.\(^1\) The endogenous growth literature relies on market power and monopoly rents from innovation for understanding aggregate economic growth.\(^2\) Surprisingly, the vast majority of production-based asset pricing models in finance ignore these mechanisms and assume instead that capital utilization is fixed and firms are fully competitive.\(^3\) We fill this gap and show that these economically motivated mechanisms can have both qualitative and quantitative effects on asset prices.

To highlight the importance of capital utilization and market power for asset pricing we focus our analysis on the pricing of a specific form of shocks to the economy, commonly referred to as investment-specific technology (IST) shocks or, in short, investment shocks. These shocks are widely used in economic models as important determinants of growth and business-cycle fluctuations. Unlike neutral total factor productivity (TFP) shocks that directly affect consumption, investment shocks are embodied in new capital and therefore affect consumption only through investment. As we show in the paper, this distinction between IST and TFP shocks turns out to be critical for understanding the role of capital utilization and market power on asset prices. In particular, these mechanisms have both qualitative and quantitative effects on the pricing of IST shocks, but they only have a quantitative impact on the pricing of TFP shocks. While we

\(^1\)See, among many others, Lucas (1970), Greenwood, Hercowitz, and Huffman (1988), Kydland and Prescott (1988), and Jaimovich and Rebelo (2009). The Federal Reserve estimates large procyclical variations in capacity utilization for the U.S. industrial sector (see the Federal Reserve’s G.17 release). The typical variation in capacity utilization over business cycles is around 10%. During the recent 2008-09 Great Recession, the capacity utilization rate drops from around 80% in January of 2008 to 67% in June of 2009, and then bounces back to 79% in June of 2014. Similar fluctuations are observed over business cycles in other periods.

\(^2\)See, e.g., Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). Aghion and Howitt (1998) and Acemoglu (2010) provide excellent surveys of the endogenous growth literature. The existence of monopoly power in the U.S. economy is a well-established fact. In a seminal study of the relation between market structure and macroeconomic fluctuations, Hall (1986, p. 286) concludes that: “These findings support the view of the monopolistic competition originally proposed by Edward Chamberlin. Through product differentiation or geographical separation, firms have market power in their own market.”

\(^3\)Monopolistic competition is featured in recent models that study the asset pricing implications of endogenous growth, see, e.g., Kung and Schmid (2015), Kung (2015), and Bena, Garlappi, and Grünig (2015). To the best of our knowledge, we are the first to highlight explicitly the importance of market power on the pricing of technology shocks. Moreover, while these existing models focus on total factor productivity, our focus is on the pricing of investment shocks.
analyze both types of shocks, our discussion in the paper will emphasize the novel aspects that we can learn from the study of IST shocks.

The key insights from our analysis are: (i) the flexibility in capital utilization affects mainly the price of risk for IST shocks, and (ii) the degree of market power affects mainly the exposure of equity returns to IST shocks. Specifically, the price of risk for IST shocks is positive under flexible capital utilization, but negative under fixed capital utilization. Similarly, the equity return exposure to IST shocks is positive under high market power, but negative under perfect competition. Our analysis further shows that, together with persistent variations in technology growth and recursive preferences, flexible capital utilization and high market power are quantitatively important for matching key macroeconomic and asset pricing moments.

Our model builds on a standard two-sector real business cycle model with investment shocks in which we allow for: (i) flexible capital utilization, which we model as variable capital utilization rates that affect both the output and the depreciation cost of equipment (see Jaimovich and Rebelo (2009)), and (ii) market power, which we model as monopolistic competition among intermediate goods producers (see Dixit and Stiglitz (1977)). Flexible capital utilization allows us to study the effect of IST shocks not only on the accumulation of new capital, but also on the utilization of existing old capital. Because we focus on the pricing of financial assets, the household’s preferences crucially affect our results. Therefore, we study the effects of households’ attitude towards the distribution of consumption over time and across states separately, by assuming that preferences are recursive (see Kreps and Porteus (1978) and Epstein and Zin (1989)). We solve for an equilibrium allocation in this economy and derive implications for the price of risk for technology shocks and the risk premium of the aggregate market portfolio.

Our first result is that flexibility in capital utilization affects mainly the price of risk for IST shocks. To illustrate the main intuition, consider the simpler case of time-separable constant relative risk aversion (CRRA) preferences, where households’ marginal utility depends only on current consumption and not future utility. In this case, if the consumption smoothing desire is not strong, fixed capital utilization implies a negative market price of risk for IST shocks. A positive IST shock, by increasing the productivity of the investment sector, diverts labor from the consumption to the investment sector. The drop in labor in the consumption sector induces a drop in current consumption and an increase in the household’s marginal utility, leading to a negative price of risk for IST shocks. In contrast, when capital utilization is flexible and endogenously determined in equilibrium, the market price of risk for IST shocks can be positive. With variable capital utilization, a positive IST shock makes capital cheaper to replace and hence increases the utilization of existing capital at the expense of faster capital depreciation. The increase in capital utilization counterbalances the decline in labor supply. When capital utilization is sufficiently responsive to IST shocks, the capital utilization effect dominates, causing
a net increase in consumption, a decline in marginal utility, and hence a positive price of risk for IST shocks. As we discuss below, a strong consumption smoothing desire has a similar effect as flexible capital utilization on the price of risk for IST shocks.

Our second result is that the degree of market power affects mainly the exposure of equity returns to IST shocks, or, in short, market IST beta. Specifically, when firms are perfectly competitive, the market IST beta is negative. A positive IST shock implies a drop in the price of capital. Since in perfectly competitive markets a firm’s value is determined by the replacement cost of its capital stock (see Hayashi (1982)), a drop in the price of capital good implies a drop in the firm value. In contrast, when firms retain some degree of market power, firms’ value includes also monopoly rents from markups. Following a positive IST shock, the increase in rents originating from lower investment cost can more than compensate the decline in value of installed capital. That is, when firms have market power, the market IST beta can be positive.

Our third result is that the asset pricing implications of capital utilization and market power discussed above are crucially shaped by households’ preferences. In our model, households have Epstein-Zin preferences and therefore their marginal utility depends on both current consumption and future utility. If households have preferences for early resolution of uncertainty, a positive IST shock leads to a higher future utility and a lower marginal utility, thereby resulting in a positive price of risk for IST shocks. The opposite is true if households have preference for late resolution of uncertainty. Our model allows us to study the interaction of this preference effect with the effects of capital utilization and market power discussed above. In particular, we show that flexible capital utilization and preference for early resolution of uncertainty reinforce each other in generating a positive price of risk for IST shocks. Moreover, market power leads to positive market IST betas only when the elasticity of intertemporal substitution (EIS) is sufficiently high. With low EIS, the strong wealth effect leads to a decline in labor supply and an increase in firms’ labor cost following a positive IST shock. This in turn leads to a drop in firm value and hence a negative market IST beta.

Our final result is that the effects of capital utilization and market power discussed above are also quantitatively important. In order to generate equity risk premia comparable to the data, we introduce small, persistent components in technology growth, following the long-run risks literature (see, e.g., Bansal and Yaron (2004) and Croce (2014)). We show that flexible capital utilization and high market power, along with preference for early resolution of uncertainty (high EIS), can quantitatively match the key macroeconomic and asset pricing moments observed in the U.S. data. In particular, our calibrated benchmark model generates an annual risk-free rate of 0.9% and an annual equity risk premium of 5.65%. Without flexible utilization and market power, the same parametrization delivers a higher annual risk-free rate of 1.29% and a counterfactual annual equity risk premium of −2.43%. Our analysis also shows that the contribution of short-run
risks to the risk premium is much smaller than that of the persistent components in technology growth. In our benchmark calibration, the short-run and long-run risks contribute respectively 14% and 86% to the total equity risk premium. This finding is consistent with the existing literature which shows that the standard production-based models have difficulty in generating high equity risk premium without long-run risks (see, e.g., Croce (2014)).

The findings of this paper shed light on the conflicting evidence in the existing literature regarding pricing implications of IST shocks. On the one hand, Kogan and Papanikolaou (2013, 2014) argue that a negative price of risk for IST shocks is needed to explain the value premium and several other cross sectional return patterns, and Papanikolaou (2011) predicts a negative exposure of equity returns to IST shocks. On the other hand, Li (2013) argues that a positive price of risk for IST shocks is needed to explain the profitability of momentum strategies. To better understand these conflicting arguments, Garlappi and Song (2015) analyze the pricing of IST shocks over a long sample period from 1930 to 2012 and find empirical evidence that supports both a positive price of risk for IST shocks, and a positive market IST beta. These empirical findings can be explained by the economic mechanisms discussed in this paper.\(^4\)

Our work is related to a large literature that studies the macroeconomic and asset pricing implications of IST shocks.\(^5\) Since the work of Solow (1960), IST shocks have become an important feature of the macroeconomics 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. Greenwood, Hercowitz, and Huffman (1988) show that variable capital utilization is important to generate positive correlation between consumption and investment as in the data. Jaimovich and Rebelo (2009) use IST shocks and capital utilization in a two-sector economy similar to ours, in order to study the effect of news on the business cycle. Christiano and Fisher (2003) explore the implications of IST shocks for aggregate asset prices and business cycle fluctuations. Papanikolaou (2011) studies the implications of IST shocks for asset prices in both the aggregate and the cross-section. Our work differs from this literature in that we investigate the equilibrium implications of capital utilization and market power on the relationship between IST shocks and asset prices.

\(^4\) Garlappi and Song (2015) further document that the empirical estimates of the price of risk for IST shocks and market IST betas are sensitive to the sample period, the testing assets, and the econometric model specification. Since capital utilization and market power have a qualitative impact on the pricing of IST shocks, time variation in the effect of these mechanisms can potentially explain some of the sensitivities observed in the data.

\(^5\) Neutral productivity shocks are the main driving force in the large literature that explores the implications of real business cycles on asset prices (see, for example, Jermann (1998), Tallarini (2000), Boldrin, Christiano, and Fisher (2001), Gomes, Kogan, and Yogo (2009)), and in the investment-based asset pricing literature (see, for example, Cochrane (1991, 1996), Berk, Green, and Naik (1999), Gomes, Kogan, and Zhang (2003), Carlson, Fisher, and Giammarino (2004), Zhang (2005), Liu, Whited, and Zhang (2009)). Other studies that explore the general equilibrium implications of technology innovations on asset prices include Garleanu, Kogan, and Panageas (2012), Garleanu, Panageas, and Yu (2012), Loualiche (2015), and Kogan, Papanikolaou, and Stoffman (2015).
Our paper is also related to the long-run risks literature, pioneered by Bansal and Yaron (2004). Kaltenbrunner and Lochstoer (2010) generate endogenous long-run consumption risk in a standard production economy with Epstein-Zin preferences. Croce (2014) empirically documents the existence of a predictable component in U.S. productivity growth and shows a production-based model with long-run risks can generate high equity risk premium. Kung and Schmid (2015) and Bena, Garlappi, and Grüning (2015) show how innovation and R&D endogenously drives a small, persistent component in the aggregate productivity (TFP), which generates long-run uncertainty about economic growth. All these models focus on long-run risks in TFP shocks. To the best of our knowledge, we are the first to study the theoretical implications of long-run risk in IST shocks.

