

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

Lorenzo Garlappi[†]
University of British Columbia

Zhongzhi Song[‡]
Cheung Kong GSB

November 20, 2016

Journal of Financial Economics, forthcoming

*We are grateful to Toni Whited (the editor) and an anonymous referee for extensive comments and constructive suggestions. We thank Paul Beaudry, Jules van Binsbergen, Murray Carlson, Jack Favilukis, Adlai Fisher, Ron Giammarino, Burton Hollifield, Nengjiu Ju, Jiri Knesl, Xiaoji Lin, Stavros Panageas, Dimitris Papanikolaou, Carolin Pflueger, Loris Rubini, Elena Simintzi, Raman Uppal, Stijn Van Nieuwerburgh, Amir Yaron, Harold Zhang, and seminar participants at the Central Bank of Mexico, Shanghai Advanced Institute of Finance, Texas A&M University, Tsinghua University, the University of British Columbia, the University of Lausanne, the University of Maryland, the University of Rochester, and conference participants at the CAPR Workshop on Production-based Asset Pricing at BI Norwegian Business School, China International Conference in Finance, Finance UC 6th International Conference at the Universidad Católica de Chile, the 2nd Meeting of the Macro Finance Society at NYU, and Summer Institute of Finance for valuable comments. We are particularly grateful to Haibo Jiang for excellent research assistance.

[†]Department of Finance, Sauder School of Business, University of British Columbia, 2053 Main Mall, Vancouver, BC V6T 1Z2, Canada, E-mail: lorenzo.garlappi@sauder.ubc.ca.

[‡]Cheung Kong Graduate School of Business, 3F, Tower E3, Oriental Plaza, 1 East Chang An Avenue, Beijing 100738, China. E-mail: zzsong@ckgsb.edu.cn.

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Abstract

Capital utilization and market power crucially affect asset prices in an economy exposed to shocks that improve real investment opportunities through capital-embodied technological innovations. We embed these two mechanisms in a standard general equilibrium model and show that (i) the price of risk for investment shocks is negative under fixed capital utilization, but positive under sufficiently flexible capital utilization, and (ii) the equity return exposure to investment shocks is negative under perfect competition, but positive under high market power. We further show that, high market power, persistent components in technology growth, and a strong preference for early resolution of uncertainty are jointly important to quantitatively match the observed equity risk premium.

JEL Classification Codes: E22; G12; O30

Keywords: Investment shocks; Capital utilization; Market power; Risk premium

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 effect 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

¹See, 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.

²See, 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."

³Monopolistic 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 Grüning (2016). 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 quantitative analysis further shows that, high market power, “long-run risks” in technology growth, and a strong preference for early resolution of uncertainty are jointly important for quantitatively 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 on 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 leads to 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 capital utilization flexibility can 'undo' some of the effects of preferences on IST pricing. For example, under preferences for late resolution of uncertainty, flexible capital utilization can change the price of risk of IST shocks from negative to positive. 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, market power, and preferences are also quantitatively important. We first document the existence of a small and persistent component in IST shocks, complementing the evidence on the existence of a similar "long-run risk" component in TFP shocks (e.g., Croce (2014)). We then show that long-run risks in technology growth, 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 log risk-free rate of 0.50% and an annual log equity risk premium of 5.14%. Without flexible utilization and market power, the same parametrization delivers a counterfactual negative equity risk premium. Our

analysis also shows that the contribution of the short-run component of technology shocks to the aggregate risk premium is much smaller than that of the long-run component. In our benchmark calibration, these short- and long-run risks contribute, respectively, 11% and 89% to the total equity risk premium. In our comparative statics analysis, we show that higher market power and stronger preference for early resolution of uncertainty lead to higher equity risk premium. The quantitative effect of capital utilization on the risk premium, however, depends on both preferences and types of shocks. If preferences are time-separable or technology shocks contain only short-run components, risk premia are affected mainly by the marginal “period” utility. In this case, higher flexibility in capital utilization amplifies the effect of technology shocks on the marginal period utility, and therefore leads to a higher equity risk premium. In contrast, in our benchmark calibration with long-run risks and recursive preferences, risk premia are affected mainly by the marginal “continuation” utility. In this case, higher flexibility in capital utilization acts like a lower capital adjustment cost and hence decreases the equity risk premium.