The rest of the paper proceeds as follows. In Section 2 we describe our two-sector general equilibrium model. We present the qualitative analysis of the economic mechanisms in Section 3. In Section 4 we calibrate the model and discuss its implications for macroeconomic quantities and asset prices. Section 5 concludes. Appendix A contains details on the model solution and Appendix B describes the data used in our analysis.

2 A two-sector general equilibrium model

In this section, we build a two-sector general equilibrium model to study the pricing impact of capital utilization and market power on asset prices. We study an economy where households have recursive preferences and production is undertaken by firms operating in two sectors: the consumption sector (C-sector) and the investment sector (I-sector). Firms optimally adjust their capital utilization and retain some degree of market power. Our model nests the cases of fixed capital utilization and perfect competition as limiting cases.

2.1 Households

Time is discrete and infinite. Markets are complete, implying the existence of a representative agent in the economy. Infinitely-lived households derive lifetime utility, $U_t = U(\{C_s, L_s\}_{s \geq t})$, from consumption $C_s$ and labor supply $L_s$, according to the following recursive structure (Epstein and Zin (1989, 1991), and Weil (1989)):

$$U_t = \left\{ (1 - \beta) \left[ C_t (1 - \psi L_t^\theta) \right]^{1 - \rho} + \beta (E_t U_{t+1}^{1 - \gamma})^{\frac{1}{1 - \gamma}} \right\}^{\frac{1}{1 - \rho}},$$

where $\beta$ is the time discount rate, $1/\rho$ is the EIS, and $\gamma$ is the coefficient of relative risk aversion (RRA hereafter). The parameters $\psi$ and $\theta$ measure, respectively, the degree and sensitivity of
disutility to working hours. The recursive utility (1) reduces to time-separable CRRA utility when \( \rho = \gamma \), and, in particular, it belongs to the class of preference for consumption and leisure discussed in King, Plosser, and Rebelo (1988).

Households supply labor \( L_t^C \) and \( L_t^I \) to the C- and I-sector respectively. The total working hours \( L_t \) is the sum of the working hours in the two sectors, that is, \( L_t = L_t^C + L_t^I \). The labor market is perfectly competitive and frictionless.

To maximize their life-time utility, households solve the following problem:

\[
V_t = \max_{\{C_s, L_s\}_{s=t}^{\infty}} U_t, \quad \text{s.t.} \quad P_s^C C_s = W_s L_s + D_s^C + D_s^I, \quad s \geq t,
\]

where \( P_s^C \) is the price of consumption good at time \( s \),\(^6\) \( W_s \) is the market wage, and \( D_s^C \) and \( D_s^I \) are the dividends paid, respectively, by the C- and I-firms, defined formally in (15) below.

From the household optimization, by a standard argument, we obtain the stochastic discount factor (SDF) in the economy. The one-period-ahead SDF at time \( t \), \( M_{t,t+1} \), which is the marginal rate of substitution between time \( t + 1 \) and time \( t \), is given by,

\[
M_{t,t+1} = \beta \left( \frac{C_{t+1}}{C_t} \right)^{-\rho} \left( \frac{1 - \psi L_{t+1}^\theta}{1 - \psi L_t^\theta} \right)^{1-\rho} \left( \frac{V_{t+1}}{(\mathbb{E}V_{t+1}^1)^{1-\gamma}} \right)^{\rho-\gamma}.
\]

### 2.2 Firms and technology

There are two productive sectors in the economy: the C-sector, producing the consumption good and the I-sector, producing the capital good. Labor and the capital good are inputs for both sectors.

Final consumption and investment good producers take intermediate goods as input and produce the final good as output in their respective sectors. The final good is produced according to the following constant elasticity of substitution (CES) technology:

\[
Y_t^J = \left[ \sum_{f=1}^{N_J} (x_{f,t}^J)^{\nu_J-1} \right]^{\nu_J / (\nu_J - 1)}, \quad J = C, I,
\]

where \( x_{f,t}^J \) is the input of intermediate good of type \( f \) in sector \( J \), and \( \nu_J \) is the elasticity of substitution between any two intermediate goods. \( N_J \) is the total number of types of intermediate goods, which we assume to be large enough to abstract away from strategic considerations. All the final output in the C-sector is used for consumption \( (C_t = Y_t^C) \) and all the final output in the I-sector is used for investment \( (I_t = Y_t^I) \). We assume that the final good producers are

\(^6\)For convenience, we choose the final consumption good as numeraire by setting \( P_t^C \equiv 1 \) for all \( t \).
perfectly competitive and so they make zero net profit in equilibrium. The final good producer’s demand $x^I_{f,t}$ of intermediate good of type $f$ at time $t$ is determined by an intra-temporal profit maximization, i.e.,

$$\max_{x^I_{f,t}} P^I_t Y^I_t - \sum_{j=1}^{N_J} p^I_{f,t} x^J_{f,t}, \quad J = C, I,$$

(5)

where $Y^I_t$ is given by (4) and the prices $P^I_t$ and $p^I_{f,t}$ of, respectively, the final and intermediate good of type $f$ are taken as given. Solving (5) yields the following demand for each type of intermediate good:

$$x^I_{f,t} = \left( \frac{P^I_t}{P^J_t} \right)^{-\nu_J} Y^I_t, \quad J = C, I$$

(6)

where the price of the final good is $P^I_t = \left[ \sum_{j=1}^{N_J} (p^I_{f,t})^{1-\nu_J} \right]^{\frac{1}{1-\nu_J}}, \quad J = C, I$.

The CES parameter $\nu_J$ measures the degree of substitutability among intermediate goods and provides a tractable way to model intermediate good firms’ market power. Perfect competition corresponds to the limiting case $\nu_J \to \infty$. In this case the intermediate goods are perfect substitutes, and we have only one type of intermediate good which is also the final good. For finite value of $\nu_J$, the intermediate goods are not perfect substitutes. As a result, each monopolistic firm has some degree of market power in the product market. As we show in Appendix A, under the constant return to scale production technology specified below in equations (7) and (8), each intermediate good firm incurs costs of labor and capital which is a fraction $(\nu_J - 1)/\nu_J$ of the corresponding benefits.\footnote{Equivalently, the total benefit from output is a multiple $\nu_J/(\nu_J - 1) > 1$ of the total cost to input. Therefore, each firm effectively charges a constant net markup equal to $1/(\nu_J - 1)$ of the cost to labor and capital input, which represents the firm’s monopolistic rent. Note that an infinite $\nu_J$ implies no markup, or no market power for perfectly competitive firms. On the other hand, a lower value of $\nu_J$ implies a higher markup, or more market power for the monopolistic firms.}

Specifically, see the first-order conditions (A6) and (A12) for labor and the first-order conditions (A8) and (A14) for capital utilization in the two sectors.
\[
\begin{align*}
y^C_{f,t} &= A_t(u^C_{f,t}k^C_{f,t})^{1-\alpha^C}(t^C_{f,t})^{\alpha^C}, \\
y^I_{f,t} &= A_t Z_t(u^I_{f,t}k^I_{f,t})^{1-\alpha^I}(t^I_{f,t})^{\alpha^I},
\end{align*}
\]

where \( A_t \) is total factor of productivity (TFP), \( Z_t \) is an investment-specific productivity shock, and \( u^I_{f,t} > 0 \) is the intensity of capital utilization. The I-sector specific shock \( Z_t \) affects directly the investment output in the I-sector and it impacts the C-sector through investment in new capital. Therefore, we refer to \( Z_t \) as an investment-specific technology (IST) shock.

The capital utilization intensity variable \( u^I_{f,t} > 0 \) captures the duration, or speed, in operating existing equipment. For example, a high level of \( u^I_{f,t} \) may represent less maintenance time or longer working hours. If we normalize the capital utilization to be \( u^I_{f,t} = 1 \) at “normal” times (steady state), then a capital utilization higher than one means that the equipment is more intensively used comparing to normal times.

The technology shocks \( A_t \) and \( Z_t \) follow geometric random walks with growth:

\[
\begin{align*}
\Delta a_t &= \bar{\mu}^a + \mu^a_{t-1} + \varepsilon^a_t, \quad \varepsilon^a_t \sim i.i.d. N(0, \sigma^2_a), \\
\Delta z_t &= \bar{\mu}^z + \mu^z_{t-1} + \varepsilon^z_t, \quad \varepsilon^z_t \sim i.i.d. N(0, \sigma^2_z),
\end{align*}
\]

where \( \Delta a_t \equiv \log(A_t/A_{t-1}) \), \( \Delta z_t \equiv \log(Z_t/Z_{t-1}) \), \( \bar{\mu}^a \) and \( \bar{\mu}^z \) are constant, and \( \mu^a_{t-1} \) and \( \mu^z_{t-1} \) represent possibly time-varying expected growth in the TFP and IST shocks.\(^9\) We assume that the shocks \( \varepsilon^a_t \) and \( \varepsilon^z_t \) are uncorrelated.

Each firm can purchase the investment good and increase its capital stock. The evolution of capital for firm \( f \) is given by

\[
k^J_{f,t+1} = k^J_{f,t}(1 + i^J_{f,t} - \delta(u^J_{f,t})), \quad J = C, I,
\]

where \( i^J_{f,t} \) denotes the investment rate and the depreciation rate \( \delta(u^J_t) \) depends explicitly on the capital utilization intensity \( u^J_{f,t} \). The dependence of depreciation on the capital utilization captures the cost of increasing utilization and ensures that firms only choose a finite utilization intensity of their capital.

We follow Jaimovich and Rebelo (2009) and specify a depreciation function that has a constant elasticity of marginal depreciation with respect to capital utilization, i.e.,

\[
\delta(u^J) = \delta_0 + \delta_1 \frac{u^{1+\xi^J} - 1}{1 + \xi^J}, \quad \xi^J > 0, \quad J = C, I,
\]

\(^9\)In the qualitative analysis of Section 3 we assume \( \mu^a_{t-1} \) and \( \mu^z_{t-1} \) to be zero. That is, the growth rates are constant. In the quantitative analysis of Section 4 we model these processes as mean reverting, following the long-run risks literature (e.g., Croce (2014)).
where $\delta_0$ corresponds to the depreciation rate under unit capital utilization, i.e., $\delta(1) = \delta_0$. The parameter $\xi^J$ measures the elasticity of marginal depreciation with respect to capital utilization, i.e., $\xi^J = \delta''(u^J)w^J/\delta'(u^J)$. A higher $\xi^J$ means that capital depreciation, i.e., the marginal cost of capital utilization, is very sensitive to the degree of utilization. In other words, a higher $\xi^J$ makes increasing capital utilization more costly. In contrast, a lower $\xi^J$ implies that capital utilization is very responsive to exogenous shocks. Therefore, the parameter $\xi^J$ measures the inflexibility of firms’ capital service in response to shocks.

The investment in new capital is subject to a convex capital adjustment cost. Specifically, to increase capital by an amount $i^J k^J$, firms need to purchase $\varphi(i^J) k^J$ units of capital goods. Following Jermann (1998), we parameterize the adjustment cost function as

$$
\varphi(i^J) = i^J + \frac{1}{\phi^J} (1 + i^J) \left[ \left( \frac{1 + i^J}{1 + i^{J*}} \right)^{\phi^J} - 1 \right], \quad \phi^J \geq 1, \quad J = C, I,
$$

where $\phi^J$ captures the degree of the adjustment cost and $i^{J*}$ denotes the steady-state level of investment. According to (13) the adjustment cost is zero in the steady-state. The cases $\phi^J = 1$ and $2$ correspond, respectively, to no adjustment cost and quadratic adjustment cost.

Each firm makes optimal hiring, investment, and capital utilization decisions in order to maximize its market value, i.e., the present value of dividends, given the level of wages, $W_t$, the price of capital good, $P^I_t$, and the stochastic discount factor, $M^t_{t,t+1}$. Importantly, in solving its maximization problem, firm $f$ takes as given the demand $x^J_{f,t}$ of intermediate good $f$ derived in (6). Specifically, the firm producing intermediate good $f$ solves the following problem:

$$
V_{f,t}^J = \max_{\{l^J, i^J, u^J\}_{s=t}^{\infty}} \mathbb{E}_t \sum_{s=t}^{\infty} M^t_{t,s} d_{f,s}^J, \quad \text{s.t.} \quad d_{f,s}^J = p_{f,s}^J y_{f,s}^J - W_s l_{f,s}^J - P_{s}^I \varphi(i_{f,s}^J) k_{f,s}^J, \quad J = C, I,
$$

where $d_{f,s}^J$ is firm $f$’s dividend at time $s$, and $M^t_{t,s}$ is the time-$t$ SDF for time-$s$ payoffs, obtained from the one-period SDF in (3) as $M^t_{t,s} = \prod_{k=t}^{s-1} M_{t+k,t+k+1}$. Note that, according to equation (6), the price of type $f$ intermediate good, $p_{f,t}^J$, depends on the quantity of intermediate good $f$. Therefore, by choosing the output quantity $y_{f,t}^J$ that satisfies the demand $x_{f,t}^J$ (i.e., $x_{f,t}^J = y_{f,t}^J$), each firm $f$ also effectively sets the price for its product, $p_{f,t}^J$.

Summing across all firms in each sector we obtain the sectoral market capitalizations

$$
V^J_t = \sum_{f=1}^{N_J} V_{f,t}^J = \mathbb{E}_t \sum_{s=t}^{\infty} M^t_{t,s} D_s^J, \quad \text{s.t.} \quad D_s^J = \sum_{f=1}^{N_J} d_{f,s}^J, \quad J = C, I,
$$

where the dividend $d_{f,s}^J$ is given by (14). The cum-dividend value of the aggregate market portfolio is the sum of the market capitalization of the two sectors,
\[ V^M_t = V^C_t + V^I_t. \]  

### 2.3 Equilibrium

In equilibrium, all markets have to clear. For the C-sector, the market clearing condition is \( C_t = Y^C_t \), where \( Y^C_t \) is given in (4). For the I-sector, we need to account for the fact that the final investment good is used for capital investment in both sectors. This implies the following market clearing condition for the final investment good:

\[
\sum_{f=1}^{N^C} \phi(i_{f,t}) k_{f,t}^C + \sum_{f=1}^{N^I} \phi(i_{f,t}) k_{f,t}^I = Y^I_t, \tag{17}
\]

where \( Y^I_t \) is given in (4).

Since all firms in each sector are affected by the same technological shocks, in equilibrium they have identical product prices, quantities, investment, labor, capital utilization choices, and firm values. This symmetry helps us to construct the following measures of aggregate capital, labor and output in the economy for each sector (\( J = C, I \)):

\[
K^J_t = N_J \cdot k^J_{f,t}, \quad L^J_t = N_J \cdot l^J_{f,t}, \quad P^J_t Y^J_t = N_J \cdot p^J_{f,t} y^J_{f,t}, \text{ and } Y^J_t = (N_J)^{\frac{\nu_J}{\nu_J - 1}} \cdot y^J_{f,t}. \tag{18}
\]

The equilibrium of the economy is determined by the solution of the households’ problem (2) and the firms’ problems (14). The equilibrium conditions derived from these problems are given in Appendix A, where we also show that the equilibrium is stationary after a suitable renormalization of all variables.

### 2.4 Asset prices

In this section, we focus our analysis on two specific quantities of interests for asset pricing: the market price of risk and the risk premium for the market portfolio associated with technology shocks. We describe our approach to study the implications of technology shocks on equilibrium asset prices and the contribution of each shock to the equity risk premium.

The economy we consider features two aggregate shocks: a neutral TFP shock, \( A_t \), and an IST shock, \( Z_t \). Projecting the log SDF process (3) on the space spanned by these shocks, we can write:

\[
m_{t,t+1} = \log(M_{t,t+1}) = E_t m_{t,t+1} - \frac{\lambda^a}{\sigma^2_a} \cdot \epsilon^a_{t+1} - \frac{\lambda^z}{\sigma^2_z} \cdot \epsilon^z_{t+1}, \tag{19}
\]
where $\varepsilon_{t+1}^a$ and $\varepsilon_{t+1}^z$ are orthogonal to each other. The quantities $\lambda_{t}^a$ and $\lambda_{t}^z$ are the market prices of risk for, respectively, the TFP shock $A_t$, and the investment specific shock $Z_t$.

From the SDF equation (19), the market price of risk for each shock is given by

$$\lambda_{t}^x = -\sigma_{x}^2 \frac{\partial m_{t,t+1}}{\partial \varepsilon_{t+1}^x}, \quad x = a, z.$$  (20)

Hence, the market price of risk of a shock is positive (negative) if a positive shock $\varepsilon_{t+1}^x > 0$ causes a decrease (increase) in the marginal utility of consumption of the representative household.

To analyze risk premia associated with these shocks, consider a similar projection of the log return $r_{j,t+1}$ of a generic asset $j$ on the space spanned by these shocks, i.e.,

$$r_{j,t+1} = \mathbb{E}_t r_{j,t+1} + \beta_{j,t}^a \varepsilon_{t+1}^a + \beta_{j,t}^z \varepsilon_{t+1}^z.$$  (21)

Accounting for the Jensen’s inequality adjustment, the log risk premium on asset $j$ can be written as

$$\mathbb{E}_t (r_{j,t+1} - r_{f,t} + \sigma_{j}^2/2) = -\text{cov}_t (m_{t,t+1}, r_{j,t+1}) = \beta_{j,t}^a \lambda_{t}^a + \beta_{j,t}^z \lambda_{t}^z,$$  (22)

where $r_{f,t}$ is the log risk-free rate from $t$ to $t + 1$, $\sigma_{j}$ is the volatility of asset $j$’s log returns, and the equality follows from (19) and (21) and the orthogonality of the shocks $\varepsilon_{t+1}^a$ and $\varepsilon_{t+1}^z$. Therefore, the risk premium associated with each shock ($x = a, z$) is the product of the ‘quantity’ of risk ($\beta^x$) and the ‘price’ of risk ($\lambda^x$).

Applying the above decomposition to the return of market portfolio, we have,

$$RP_{M,t} = \beta_{M,t}^a \lambda_{t}^a + \beta_{M,t}^z \lambda_{t}^z,$$  (23)

where the loadings are given by

$$\beta_{M,t}^x = \frac{\partial r_{M,t+1}}{\partial \varepsilon_{t+1}^x} = \frac{\partial \log(V_{t+1}^M)}{\partial \varepsilon_{t+1}^x}.$$  (24)

Therefore, $RP_{M,t}^x = \beta_{M}^x \lambda^x$ is the contribution of each shock $X = A, Z$ to the aggregate equity risk premium.

3 Qualitative analysis

In this section we illustrate how market power and flexible capital utilization affect the pricing of investment specific shocks. To isolate the unique effect of these two channels, in the analysis that follows we consider the simpler case with constant growth rates of TFP and IST shocks.
That is, we set

\[ \mu_t^a = 0, \quad \text{and} \quad \mu_t^z = 0, \]  

(25)
in the specifications (9) and (10). We relax this assumption and consider time varying expected growth in technology in the quantitative analysis of Section 4.

To highlight the effect of households’ preference, we first consider the case of time-separable, constant relative risk aversion (CRRA) utility in Section 3.1 and then discuss the more general case of Epstein-Zin preferences in Section 3.2. The latter case allows us to investigate households’ preference towards the temporal resolution of uncertainty, as captured by the difference between the parameter \( \rho \), representing the inverse of the EIS and \( \gamma \), the RRA parameter.

### 3.1 CRRA utility

By setting \( \rho = \gamma \) in (1), households’ preferences have the following CRRA representation:

\[ U_t = \sum_{j=0}^{\infty} \beta^j \left[ C_{t+j}(1 - \psi L_{t+j}^\theta) \right]^{1-\gamma} \frac{1}{1-\gamma}. \]  

(26)

This preference specification implies that the SDF in (3) takes the simpler form:

\[ M_{t,t+1} = \beta \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} \left( \frac{1 - \psi L_{t+1}^\theta}{1 - \psi L_t^\theta} \right)^{1-\gamma}. \]  

(27)

#### 3.1.1 The effect of flexible capital utilization

Figure 1 reports the impulse response functions (IRFs) of log consumption (logC), log labor supply (logL), log SDF (logSDF) and log aggregate market value (log \( V^M \)) to one standard deviation shock to \( Z_t \). The solid lines refer to the case of flexible capital utilization (\( \xi^C = \xi^I = 0.3 \) in the depreciation function (12)) while the dashed lines refer to the case in which capital utilization is fixed (which we approximate by setting \( \xi^C = \xi^I = 3000 \) in (12)). We consider the case of a household with log preferences, that is, \( \gamma = 1 \) in (26) and therefore EIS = 1/\( \rho \) = 1. The firms are fully competitive, which we approximate by setting \( \nu_C = \nu_I = 40000 \) in the final good production technology (4).

The top panel shows that capital utilization flexibility has a direct impact on the consumption reaction to IST shocks. Because the capital stock at time \( t \) is determined in period \( t-1 \), when capital utilization is fixed (dashed line), only labor supply to the consumption sector can affect

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Note the slight abuse of notation in (26) where \( U_t \) represents the quantity \( U_t^{1-\gamma} \) in (1). Furthermore, the utility in (1) corresponds to (26) only after rescaling it by the factor \((1-\beta)(1-\gamma)\). This rescaling does not affect households’ preference towards consumption and leisure.
consumption output. Upon a positive I-sector shock at time \( t \), workers with relatively high EIS (equal to one in this example) would prefer to work in the more productive I-sector, thereby leading to a drop in the labor for the C-sector.\(^{11}\) In other words, households are willing to decrease current consumption in expectation of higher expected future consumption and work longer to take advantage of the increased productivity in the investment sector. This leads to an increase in the marginal utility and a higher SDF. The price of risk for IST shocks is therefore negative: households are willing to accept a return less than the risk-free rate to hold a security that pays off when marginal utility is high. The increase in supply of the capital good produced by the I-sector lowers the capital good price. Because a firm’s value is equal to the replacement cost of its capital stock, a drop in the price of capital leads to a drop in firm value and hence in the value of the market portfolio \( V^M \).