The findings of this paper shed light on the conflicting evidence in the existing literature regarding the 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 (2015) argues that a positive price of risk for IST shocks is needed to explain the profitability of momentum strategies.⁴ To better understand these conflicting arguments, Garlappi and Song (2016) 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.⁵ The economic mechanisms discussed in this paper help explain these empirical findings, and therefore lend support to a positive IST price of risk, as assumed by Li (2015). In addition, our study also helps us to better understand the pricing effect of other shocks that are similar to IST shocks. For example, Belo, Lin, and Bazdresch (2014) incorporate labor adjustment costs into a standard investment model, where adjustment costs are subject to stochastic shocks that are analogous to IST shocks. They find that an exogenously specified negative price of risk for the adjustment costs shocks helps to explain the cross section of return of firms with different hiring rates. Our study implies that the mechanisms affecting the pricing of IST shocks should also have a similar qualitative effect on the pricing of adjustment cost shocks, and hence can change the effect of these shocks on cross-sectional returns.

⁴Because the shocks to the price of capital goods in Li (2015) can be viewed as the inverse of the IST shocks (see, e.g., Greenwood, Hercowitz, and Krusell (1997)), a negative price of risk for the price shocks is equivalent to a positive price of risk for IST shocks.

⁵Garlappi and Song (2016) 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.

Our work is related to a large literature that studies the macroeconomic and asset pricing implications of IST shocks.⁶ 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.

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 (2016) show how innovation endogenously drives a small, persistent component in aggregate productivity (TFP) and 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 empirically document the existence of a persistent component in IST shocks and to study the theoretical implications of this long-run risk component.

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 quantitative implications for macroeconomic quantities and asset prices. Section 5 concludes. Appendix A contains details on the model solution, Appendix B provides details on the model simulation, and Appendix C describes the data used in our calibration.

⁶Neutral 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).

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)):

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

where β is the time discount rate, $1/\rho$ is the EIS, and γ is the coefficient of relative risk aversion (RRA hereafter). The parameters ψ and θ 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:

$$V_t = \max_{\{C_s, L_s\}_{s=t}^\infty} U_t, \quad \text{s.t.} \quad P_s^C C_s = W_s L_s + D_s^C + D_s^I, \quad s \geq t, \quad (2)$$

where P_s^C is the price of consumption good at time s ,⁷ 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 , $\mathbb{M}_{t,t+1}$, which is the marginal rate of substitution between time $t+1$ and time t , is given by,

⁷For convenience, we choose the final consumption good as numeraire by setting $P_t^C \equiv 1$ for all t .

$$M_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \left(\frac{1 - \psi L_{t+1}^\theta}{1 - \psi L_t^\theta} \right)^{1-\rho} \left(\frac{V_{t+1}}{(\mathbb{E}_t V_{t+1}^{1-\gamma})^{\frac{1}{1-\gamma}}} \right)^{\rho-\gamma}. \quad (3)$$

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:

$$Y_t^J = \left[\sum_{f=1}^{N_J} (x_{f,t}^J)^{\frac{\nu_J-1}{\nu_J}} \right]^{\frac{\nu_J}{\nu_J-1}}, \quad J = C, I, \quad (4)$$

where $x_{f,t}^J$ is the input of intermediate good of type f in sector J , and ν_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 perfectly competitive and so they make zero net profit in equilibrium.⁸ The final good producer's demand $x_{f,t}^J$ of intermediate good of type f at time t is determined by an intra-temporal profit maximization, i.e.,

$$\max_{x_{f,t}^J} P_t^J Y_t^J - \sum_{f=1}^{N_J} p_{f,t}^J x_{f,t}^J, \quad J = C, I, \quad (5)$$

where Y_t^J is given by (4) and the prices P_t^J and $p_{f,t}^J$ 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:

$$x_{f,t}^J = \left(\frac{p_{f,t}^J}{P_t^J} \right)^{-\nu_J} Y_t^J, \quad J = C, I \quad (6)$$

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

⁸This implies that the final good producers have zero market value, so they do not affect the households' budget constraint and do not contribute to the market portfolio. An equivalent interpretation is that consumers have CES preferences over intermediate consumption goods in the spirit of Dixit and Stiglitz (1977). We then can think of the final consumption good producers as the consumers themselves. Similarly, we can interpret the intermediate good producers as producers of the final investment good endowed with a CES production technology.