In contrast, when capital utilization is flexible (solid line), upon a positive shock to the I-sector specific technology, firms have an incentive to increase the intensity of capital utilization because the user (or replacement) cost of capital is lower. All else being equal, a higher utilization of capital induces more consumption output, a lower SDF and a positive price of risk.\(^{12}\) Since the firm value is determined by the price of capital goods—which declines after a positive IST shock—flexible capital utilization only has quantitative impact on the magnitude of drop in the market value \( V^M \).

### 3.1.2 The effect of firms’ market power

Figure 2 reports the same IRFs as those in Figure 1 but focuses on the effect of market power. The dashed lines refer to the case in which firms are perfectly competitive, that is, they have zero markup; the solid lines refer to the case of monopolistically competitive firms. We approximate the perfectly-competitive case by setting the elasticity parameter \( \nu_C = \nu_I = 40000 \) in the production function (4) and we model the case of market power by setting \( \nu_C = \nu_I = 4 \), corresponding to a markup of 33\%. Capital utilization is flexible in both cases (\( \xi_C = \xi_I = 0.3 \)).

Compared to Figure 1, the market power has only quantitative effects on consumption (the top panel), labor supply (the second panel), and SDF (the third panel), but it has a qualitative impact on the market portfolio value (the bottom panel). Specifically, the market value drops if firms are perfectly competitive (dashed line), while it increases if the firms have market power (solid line). When firms are perfectly competitive, their value is determined by the replacement cost of capital. Since a positive IST shock decreases the capital good price, it also reduces the

\(^{11}\)Under the preferences specification for consumption and leisure in (1) and (26), in response to an IST shock, the total number of working hours \( L_t \) moves always in the opposite direction as that of the working hours \( L^C_t \) of the C-sector (see, e.g., Jaimovich and Rebelo (2009)).

\(^{12}\)Note that, because Figure 1 refers to the case of log utility, the SDF in (27) depends only on consumption and not on labor.
value of competitive firms’ existing capital. However, if firms have market power, their market value is determined not only by the replacement cost of existing capital but also by monopoly rents. In this case, the decrease in new capital good price upon a positive IST shock increases the value of the future markups. Therefore, firms’ market power has a direct effect on the market portfolio’s response to IST shocks.

3.1.3 The effect of elasticity of intertemporal substitution

Figure 3 reports the same IRFs as in the previous two figures but focuses on the role of EIS. The solid line refer to the case of EIS = 1.0 and the dashed line refers to the case of EIS = 0.2. Capital utilization is fixed and firms are perfectly competitive.

The figure shows that the value of EIS has a direct impact on the response of consumption, labor supply, and SDF to IST shocks. In particular, upon a positive IST shock, consumption decreases under high EIS, but increases under low EIS. The opposite is true for the labor supply (second panel). As a result, the SDF increases under high EIS (IST risk has a negative price), but decreases under low EIS (IST risk has a positive price). The intuition is that under CRRA utility, EIS measures the households desire to substitute consumption across time. When EIS is low, households have a stronger preference for consumption smoothing. Upon a positive IST shock, all else equal, future consumption increases. To smooth consumption, household with low EIS would choose to have higher consumption today. Similarly, household would like to work less and increase leisure, in order to smooth their utility across time.

In contrast, when the EIS is high, households are willing to decrease current consumption and increase current labor supply in anticipation of a higher future consumption. Therefore, the consumption (or utility) smoothing motive explains the reaction of consumption, labor supply, and SDF to IST shocks. Note finally that the EIS has only quantitative effect on the market value response to IST shocks: a positive IST shocks leads to a drop in the capital good price, independent of the level of EIS, and, consequently, a drop in the aggregate market value $V^M$.

3.2 Epstein-Zin preference

In the above analysis, we establish that when households have time-separable CRRA preferences, the intensity of the household desire to smooth consumption over time, captured by the EIS parameter, affects the pricing of IST shocks. When households’ preferences are not time-separable, an additional concern arise, namely, the attitude towards the timing of resolution of uncertainty. In the Epstein-Zin recursive utility formulation (1), households’ preference towards early vs. late resolution of uncertainty is captured by the difference $\rho - \gamma$, where $\rho = 1/EIS$ and $\gamma$ is RRA.
Households prefer early (late) resolution of uncertainty if $\rho < \gamma$ ($\rho > \gamma$). In this subsection we show that this property of preferences is an important channel for the pricing of IST shocks.

### 3.2.1 Preference towards temporal resolution of uncertainty

Figure 4 reports the same IRFs considered in Figures 1–3 above. In the figure we focus on households’ preference towards temporal resolution of uncertainty and report three separate cases: preference for early resolution (solid line), indifference between early and late resolution of uncertainty (dotted line), and preference for late resolution (dash-dotted line).

The top panel shows that consumption drops under indifference or preference towards early resolution of uncertainty, while it increases under preference for late resolution of uncertainty. Because $\gamma$ is fixed in Figure 4, different values of $\rho - \gamma$ correspond to different values in EIS. Labor supply, in the second panel, exhibits an opposite pattern to consumption. Therefore the effect on consumption and labor is identical to the EIS effect discussed in Figure 3.

With recursive preferences, however, the response of SDF to a change in consumption is not necessarily the opposite of a response to consumption and leisure, as in the case of CRRA preference. For example, in the third panel of Figure 4, when household prefer late resolution of uncertainty ($\rho > \gamma$) consumption increases upon a positive IST shock (as in the case of $EIS = 0.2$ for CRRA preferences in Figure 3) but, unlike the CRRA case, SDF also increases. The reason for this lies in the structure of the SDF equation (3) implied by recursive preferences. The preference towards the temporal resolution of uncertainty $\rho - \gamma$ directly affects the “continuation” utility part of the SDF, captured by the term:

$$\left( \frac{V_{t+1}}{(E_t V_{t+1})^{\frac{1}{1-\gamma}}} \right)^{\rho-\gamma}$$

in Equation (3). Upon a positive IST shock, the continuation utility $V_{t+1}$ is higher than expected. If $\rho > \gamma$, that is, households prefer late resolution of uncertainty, the increased continuation utility increases the SDF. The opposite is true if $\rho < \gamma$.

The bottom panel of Figure 4 shows that market value drops in all three cases, because the value of existing capital drops. Note, however, that a lower value of $\rho - \gamma$ (preference towards early resolution of uncertainty) makes the drop in firm value smaller. When households prefer early resolution of uncertainty, the wealth effect of IST shocks is smaller than the substitution effect and they are willing to supply more labor in response to a positive IST shock (second panel). As a result, all else equal, firms benefit from a smaller increase in labor costs and therefore smaller drop in the firm value.
### 3.2.2 The joint effect of preferences, market power and capital utilization

In the above analysis, we discussed how each of the three channels (market power, capital utilization, and households’ preferences) separately affects qualitatively the pricing of IST shocks. In particular, we show that while the price of risk (inferred from the IRF of logSDF) is mainly affected by both the capital utilization and preference, market beta (inferred from the IRF of market value) is affected mainly by firms’ market power. In equilibrium these three channels are interrelated. In this section we discuss this inter-dependence and its effect on IST pricing. This discussion is informative for the quantitative analysis that we carry out in Section 4.

The effect on the price of risk for IST shocks can be inferred from the “logSDF” panels: a negative IRF implies a positive price of risk and vice-versa. As the figures show, the IRF of logSDF with time-separable log utility (EIS = 1) under flexible capital utilization (Figure 1) is similar to that of CRRA utility with stronger consumption smoothing (EIS = 0.2) and fixed capital utilization (Figure 3) and to that of Epstein-Zin utility with preference for early resolution of uncertainty and fixed capital utilization (Figure 4). Therefore, in general, flexible capital utilization and preferences for early resolution of uncertainty will have similar effects on the price of risk for IST shocks.

In Figure 2 we show that, when EIS is high, market power can change the market IST beta from negative to positive. However, our analysis also show that, when EIS is low, or households prefer late resolution of uncertainty ($\rho - \gamma > 0$), firm value drops irrespective of firms’ market power. In other words, in order for market power to generate a positive IST beta, the wealth effect induced by a IST shock has to be weaker than the substitution effect. A weak wealth effect induces an increase in labor supply. All else equal, this lowers firms’ labor costs and improves firms’ valuation.

Note, finally, that, although both variable capital utilization and preference for early resolution of uncertainty can generate a positive price of risk for IST shocks, the two mechanisms are conceptually quite different. The former is a property of the production technology and has direct impact on both macroeconomic quantities and asset prices. The latter is a property of households’ preferences and mainly impacts asset prices. Similarly, the mechanism induced by high market power can be thought of as isomorphic to decreasing return to scale in the underlying technology. Both market power and decreasing return to scale generate a concave profit function but the two mechanisms are conceptually different. Market power is a property of a product market while decreasing return to scale is a property of a firm’s technology. Furthermore, while there is scant evidence in favor of decreasing return to scale at the aggregate level...
(see, e.g., Burnside, Eichenbaum, and Rebelo (1995)) there is ample evidence of violation of the assumption of perfectly competitive markets.\(^{13}\)

### 3.3 Implications for the market risk premium

The IRFs studied in the previous sections are directly related to asset prices. In particular, according to (20), the negative of the IRF of the logSDF represents the market price of risk \(\lambda^z\) of IST shocks. Similarly, from (24), the IRF of the \(\log V^M\) represents the IST beta loading of the market portfolio \(\beta^z_M\). In this section, we analyze the effect of market power, capital utilization and household preferences on the component of the aggregate market risk premium that is attributable to IST risk \((\beta^z_M \lambda^z)\). We do so by studying how market power, capital flexibility and household preferences affect the price of IST risk, \(\lambda^z\), and the “quantity” of IST risk \(\beta^z_M\), embedded in the market risk premium.

Figure 5 reports the results under two values of EIS: “Low EIS” (EIS = 1/3, left panels) and “High EIS” (EIS = 2, right panels). In the figure we fix the RRA parameter to \(\gamma = 2\), so that the Low (High) EIS case corresponds to preference for late (early) resolution of uncertainty. In each case, we report: (i) the IST price of risk, \(\lambda^z\) (ii) the IST beta, \(\beta^z_M\), and (iii) the IST market risk premium, \(\beta^z_M \lambda^z\).

Let us first focus on the left panels, representing the case of preference for late resolution of uncertainty, i.e., \(\rho - \gamma > 0\). Panel A shows that the IST price of risk is negative under inflexible capital utilization (lower part of the panel), and becomes positive under flexible capital utilization (upper part of the panel). Panel B shows that market IST beta changes from negative, when capital utilization is inflexible and market power is low (south-west corner), to positive when capital utilization is flexible and market power is high (north-east corner). Combining the first two panels, panel C reports that the IST risk premium can be positive under two scenarios: (i) inflexible capital utilization, irrespective of market power; and (ii) high market power with flexible capital utilization. Note that the economy with fixed capital utilization and perfectly competitive firms studied by Papanikolaou (2011) is a special case of the first scenario, corresponding to the origin in panel C. Our analysis highlights that there are alternative structures of the economy, represented by the north-east corner in panel C, for which the market risk premium can be positive. The left panels also illustrate that while in the economy of Papanikolaou (2011) positive IST risk premia are obtained through negative IST prices of risk (panel A), and negative IST betas (panel B), in the economies characterized by market power

\(^{13}\)Jaimovich and Rebelo (2009) propose to introduce decreasing returns to scale of production to capital and labor in order to generate a positive response of firm value to news shocks about productivity. To obtain balanced growth, they need a third production factor, besides capital and labor, which is outside their model. In contrast, our modeling of market power through monopolistic competition preserves balanced growth without relying on any further assumptions on factors outside our model.
and capital flexibility, positive IST risk premia obtain because both the price of risk and market betas are positive. Whether an economy is better described by the first or second scenario is ultimately an empirical question.

The right panels in Figure 5 report the case in which the household has a preference for early resolution of uncertainty, i.e., $\rho - \gamma < 0$. Panel D shows that the IST price of risk is always positive in this case, although, as before, higher capital flexibility implies higher IST prices of risk. Panel E shows that market IST beta is mostly positive, except when the market power is low (left side of the graph). Combining these two panels, panel F reports that IST risk premium is positive for high level of market power. Note that in this case, market power changes the sign of the IST beta and therefore of the IST risk premium, while capital flexibility mainly affects the level of the IST risk premium.

Figure 5 provides some guidance for our quantitative analysis of the next section. Comparing the bottom two panels in the figure, we note that market risk premia are typically higher when households have a preference for early resolution of uncertainty (right panels) and the economy is characterized by (a) flexible capital utilization and (b) a high degree of market power (north-east corner of panel F).

4 Quantitative analysis with long-run technology risks

In this section, we study the quantitative implications of market power and flexible capital utilization on the IST risk premium under Epstein-Zin preference. In particular, we explore whether these two mechanisms can generate an equity risk premium comparable to what observed in the data. As it is well known, reconciling asset pricing facts and aggregate macroeconomic quantities is a challenge for production-based dynamic stochastic general equilibrium models.

Following Croce (2014), who empirically documents the existence of a predictable component in U.S. productivity growth, we assume that the growth rate in both the TFP and IST shocks are time-varying. Specifically, we assume that the expected growth rates $\mu^a_t$ and $\mu^z_t$ of the technology shocks (9) and (10) are mean-reverting, according to the following specification:

$$\mu^a_t = \rho^a \mu^a_{t-1} + \varepsilon^a_t, \quad \varepsilon^a_t \sim i.i.d. \mathcal{N}\left(0, \sigma^2_{\mu^a}\right),$$

$$\mu^z_t = \rho^z \mu^z_{t-1} + \varepsilon^z_t, \quad \varepsilon^z_t \sim i.i.d. \mathcal{N}\left(0, \sigma^2_{\mu^z}\right),$$

with $0 < \rho^a < 1$ and $0 < \rho^z < 1$. We assume that $\varepsilon^a_t$ and $\varepsilon^z_t$ are independent of each other and of the short run shocks, $\varepsilon^a_t$ and $\varepsilon^z_t$.

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The presence of persistent and time-varying expected growth rates in technology growth introduces concerns for “long-run risks”: household demand high risk premia when they fear that lower expected growth can lower asset prices (see Bansal and Yaron (2004)). We introduce long-run risks in both the capital disembodied TFP (specification (29)) and the capital embodied IST (specification (30)).

4.1 Calibration

We calibrate the model’s parameters to match key macro and asset pricing moments. The calibration of this section will serve as a benchmark for the quantitative analysis of the model’s economic mechanisms in Section 4.2.

4.1.1 Parameters

The model parameters belong to three groups: preference, production, and technology shocks. We calibrate our model to a monthly frequency, and then derive time-aggregated annual statistics. We report our parameter choice, in annualized values, in Table 1.

**Preferences.** We choose a time discount factor $\beta = 0.985$, RRA $\gamma = 10$, and EIS $= 1/\rho = 2$. To generate the empirically observed volatility in labor supply, we set the sensitivity of disutility to working hours to $\theta = 1.1$, slightly smaller than the value used in Jaimovich and Rebelo (2009). The value $\psi$ for the degree of disutility to working hours is chosen in such a way as to insure that in the deterministic steady state the value $L_t$ of working hours is equal to 23% of the time in a year.

**Production.** We set the labor share of output to $\alpha^C = \alpha^I = 0.60$. The capital adjustment cost parameter is set to $\phi^C = 21$ for the consumption sector, and $\phi^I = 5$ for the investment sector. The difference in adjustment cost is important to generate the observed difference in the volatility of consumption and investment growth. The deterministic steady state depreciation rate is set to $\delta_0 = 10\%$ per year. The other depreciation parameter in (12), $\delta_1$, is chosen such that the capital utilization in the deterministic steady state is equal to 1. The curvature parameter of the depreciation in capital utilization is set to $\xi^C = 0.40$ for the consumption sector and $\xi^I = 0.31$ for the investment sector. Both values are higher than the value of $\xi = 0.15$ in Jaimovich and Rebelo (2009). Note that a higher value of $\xi$ implies less flexibility in adjusting capital utilization in equilibrium. We choose a higher value of $\xi$ to match the volatility of capacity utilization variation for the U.S. industrial sector as reported by the Federal Reserve (see Appendix B for details). We choose market power parameters $\nu_C = \nu_I = 4$, which imply a 33% markup for firms in both

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sectors. This markup value is slightly lower than the 36% markup value calibrated by Bilbiie, Ghironi, and Melitz (2012).

**Technology shocks.** To match the average and volatility of growth rates in macro quantities, such as consumption and investment, we set the annual growth rates (volatilities) of the shocks $A_t$ and $Z_t$, respectively, to $\bar{\mu}^a = 0.1\%$ ($\sigma_a = 1\%$), and $\bar{\mu}^z = 2.9\%$ ($\sigma_z = 2.5\%$). The low growth rate and volatility of TFP shock $A_t$ is necessary to match the model-implied moments of consumption growth to those from the data. The high growth rate and volatility of the IST shock $Z_t$ is needed to match the mean and volatility of the growth rate of the relative price of capital goods observed in the U.S. data. For the long-run risks, we set the persistence to $\rho_{\mu^a} = \rho_{\mu^z} = 0.67$, which is smaller than the value of 0.8 used in Croce (2014). For the volatility of long-run risks, we follow Croce (2014), and set it to be 10% of the short-run risk volatility. That is, $\sigma_{\mu^j} = 0.1 \times \sigma_j$, $j = a, z$.

### 4.1.2 Macroeconomic and asset pricing moments

Using the parameter values in Table 1, we solve the model numerically through second order perturbations around the deterministic steady state. To better approximate the moments of levered claims on capital when comparing the data to the model, we multiply risk premia and standard deviations of firms’ returns by a leverage factor of 2, as in Croce (2014).

Table 2 reports the results from our benchmark calibration. The table compares macroeconomic (panel A) and asset pricing (panel B) moments of the data to simulated moments from the model. For the model-implied moments, we report the median of 1,000 simulations as the point estimates as well as the 2.5- and 97.5-percentiles across simulations. The empirical moments are estimated from the U.S. annual sample from 1930–2012, with the exception of the labor time series which starts in 1947 and the capacity utilization for the U.S. industrial sector whose time series starts in 1967.

Overall, the model replicates fairly well the growth rate and volatility of consumption, investment, labor supply, output, equipment price, and capital utilization. The model also does a fairly good job in replicating the average level of risk free rate and market risk premium. For example, the model generates an annual risk free rate of 0.90% vs. 0.54% in the data, and equity risk premium of 5.65% in the model vs. 5.53% in the data. The volatility of the risk-free rate and of the aggregate equity risk premium implied by the model is lower than that in the data, which is typical in this type of production-based models.
4.2 Quantitative effects on asset pricing

In this section, we show the quantitative importance of the three channels discussed in Section 3. To this purpose, we consider the following alternatives to the benchmark calibration of Section 4.1: (i) Fixed, instead of flexible, capital utilization; (ii) Perfectly competitive, instead of monopolistically competitive, firms; and (iii) EIS smaller, instead of larger, than one. We solve and simulate the model under all possible eight combinations of parameters and report the implications for the resulting equilibrium risk-free rate and market risk premium. In order to better understand the quantitative impact of each channel, we further decompose the aggregate risk premium into its constituent parts originating from each shock. To perform this decomposition, we follow equations (19) and (21) and estimate $\lambda$’s and $\beta$’s through ordinary linear regressions on the simulated data. We then construct the contribution to the risk premium of each shock according to equation (22), with an adjustment factor of 2 to account for leverage.\(^{15}\)

Panel A of Table 3 analyzes the effects of the three channels on the risk free rate. The following three points are worth mentioning. First, market power has a mild effect on the risk-free rate. Comparing the column “MP” with column “No-MP” in the table, we see that market power slightly decreases (increases) the risk-free rate when EIS is high (low). Second, capital flexibility decreases the risk-free rate. The intuition is that under flexible capital utilization consumption and continuation utility co-move in response to an IST shock (see equation (3)), and this increases the volatility of SDF. Given the convexity of the SDF in continuation utility, higher volatility implies a higher average SDF and so a lower risk-free rate. Finally, as is well known, EIS has a large quantitative impact on risk-free rate. When EIS is high (EIS = 2), the risk-free rate is around 1%. However, when EIS is low (EIS = 0.5), the risk-free rate is around 5%. This is because the low-EIS household dislikes uneven consumption profile over time and hence borrows to smooth consumption. Since the risk free asset is in zero net supply, the risk free rate has to rise to clear the bond market. Notice that, because the RRA coefficient is equal to $\gamma = 10$, both cases describe household who prefer early resolution of uncertainty, or $\rho < \gamma$.

Panel B reports the risk premium under different combinations of the three channels. The following three points are noteworthy. First, market power has a first order impact on the risk premium. For example, when EIS is high, market power increases the risk premium from $-3.71\%$ ($-2.43\%$) to $5.65\%$ ($4.96\%$) under flexible (fixed) capital utilization. Note also the risk premium is always negative in the absence of market power. Second, capital utilization increases the risk premium when firms have market power. For example, when EIS is high and firms have market power, capital flexibility increases the risk premium from $4.96\%$ to $5.65\%$. Finally, EIS affects

\(^{15}\)Note that the long-run risks $\varepsilon_a^\infty$ and $\varepsilon_z^\infty$ in equations (29) and (30) are treated in the same way as the short-run risks $\varepsilon_a$ and $\varepsilon_z$ in equations (19) and (21). Therefore, similar to the short-run risks, the long-run risks also contribute to the risk premium in equation (22).
the sign of the risk premium. In particular, when EIS is low, the risk premium becomes negative, irrespective to market power and capital flexibility.