The CES parameter ν_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 $\nu_J \rightarrow \infty$. 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 ν_J , the intermediate goods are not perfect substitutes. As a result, each monopolistic firm has some degree of market power in the product market. 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. 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 ν_J implies no markup, or no market power for perfectly competitive firms. On the other hand, a lower value of ν_J implies a higher markup, or higher market power for the monopolistic firms.

Each intermediate good firm f produces good f by using capital, $k_{f,t}^J$, and labor, $l_{f,t}^J$, according to the following Cobb-Douglas production technology:

$$y_{f,t}^C = A_t (u_{f,t}^C k_{f,t}^C)^{1-\alpha^C} (l_{f,t}^C)^{\alpha^C}, \quad (7)$$

$$y_{f,t}^I = A_t Z_t (u_{f,t}^I k_{f,t}^I)^{1-\alpha^I} (l_{f,t}^I)^{\alpha^I}, \quad (8)$$

where A_t is total factor of productivity (TFP), Z_t is an investment-specific productivity shock, and $u_{f,t}^J > 0$ 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 $u_{f,t}^J > 0$ captures the duration, or speed, in operating existing equipment. For example, a high level of $u_{f,t}^J$ may represent less maintenance time or longer working hours. If we normalize the capital utilization to be $u_{f,t}^J = 1$ 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:

$$\Delta a_t = \bar{\mu}^a + \mu_{t-1}^a + \varepsilon_t^a, \quad \varepsilon_t^a \sim i.i.d. \mathcal{N}(0, \sigma_a^2), \quad (9)$$

$$\Delta z_t = \bar{\mu}^z + \mu_{t-1}^z + \varepsilon_t^z, \quad \varepsilon_t^z \sim i.i.d. \mathcal{N}(0, \sigma_z^2), \quad (10)$$

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 μ_{t-1}^a and μ_{t-1}^z represent possibly time-varying expected growth in the TFP and IST shocks.⁹ We assume that the shocks ε_t^a and ε_t^z are uncorrelated.

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

$$k_{f,t+1}^J = k_{f,t}^J(1 + i_{f,t}^J - \delta(u_{f,t}^J)), \quad J = C, I, \quad (11)$$

where $i_{f,t}^J$ denotes the investment rate and the depreciation rate $\delta(u_{f,t}^J)$ depends explicitly on the capital utilization intensity $u_{f,t}^J$. 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.,

$$\delta(u^J) = \delta_0 + \delta_1 \frac{u^{1+\xi^J} - 1}{1 + \xi^J}, \quad \xi^J > 0, \quad J = C, I, \quad (12)$$

where δ_0 corresponds to the depreciation rate under unit capital utilization, i.e., $\delta(1) = \delta_0$. The parameter ξ^J measures the elasticity of marginal depreciation with respect to capital utilization, i.e., $\xi^J = \delta''(u^J)u^J/\delta'(u^J)$. A higher ξ^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 ξ^J makes increasing capital utilization more costly. In contrast, a lower ξ^J implies that capital utilization is very responsive to exogenous shocks. Therefore, the parameter ξ^J measures the inflexibility of firms' capital service in responses to shocks. We restrict the capital depreciation to be non-negative.

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

$$\varphi(i^J) = i^{J*} + \frac{1}{\phi^J}(1 + i^{J*}) \left[\left(\frac{1 + i^J}{1 + i^{J*}} \right)^{\phi^J} - 1 \right], \quad \phi^J \geq 1, \quad J = C, I, \quad (13)$$

where ϕ^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.

⁹In the qualitative analysis of Section 3 we assume μ_{t-1}^a and μ_{t-1}^z 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)).

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_t^I , and the stochastic discount factor, $\mathbb{M}_{t,t+1}$. Importantly, in solving its maximization problem, firm f takes as given the demand $x_{f,t}^J$ for intermediate good f derived in (6). Specifically, the firm producing intermediate good f solves the following problem:

$$\begin{aligned} V_{f,t}^J &= \max_{\{l_{f,s}^J, i_{f,s}^J, u_{f,s}^J\}_{s=t}^{\infty}} \mathbb{E}_t \sum_{s=t}^{\infty} \mathbb{M}_{t,s} d_{f,s}^J, \\ \text{s.t. } d_{f,s}^J &= p_{f,s}^J y_{f,s}^J - W_s l_{f,s}^J - P_s^I \varphi(i_{f,s}^J) k_{f,s}^J, \quad J = C, I, \end{aligned} \quad (14)$$

where $d_{f,s}^J$ is firm f 's dividend at time s , and $\mathbb{M}_{t,s}$ is the time- t SDF for time- s payoffs, obtained from the one-period SDF in (3) as $\mathbb{M}_{t,s} = \prod_{k=0}^{s-t-1} \mathbb{M}_{t+k,t+k+1}$. 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

$$V_t^J = \sum_{f=1}^{N_J} V_{f,t}^J = \mathbb{E}_t \sum_{s=t}^{\infty} \mathbb{M}_{t,s} D_s^J, \quad \text{s.t. } D_s^J = \sum_{f=1}^{N_J} d_{f,s}^J, \quad J = C, I, \quad (15)$$