To understand the above findings, we decompose the risk premium along two dimensions: (i) contribution of each shock to the risk premium, and (ii) contribution of “price” of risk, λ, and “quantity” of risk, β, to risk premium. Table 4 reports the risk premium decomposition under different combinations of the three channels. Panel A reports the results for our benchmark calibration. In this case, all the prices and quantities of risk are positive. Out of the total risk premium of 5.65% (column labeled “ΣX”), 0.46% comes from the short-run TFP-shock (A), 0.32% from short-run IST shock (Z), 2.30% from the long-run TFP-shock (μa), and 2.57% from the long-run IST shock (μz). That is, the short-run and long-run risks contribute 0.78% and 4.87% respectively to the risk premium. In other words, the risk premium mainly comes from the two sources of long-run risk in technology growth. In the following subsections, we highlight the quantitative effect of the three channels by comparing different channel combinations with our benchmark calibration.

4.2.1 The effect of firms’ market power

Panel B of Table 4 reports the same risk premium decomposition as the benchmark calibration in Panel A, but removes firm’s market power. The difference between Panels A and B highlights the effect of market power on asset prices. When firms do not have market power, the price of risks are similar to the values in Panel A, but the β’s becomes all negative, except for the A-shock. This leads to negative contributions to the aggregate risk premium from all the shocks, except the A-shock. The aggregate risk premium in this case is −3.71%. A similar quantitative effect of market power on risk premium is evident by comparing the cases with fixed capital utilization and high EIS (i.e., Panels C and D). The intuition is the same as the one discussed in Section 3.1.2: market power allows firms to benefit from an improvement in technology, thereby increasing the value of retained monopoly rents.

As we discussed in Section 3.1.2, EIS also affects the impact of market power on risk premium. When EIS is low, the risk premium becomes negative in all four cases (Panels E–H). In these cases, market power could not change the sign of the risk premium, and only has mild qualitative effects. This is because the strong wealth effect under low EIS dominates the substitution effect as discussed in Section 3.2.2.

Note that while the loading with respect to the short-run TFP shocks (βa) is positive, the loadings with respect to the long-run TFP shocks (βμa) as well as short- and long-run IST shocks (βZ and βμZ) are all negative. The key difference between these two groups of shocks lies in their effect on consumption. While the short-run TFP shocks affect directly the current consumption, the long-run component of TFP and both components of IST shocks affect only the future consumption. Therefore, the long-run TFP shocks as well as short- and long-run IST shocks all behave, de-facto, as “news shocks” about future consumption.
4.2.2 The effect of flexible capital utilization

Panel C of Table 4 reports the same risk premium decomposition as the benchmark calibration of Panel A, but removes flexibility in capital utilization. The difference between Panels A and C highlights the effect of flexible capital utilization when firms have market power and EIS is high. The results show that in this case capital utilization has a mild effect on the risk premium: it increases the risk premium from 4.96%, when utilization is fixed, to 5.65% when utilization is flexible. A similar comparison between Panels B and D shows that flexible capital utilization decreases risk premium when firms do not have market power.

When EIS is low, flexible capital utilization increases the risk premium: risk premium increases from −3.32% (Panel G) to −0.62% (Panel E) when firms have market power, and from −2.67% (Panel H) to −2.03% (Panel F) when firms do not have market power. However, note that in all these cases the risk premium is counterfactually negative.

4.2.3 The effect of the elasticity of intertemporal substitution

Finally, Table 4 shows that EIS has a direct impact on the sign of the risk premium. In particular, when EIS is low, the risk premium is always negative (Panels E–H). Only a high EIS induces a positive risk premium (Panels A and C). Note also, that this negative risk premium is a result of negative risk loading $\beta$‘s, as the price of risk $\lambda$‘s are all positive under preference for early resolution of uncertainty. The negative risk loadings under low EIS are due to the strong wealth effect of household, which increases firms’ labor cost, thereby causing a drop in firm value upon a positive IST shock, and/or a positive shock to long run component of both TFP and IST shocks.

In summary, this section shows that the three channels studied in this paper have important quantitative effect on the risk premium: (1) market power can change the risk premium from a large negative value to a large positive value; (2) flexible capital utilization, along with market power and high EIS, can generate a sizable increase in the risk premium; and, (3) a strong preference for early resolution of uncertainty can generate a large and positive risk premium. Combining these three channels, our model can generate asset returns and macroeconomic quantities that match those observed in the data.

5 Conclusion

We provide a new perspective on the implications of IST shocks for asset pricing. We argue that capital utilization and firms’ market power have an important effect on the market price
of risk and risk premia of IST shocks. Under fixed capital utilization, the current consumption drops upon a positive IST shock as workers in the consumption sector switch to the investment sector. Variable capital utilization allows agents to expand current consumption by more intensely utilizing the existing capital. Market power shields firms from competition and therefore allows positive IST shock to positively impact firm’s value.

We identify three main mechanisms that drive the connection between IST shocks and asset prices. First, market power affects the sign of risk premium associated with IST shock by reducing the negative impact of competitive pressures on firms's profits. Second, variable capital utilization mainly affects current consumption and can affect the sign of the market price of risk for IST shock when EIS is low. Finally, the EIS affects both the market price of risk and risk premium of IST shocks through the stochastic discount factor channel.

Our quantitative analysis shows that while the three mechanisms we study help to generate key macro moments consistent with the empirical data, the short-run risks in technology growth can only generate a relatively small risk premium. By incorporating long-run risks in the process describing technology growth, we show that these mechanisms are both qualitatively and quantitatively important to obtain level of risk premia comparable to those observed in the data. Our analysis suggests that accounting for market power and capital flexibility can potentially benefit further explorations of time series and cross sectional properties of asset returns.
A Model solution

In this appendix we describe the procedure we utilize in solving the model described in Section 2. A.1 describes the set of optimality conditions for the original problem. A.2 illustrates the construction of a growth-stationary version of the model that allows the derivation of the deterministic steady state. A.3 describes the construction of a rescaled version of the model that is both mean and co-variance stationary.

A.1 Original problem

The household’s problem is given by (2), which we reproduce here:

\[ V_t = \max_{\{C_s, L_s\}_{s=t}^{\infty}} U_t, \quad \text{s.t.} \quad P_s C_s = W_s L_s + D_s^C + D_s^I, \quad s \geq t, \]

and the corresponding Lagrangian is:

\[ L^H_t = U_t + \sum_{s=t}^{\infty} \lambda_s (W_s L_s + D_s^C + D_s^I - P_s C_s). \quad (A1) \]

The first order conditions with respect to consumption and labor supply are given by:

\[ \text{FOC}_1 C: 0 = \lambda_t P_t^C - (1 - \beta) C_t^{-\rho} (1 - \psi L_t^0)^{1-\rho} U_t^0. \quad (A2) \]

\[ \text{FOC}_2 L: 0 = \lambda_t W_t - (1 - \beta) C_t^{-\rho} (1 - \psi L_t^0)^{-\rho} U_t^0 \theta \psi L_t^0 - L_t^{C} \psi L_t^{C}. \quad (A3) \]

\[ \text{FOC}_3 \lambda: 0 = C_t - A_t (N_C)^{-\nu_C} (u_C K_t^C)^{1-\alpha_C} (L_t^{C})^{\alpha_C}. \quad (A4) \]

The C-firm’s problem is given by (14), which we reproduce here:

\[ V_{f,t}^C = \max_{\{l_{f,s}^C, u_{f,s}^C\}} \mathbb{E}_t \sum_{s=t}^{\infty} M_{t,s} d_{f,s}^C, \quad \text{s.t.} \quad d_{f,s}^C = p_{f,s}^C y_{f,s}^C - W_s l_{f,s}^C - P_s I_k (i_{f,s}^C) k_{f,s}^C, \]

and the corresponding Lagrangian is:

\[ L_{f,t}^C = \mathbb{E}_t \sum_{s=t}^{\infty} M_{t,s} (p_{f,s}^C y_{f,s}^C - W_s l_{f,s}^C - P_s I_k (i_{f,s}^C) k_{f,s}^C + \eta_k (k_{f,s}^C (1 + i_{f,s}^C - \delta (u_{f,s}^C)) - k_{f,s+1}^C)). \quad (A5) \]

Note that \( p_{f,t}^C = (y_{f,t}^C / Y_t^C)^{-1/\nu_C} P_t^C \) according to equation (6) and \( y_{f,t}^C \) is given by equation (7).
The firm takes the aggregate prices and quantities as given and makes optimal decisions on hiring, investment, and capital utilization intensity. The corresponding first order conditions are:

\[
\text{FOC}_{-4_{lc}}: 0 = \left(1 - \frac{1}{\nu_c}\right) \frac{\alpha_c p_{f,t}^C y_{f,t}^C}{y_{f,t}^C - W_t}. \tag{A6}
\]

\[
\text{FOC}_{-5_{ic}}: 0 = \eta_i^C - P_t^I \varphi'(i_{f,t}^I). \tag{A7}
\]

\[
\text{FOC}_{-6_{uc}}: 0 = \left(1 - \frac{1}{\nu_c}\right) \frac{(1 - \alpha_c^C)p_{f,t+1}^C y_{f,t+1}^C}{u_{f,t}^C - \eta_i^C + \delta(u_{f,t}^C)k_{f,t}^C}. \tag{A8}
\]

\[
\text{FOC}_{-7_{kc}}: 0 = \mathbb{E}_t \mathbb{M}_{t,t+1} \left\{ \left(1 - \frac{1}{\nu_c}\right) \frac{(1 - \alpha_c^C)p_{f,t+1}^C y_{f,t+1}^C}{k_{f,t+1}^C} - P_t^I \varphi(i_{f,t+1}^I) + \eta_i^C(1 + i_{f,t+1}^I + \delta(u_{f,t+1}^C)) \right\} - \eta_i^C. \tag{A9}
\]

\[
\text{FOC}_{-8_{yc}}: 0 = k_{f,t}^C(1 + i_{f,t}^C - \delta(u_{f,t}^C)) - k_{f,t+1}^C. \tag{A10}
\]

The I-firm’s problem is given by (14), which we also reproduce here:

\[
V_{f,t}^I = \max_{\{t', i', u'\}} \mathbb{E}_t \sum_{s=t}^\infty \mathbb{M}_{t,s} d_{f,s}^I, \quad \text{s.t.} \quad d_{f,s}^I = p_{f,s}^I y_{f,s}^I - W_{f,s}^I - P_{s}^I \varphi(i_{f,s}^I)k_{f,s}^I,
\]

and the corresponding Lagrangian is:

\[
\mathcal{L}_{f,t}^I = \mathbb{E}_t \sum_{s=t}^\infty \mathbb{M}_{t,s} (p_{f,s}^I y_{f,s}^I - W_{f,t}^I - P_{s}^I \varphi(i_{f,s}^I)k_{f,s}^I + \eta_i^s(k_{f,s}^C(1 + i_{f,s}^I - \delta(u_{f,s}^C)) - k_{f,s+1}^C)). \tag{A11}
\]

Note that \( p_{f,t}^I = (y_{f,t}^I / Y_t^I)^{-1/\nu_t} P_t^I \) according to equation (6), and \( y_{f,t}^I \) is given by equation (7).

The I-firm also takes the aggregate prices and quantities as given and makes optimal decisions on hiring, investment, and capital utilization intensity. The corresponding first order conditions are:

\[
\text{FOC}_{-9_{li}}: 0 = \left(1 - \frac{1}{\nu_I}\right) \frac{\alpha_I p_{f,t}^I y_{f,t}^I}{y_{f,t}^I - W_t}. \tag{A12}
\]

\[
\text{FOC}_{-10_{ii}}: 0 = \eta_i^I - P_t^I \varphi'(i_{f,t}^I). \tag{A13}
\]

\[
\text{FOC}_{-11_{ui}}: 0 = \left(1 - \frac{1}{\nu_I}\right) \frac{(1 - \alpha_I^C)p_{f,t+1}^I y_{f,t+1}^I}{u_{f,t}^I - \eta_i^I + \delta(u_{f,t}^I)k_{f,t}^I}. \tag{A14}
\]

\[
\text{FOC}_{-12_{ki}}: 0 = \mathbb{E}_t \mathbb{M}_{t,t+1} \left\{ \left(1 - \frac{1}{\nu_I}\right) \frac{(1 - \alpha_I^C)p_{f,t+1}^I y_{f,t+1}^I}{k_{f,t+1}^I} - P_t^I \varphi(i_{f,t+1}^I) + \eta_i^I(1 + i_{f,t+1}^I + \delta(u_{f,t+1}^I)) \right\} - \eta_i^I. \tag{A15}
\]

\[
\text{FOC}_{-13_{yi}}: 0 = k_{f,t}^I(1 + i_{f,t}^I - \delta(u_{f,t}^I)) - k_{f,t+1}^I. \tag{A16}
\]
There are three market clearing conditions. The market clearing condition for the final consumption good is given by (A4). The market clearing conditions for labor and the final investment good are:

\[
\text{MCC}_{14}: L_t = L_t - \sum_{f=1}^{N^C} l_{f,t}^C - \sum_{f=1}^{N^I} l_{f,t}^I. \quad (A17)
\]

\[
\text{MCC}_{15}: I_t = \sum_{f=1}^{N^C} \varphi(i_t^C)k_{f,t}^C + \sum_{f=1}^{N^I} \varphi(i_t^I)k_{f,t}^I - A_t(N^I)^{\frac{1}{1-\alpha_I}} Z_t(u_t^I K_t^I)^{1-\alpha_I} (L_t^I)^{\alpha_I}. \quad (A18)
\]

The above equations can be rewritten in terms of aggregate quantities by using the symmetry among firms in each sector (see equation (18)). In turn, we have total 17 equations (the above 15 plus the equation for SDF in (3) and the definition of recursive utility in (1)) to solve 17 endogenous variables (10 decision variables: \(C, L, L^C, i^C, i^I, u^C, u^I, K^C, K^I\); 3 prices: \(M, W, P^I\); 3 Lagrangian multipliers: \(\lambda, \eta^C, \eta^I\); and the utility \(U\)). Note that, because we choose the final consumption good as the numeraire, the price \(P^C \equiv 1\). All other quantities can be derived from these variables.

### A.2 Detrended problem

The original problem is non-stationary due to technology growth over time. To find the steady state of the economy, we first need to detrend the problem.

We assume there is no growth in the total labor supply. From the market clearing condition for the final capital good in (A18), the balanced growth rate of capital in the two sectors is the same, which is given by

\[
g_{k^C} = g_{k^I} = (g_a g_z)^{\frac{1}{\alpha}}, \quad \text{where} \quad g_a = e^{\beta^a}, \ g_z = e^{\beta^z}.
\]

Similarly, the market clearing condition for the final consumption good in (A4) gives the growth rate of consumption:

\[
g_c = g_a (g_{k^C})^{1-\alpha^C}.
\]

Since consumption equals the sum of wage and dividends from the two sectors, the growth rates of wage and investment cost have to be the same as that of consumption for the balanced growth to exist. In addition, the utility function is written as the certainty equivalent in consumption, so it has the same growth rate as consumption. Therefore, we have,

\[
g_w = g_c, \quad g_{p^I} = g_c / g_{k^C}, \quad \text{and} \quad g_u = g_c.
\]
The original problem then can be written in terms of these detrended variables (e.g., the detrended consumption $\hat{C}_t = C_t/g_C$). The deterministic steady state of the detrended problem can then be solved.

### A.3 Rescaled problem

Even though the detrended problem in the previous section is mean stationary, it is not covariance stationary. This is due to the fact that the technological shocks are modeled as geometric random walks and therefore their effect is permanent. To solve the model, we need to rescale our original problem to make it stationary in both mean and covariance.

To achieve stationarity, we rescale:

1. $C_t, U_t, W_t, \text{and } V_t^{C,I}$ by $A_t \left[ (N^C)^{\frac{1}{\nu_C-1}} (K_t^C)^{1-\alpha_C} \right]$;

2. $P_t^I$ by $A_t \left[ (N^C)^{\frac{1}{\nu_C-1}} (K_t^C)^{1-\alpha_C} \right]$;


The rescaled problem is fully described by the following two stationary state variables:

\[ k_t \equiv \log \left( \frac{K_t^I}{K_t^C} \right), \quad \text{and } \Omega_t \equiv \log \left( \frac{(N^I)^{\frac{1}{\nu_I-1}} A_t Z_t}{(K_t^I)^{\alpha_I}} \right), \]

(A19)

whose evolution is given by

\[
\begin{align*}
    k_{t+1} &= k_t + \log(1 + i_t^I - \delta(u_t^I)) - \log(1 + i_t^C - \delta(u_t^C)), \\
    \Omega_{t+1} &= \Omega_t - \alpha^I \log(1 + i_t^I - \delta(u_t^I)) + \tilde{\mu}^a + \tilde{\mu}^z + \mu^a + \mu^z + \varepsilon^a_{t+1} + \varepsilon^z_{t+1}.
\end{align*}
\]

(A20)

The equilibrium for the original problem is easily recovered from the rescaled equilibrium. For example, asset values are given by

\[ V_t^J = A_t(N^C)^{\frac{1}{\nu_C-1}} (K_t^C)^{1-\alpha_C} v_t^J(k_t, \Omega_t), \quad J = C, I, M, \]

(A22)

with $v_t^J(k_t, \Omega_t)$ denoting the rescaled asset value.

### B Data construction

*Macroeconomic quantities.* Consumption is nondurables plus services. Investment is nonresidential fixed investment. Output is GDP excluding government consumption and investment. We
report the real per-capita growth rates by adjusting for growth in population and consumption good price. Data on these quantities come from the National Income and Product Accounts (NIPA) tables from the Bureau of Economic Analysis. Labor supply is hours in the non-farm business sector, which is from the Bureau of Labor Statistics. We adjust the labor supply for population growth. The quality adjusted capital good price relative to consumption good price is from the extended price series of Israelsen (2010). The capital utilization data is based on the capacity utilization of the industrial sector (‘total index’) of the Federal Reserve’s G.17.

Asset returns. The risk free rate and market excess return data are obtained from Kenneth French’s website. In estimating the volatility of risk-free rate, we follow a similar procedure as in Bansal, Kiku, and Yaron (2012) and compute the volatility of the fitted real risk free rate which we obtain by projecting the real risk-free rate at time $t$ to its one-year lagged value at time $t - 1$. 
Table 1: Parameter values

This table reports the annualized parameter values used in the benchmark monthly calibration of the model.

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
<th>Symbol</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferences</td>
<td>Time discount rate</td>
<td>$\beta$</td>
<td>0.985</td>
</tr>
<tr>
<td></td>
<td>Relative risk aversion</td>
<td>$\gamma$</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>EIS</td>
<td>$1/\rho$</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Degree of labor disutility</td>
<td>$\theta$</td>
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</tr>
<tr>
<td></td>
<td>Sensitivity of labor disutility</td>
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<tr>
<td>Production</td>
<td>Depreciation rate constant</td>
<td>$\delta_0$</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Depreciation rate slope</td>
<td>$\delta_1$</td>
<td>15.5%</td>
</tr>
<tr>
<td></td>
<td>Labor share of output for C-sector</td>
<td>$\alpha_C$</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>Labor share of output for I-sector</td>
<td>$\alpha_I$</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>Degree of capital adjustment cost for C-sector</td>
<td>$\phi_C$</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Degree of capital adjustment cost for I-sector</td>
<td>$\phi_I$</td>
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<td></td>
<td>Elasticity of marginal depreciation for C-sector</td>
<td>$\xi_C$</td>
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<td>Elasticity of marginal depreciation for I-sector</td>
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<td></td>
<td>Constant elasticity of substitution for C-sector</td>
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<tr>
<td></td>
<td>Constant elasticity of substitution for I-sector</td>
<td>$\nu_I$</td>
<td>4.00</td>
</tr>
<tr>
<td>Shocks</td>
<td>Growth rate of A-shock</td>
<td>$\bar{\mu}^a$</td>
<td>0.1%</td>
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<tr>
<td></td>
<td>Standard deviation of A-shock</td>
<td>$\sigma_a$</td>
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<td></td>
<td>Persistency of long-run risk for A-shock</td>
<td>$\rho_{\mu a}$</td>
<td>0.67</td>
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<tr>
<td></td>
<td>Standard deviation of long-run risk for A-shock</td>
<td>$\sigma_{\mu a}$</td>
<td>0.1%</td>
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<td></td>
<td>Growth rate of Z-shock</td>
<td>$\bar{\mu}^z$</td>
<td>2.9%</td>
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<tr>
<td></td>
<td>Standard deviation of Z-shock</td>
<td>$\sigma_z$</td>
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<tr>
<td></td>
<td>Persistency of long-run risk for Z-shock</td>
<td>$\rho_{\mu z}$</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Standard deviation of long-run risk for Z-shock</td>
<td>$\sigma_{\mu z}$</td>
<td>0.25%</td>
</tr>
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</table>
This table compares macroeconomic and asset pricing moments of the data to simulated moments from the model (in percentage). The empirical moments are estimated from the U.S. annual sample from 1930-2012 (the labor time series starts in 1947, and capacity utilization starts in 1967). The log growth rates of consumption ($\Delta c$), investment ($\Delta i$), total output ($\Delta y$) are adjusted for inflation and population. The log growth rate of labor ($\Delta l$) is adjusted for population. The growth rate of relative price of investment good ($\Delta p^I$) is adjusted for quality. The log growth rate in capital utilization ($\Delta u$) in the model is based on the average of the two sectors. $r_f$ is the log risk-free rate adjusted for inflation and $r_{ex}^M$ is the log market risk premium, i.e., the log market return in excess of the log risk-free rate. For the empirical moments, we report both the point estimates and the 95-percent confidence intervals. For the model implied moments, we report the median of 1,000 simulations as the point estimates and the 2.5- and 97.5-percentiles for the 1,000 simulations. Further details on the data constructions are provided in Appendix B.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Mean</th>
<th>Data Volatility</th>
<th>Model Mean</th>
<th>Model Volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta c$</td>
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<td>2.22</td>
<td>2.22</td>
<td>2.86</td>
</tr>
<tr>
<td></td>
<td>[1.53, 2.01]</td>
<td>[1.85, 2.53]</td>
<td>[0.75, 3.71]</td>
<td>[2.37, 3.50]</td>
</tr>
<tr>
<td>$\Delta i$</td>
<td>2.19</td>
<td>13.58</td>
<td>2.23</td>
<td>13.17</td>
</tr>
<tr>
<td></td>
<td>[-0.73, 5.11]</td>
<td>[11.32, 15.50]</td>
<td>[0.55, 3.86]</td>
<td>[10.60, 16.13]</td>
</tr>
<tr>
<td>$\Delta l$</td>
<td>-0.02</td>
<td>2.62</td>
<td>0.00</td>
<td>2.41</td>
</tr>
<tr>
<td></td>
<td>[-0.66, 0.61]</td>
<td>[2.12, 3.04]</td>
<td>[-0.12, 0.11]</td>
<td>[2.04, 2.84]</td>
</tr>
<tr>
<td>$\Delta y$</td>
<td>1.93</td>
<td>5.58</td>
<td>2.24</td>
<td>4.11</td>
</tr>
<tr>
<td></td>
<td>[0.73, 3.13]</td>
<td>[4.65, 6.37]</td>
<td>[0.76, 3.71]</td>
<td>[3.45, 4.80]</td>
</tr>
<tr>
<td>$\Delta p^I$</td>
<td>-3.45</td>
<td>3.65</td>
<td>-3.09</td>
<td>3.76</td>
</tr>
<tr>
<td></td>
<td>[-4.24, -2.67]</td>
<td>[3.05, 4.17]</td>
<td>[-4.73, -1.52]</td>
<td>[3.05, 4.64]</td>
</tr>
<tr>
<td>$\Delta u$</td>
<td>-0.26</td>
<td>4.21</td>
<td>-0.01</td>
<td>4.35</td>
</tr>
<tr>
<td></td>
<td>[-1.49, 0.97]</td>
<td>[3.23, 5.01]</td>
<td>[-0.46, 0.43]</td>
<td>[3.54, 5.37]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Mean</th>
<th>Data Volatility</th>
<th>Model Mean</th>
<th>Model Volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_f$</td>
<td>0.54</td>
<td>2.85</td>
<td>0.90</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>[-0.08, 1.16]</td>
<td>[2.37, 3.25]</td>
<td>[0.33, 1.52]</td>
<td>[0.66, 1.23]</td>
</tr>
<tr>
<td>$r_{ex}^M$</td>
<td>5.53</td>
<td>20.46</td>
<td>5.65</td>
<td>8.09</td>
</tr>
<tr>
<td></td>
<td>[1.13, 9.93]</td>
<td>[17.07, 23.37]</td>
<td>[4.13, 7.20]</td>
<td>[7.05, 9.23]</td>
</tr>
</tbody>
</table>
Table 3: Capital utilization, market power, and preferences: quantitative effect on asset prices