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,

$$V_t^M = V_t^C + V_t^I. \quad (16)$$

2.3 Equilibrium

In equilibrium, all markets have to clear. For the C-sector, the market clearing condition is $C_t = Y_t^C$, where Y_t^C 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:

$$\sum_{f=1}^{N^C} \varphi(i_{f,t}^C) k_{f,t}^C + \sum_{f=1}^{N^I} \varphi(i_{f,t}^I) k_{f,t}^I = Y_t^I, \quad (17)$$

where Y_t^I 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 ($J = C, I$):

$$K_t^J = N_J k_{f,t}^J, L_t^J = N_J l_{f,t}^J, P_t^J Y_t^J = N_J p_{f,t}^J y_{f,t}^J, \text{ and } Y_t^J = (N_J)^{\frac{\nu_J}{\nu_J-1}} y_{f,t}^J. \quad (18)$$

The equilibrium of the economy is determined by the solution of the households' problem (2) and the firms' problems (14). In Appendix A we 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 SDF process (3) on the space spanned by these shocks, we can write:

$$\mathbb{M}_{t,t+1} = \mathbb{E}_t [\mathbb{M}_{t,t+1}] - \frac{\lambda_t^a}{\sigma_a^2} \cdot \varepsilon_{t+1}^a - \frac{\lambda_t^z}{\sigma_z^2} \cdot \varepsilon_{t+1}^z, \quad (19)$$

where ε_{t+1}^a and ε_{t+1}^z are orthogonal to each other. The quantities λ_t^a and λ_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

$$\lambda_t^x = -\text{Cov}_t(\mathbb{M}_{t,t+1}, \varepsilon_{t+1}^x), \quad x = a, z. \quad (20)$$

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 gross return $R_{j,t+1} = \frac{V_{t+1}^j}{V_t^j - D_t^j}$ of a generic asset j on the space spanned by these shocks, i.e.,

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

The risk premium on asset j can be written as

$$RP_{j,t} \equiv \frac{\mathbb{E}_t[R_{j,t+1}]}{R_{f,t}} - 1 = -\text{Cov}_t(\mathbb{M}_{t,t+1}, R_{j,t+1}) = \beta_{j,t}^a \lambda_t^a + \beta_{j,t}^z \lambda_t^z, \quad (22)$$

where $R_{f,t} = 1/\mathbb{E}_t[\mathbb{M}_{t,t+1}]$ is the one-period risk-free rate at time t and the equality follows from (19) and (21) and the orthogonality of the shocks ε_{t+1}^a and ε_{t+1}^z . Therefore, the risk premium associated with each shock ($x = a, z$) is the product of the ‘quantity’ of risk (β^x) and the ‘price’ of risk (λ^x).

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

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

where, from (21), the loadings are given by

$$\beta_{M,t}^x = \frac{\text{Cov}_t(R_{M,t+1}, \varepsilon_{t+1}^x)}{\sigma_x^2}, \quad x = a, z, \quad (24)$$

where the market return, $R_{M,t+1}$, is determined by the cum-dividend aggregate market value defined in (15) and (16). Therefore, $\beta_M^x \lambda^x$ represents 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

$$\mu_t^a = 0, \text{ and } \mu_t^z = 0, \quad (25)$$

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 ρ , representing the inverse of the EIS and γ , the RRA parameter. Section 3.3 illustrates the implication of capital utilization, market power, and preferences for the aggregate market risk premium. All the results in this section are obtained by solving the model at the annual frequency using value function iteration as discussed in detail in Appendix A.