This table reports the effects on risk-free rate and market risk premia from the three channels discussed in the paper. We consider the following alternative choices: (i) “Flexible KU” represents the flexible capital utilization as in the benchmark calibration and “Fixed KU” represents the case with fixed capital utilization ($\xi^C = \xi^I = 5000$); (ii) “MP” represents the case with market power as in the benchmark calibration and “No-MP” represents the case with no market power ($\nu^C = \nu^I = 40000$); and (iii) “High EIS” as in the benchmark calibration (EIS = 2) and “Low EIS” represents a lower value of EIS (EIS = 0.5). All the other parameters are kept to their benchmark levels contained in Table 1. For each combination of alternative parameters, we simulate the model and report the median across 1,000 simulations. We highlight in bold the values obtained under the benchmark calibration reported in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>High EIS</th>
<th>Low EIS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No-MP</td>
<td>MP</td>
</tr>
<tr>
<td>Panel A: risk-free rate $r_f(%)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible KU</td>
<td>0.96</td>
<td><strong>0.90</strong></td>
</tr>
<tr>
<td>Fixed KU</td>
<td>1.29</td>
<td>1.24</td>
</tr>
<tr>
<td>Panel B: equity risk-premium $r_m^{ex}(%)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible KU</td>
<td>-3.71</td>
<td><strong>5.65</strong></td>
</tr>
<tr>
<td>Fixed KU</td>
<td>-2.43</td>
<td>4.96</td>
</tr>
</tbody>
</table>
Table 4: Decomposition of aggregate market risk premium

This table reports the decomposition of market risk premia into prices of risk and betas of the four different shocks, $A_t$, $Z_t$, $\mu^a_t$, and $\mu^z_t$. We consider the following alternative choices: (i) “Flexible KU” represents the flexible capital utilization as in the benchmark calibration and “Fixed KU” represents the case with fixed capital utilization ($\xi^C = \xi^I = 5000$); (ii) “MP” represents the case with market power as in the benchmark calibration and “No-MP” represents the case with no market power ($\nu^C = \nu^I = 40000$); and (iii) “High EIS” as in the benchmark calibration (EIS = 2) and “Low EIS” represents a lower value of EIS (EIS = 0.5). RRA $\gamma = 10$. All the other parameters are kept to their benchmark levels contained in Table 1. For each combination of alternative parameters, we simulate the model and report the median values across 1,000 simulations for the following variables: (i) price of risk ($\lambda$), (ii) market return loading ($\beta$), and (iii) leveraged risk premium ($2\beta\lambda$) for each shock and the summation of all shocks (column “$\sum X$”). We highlight in bold the risk premia due to each shock and the aggregate equity risk premium obtained under the benchmark calibration reported in Table 2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>High EIS</th>
<th>Low EIS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shock (X)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$A$</td>
<td>$Z$</td>
</tr>
<tr>
<td>Panel A: Flexible KU and MP</td>
<td>$\lambda^X$</td>
<td>0.16%</td>
</tr>
<tr>
<td></td>
<td>$\beta^X_M$</td>
<td>1.41</td>
</tr>
<tr>
<td></td>
<td>$2\beta^X_M\lambda^X$</td>
<td><strong>0.46%</strong></td>
</tr>
<tr>
<td>Panel B: Flexible KU and No-MP</td>
<td>$\lambda^X$</td>
<td>0.16%</td>
</tr>
<tr>
<td></td>
<td>$\beta^X_M$</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>$2\beta^X_M\lambda^X$</td>
<td>0.14%</td>
</tr>
<tr>
<td>Panel C: Fixed KU and MP</td>
<td>$\lambda^X$</td>
<td>0.16%</td>
</tr>
<tr>
<td></td>
<td>$\beta^X_M$</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>$2\beta^X_M\lambda^X$</td>
<td>0.43%</td>
</tr>
<tr>
<td>Panel D: Fixed KU and No-MP</td>
<td>$\lambda^X$</td>
<td>0.16%</td>
</tr>
<tr>
<td></td>
<td>$\beta^X_M$</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>$2\beta^X_M\lambda^X$</td>
<td>0.19%</td>
</tr>
</tbody>
</table>
Figure 1: The effect of flexible capital utilization

The figure plots the impulse response functions (IRFs) of consumption (log $C$), SDF (log $SDF$), and market portfolio value (log $V^M$), to one standard deviation shock to the investment-specific technology. The utility is a log function ($\rho = \gamma = 1$) and firms do not have market power ($\nu_C = \nu_I = 40000$). For each variable, the figure reports the IRFs under two calibrations: (i) capital utilization is flexible ($\xi^C = \xi^I = 0.3$), solid line; (ii) capital utilization is fixed ($\xi = 3000$), dashed line. The capital adjustment cost parameter $\phi^C = \phi^I = 2$. All the other parameter values are the same as in Table 1.
Figure 2: The effect of market power
The figure plots the impulse response functions (IRFs) of consumption ($\log C$), SDF ($\log SDF$), and market portfolio value ($\log V^M$), to one standard deviation shock to the investment-specific technology. The utility is a log function ($\rho = \gamma = 1$) and capital utilization is flexible ($\xi^C = \xi^I = 0.3$). For each variable, the figure reports the IRFs under two calibrations: (i) firms have market power ($\nu^C = \nu^I = 4$), solid line; (ii) firms are perfectly competitive ($\nu^C = \nu^I = 40000$), dashed line. The capital adjustment cost parameter $\phi^C = \phi^I = 2$. All the other parameter values are the same as in Table 1.
Figure 3: The effect of EIS

The figure plots the impulse response functions (IRFs) of consumption (log $C$), SDF (log $SDF$), and market portfolio value (log $V^M$), to one standard deviation shock to the investment-specific technology. The utility is CRRA ($\gamma = 1/EIS$), capital utilization is fixed ($\xi^C = \xi^I = 3000$), and firms are perfectly competitive ($\nu_C = \nu_I = 40000$). For each variable, the figure reports the IRFs under two calibrations: (i) high EIS (EIS = 1), solid line; (ii) low EIS (EIS = 0.2), dashed line. The capital adjustment cost parameter $\phi^C = \phi^I = 2$. All the other parameter values are the same as in Table 1.
Figure 4: The effect of preference towards temporal resolution of uncertainty
The figure plots the impulse response functions (IRFs) of consumption (log $C$), SDF (log $SDF$), and market portfolio value (log $V^M$), to one standard deviation shock to the investment-specific technology. Capital utilization is fixed ($\xi^C = \xi^I = 3000$), and firms are perfectly competitive ($\sigma^C = \sigma^I = 40000$). For each variable, the figure reports the IRFs under three calibrations: (i) Preference towards early resolution of uncertainty ($\rho < \gamma$, with $\rho = 0.5$ and $\gamma = 2$), dashed line; (ii) Indifference between early vs. late resolution of uncertainty ($\rho = \gamma = 2$), solid line, and (iii) Preference towards late resolution of uncertainty ($\rho > \gamma$, with $\rho = 3$ and $\gamma = 2$), dotted line. The capital adjustment cost parameter $\phi^C = \phi^I = 2$. All the other parameter values are the same as in Table 1.
Figure 5: Asset pricing implications of capital flexibility, market power, and EIS
The figure plots the heatmap of three variables as a function of capital flexibility (vertical axis) and market power (horizontal axis): (i) IST market price of risk ($\lambda_z$), (ii) IST market beta ($\beta_{zM}$), and (iii) IST risk premium ($RP_{zM}$). The household has Epstein-Zin preferences with RRA $\gamma = 2$, $EIS = 1/3$ in the “Low EIS” column (Panels A, B, and C), and $\gamma = 2$, $EIS = 2$ in the “High EIS” column (Panels D, E, and F). We change the capital inflexibility parameter $\xi_C = \xi^f$ in the interval [0.02, 100], and the market power parameter $\nu^C = \nu^f$ in the interval [1.2, $10^{12}$]. The capital adjustment cost parameter in both sectors is set to $\phi^C = \phi^f = 2$. All the other parameter values are the same as in Table 1.
References