3.1 CRRA utility

By setting $\rho = \gamma$ in (1), households' preferences have the following CRRA representation:¹⁰

$$U_t = \sum_{j=0}^{\infty} \frac{\beta^j [C_{t+j}(1 - \psi L_{t+j}^\theta)]^{1-\gamma}}{1 - \gamma}. \quad (26)$$

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

$$\mathbb{M}_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \left(\frac{1 - \psi L_{t+1}^\theta}{1 - \psi L_t^\theta} \right)^{1-\gamma}. \quad (27)$$

3.1.1 The effect of flexible capital utilization

Figure 1 reports the impulse response functions (IRFs) of log consumption ($\log C$), log labor supply ($\log L$), log SDF ($\log SDF$) and log aggregate market value ($\log V^M$) to one standard deviation shock to Z_t .¹¹ 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 $\nu_C = \nu_I = 10000$ 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 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.¹² 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. Therefore, the price of risk for IST shocks is negative: households are willing to accept a return lower than the risk-free rate to hold a security

¹⁰Note the slight abuse of notation in (26) where U_t represents the quantity $U_t^{1-\rho}$ in (1). Furthermore, the utility in (1) corresponds to (26) only after rescaling it by the factor $(1 - \beta)(1 - \gamma)$. The transformation and rescaling do not affect households' preference towards consumption and leisure.

¹¹All the impulse response functions reported in the paper are computed as in Petrosky-Nadeau and Zhang (2016). Specifically, starting from the median of the model's ergodic distribution as the initial point, we simulate two time series of the model that differ only by one-standard-deviation shock to IST at $t = 1$. We then average the difference between the two time series of interest over 100,000 simulations.

¹²Under 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_t^c of the C-sector (see, e.g., Jaimovich and Rebelo (2009)).

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 IST risk.¹³ 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 $\nu_C = \nu_I = 10000$ 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 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.

¹³Note that, because Figure 1 refers to the case of log utility, the SDF in (27) depends only on consumption and not on labor.

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 Recursive preferences

In the above analysis, we established 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 arises, 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 γ 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 γ 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 is not necessarily the opposite of the response of consumption and leisure, as in the case of CRRA preferences. For example, in the third panel of Figure 4, when households 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:

$$\left(\frac{V_{t+1}}{(\mathbb{E}_t V_{t+1}^{1-\gamma})^{\frac{1}{1-\gamma}}} \right)^{\rho-\gamma} \quad (28)$$

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 $\log SDF$) 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 IRF of $\log SDF$: a negative IRF implies a positive price of risk and vice-versa. As the figures show, the IRF of $\log SDF$ 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 an 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.¹⁴

¹⁴Jaimovich 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.

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 SDF represents the market price of risk λ^z of IST shocks. Similarly, from (24), the IRF of V^M represents the IST beta loading of the market portfolio β_M^z . 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 ($\beta_M^z \lambda^z$). We do so by studying how market power, capital flexibility and household preferences affect the price of IST risk, λ^z , and the “quantity” of IST risk, β_M^z , 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 this 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, λ^z (ii) the IST beta, β_M^z , and (iii) the IST market risk premium, $\beta_M^z \lambda^z$.

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 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 flexible capital utilization and market power on the equity risk premium under Epstein-Zin preference. In order to generate sizeable equity risk premium, we assume that there are long-run risk components in both the TFP and IST shocks. Specifically, we assume that the expected growth rates μ_t^a and μ_t^z of the technology shocks (9) and (10) are mean-reverting, according to the following specification:

$$\mu_t^a = \rho_{\mu^a} \mu_{t-1}^a + \varepsilon_t^{\mu^a}, \quad \varepsilon_t^{\mu^a} \sim i.i.d. \mathcal{N}(0, \sigma_{\mu^a}^2), \quad (29)$$

$$\mu_t^z = \rho_{\mu^z} \mu_{t-1}^z + \varepsilon_t^{\mu^z}, \quad \varepsilon_t^{\mu^z} \sim i.i.d. \mathcal{N}(0, \sigma_{\mu^z}^2), \quad (30)$$

with $0 < \rho_{\mu^a} < 1$ and $0 < \rho_{\mu^z} < 1$. We assume that $\varepsilon_t^{\mu^a}$ and $\varepsilon_t^{\mu^z}$ are independent of each other and of the short run shocks, ε_t^a and ε_t^z .

Croce (2014) documents that TFP shocks contain a small and persistent component. He estimates that the persistence ρ_{μ^a} of this “long-run risk” component ranges between 0.66 and 0.99, and that its volatility, relative to the “short-run risk” component (σ_{μ^a}/σ_a) is between 4% and 32%, depending on the choice of empirical measures and econometric methods. We follow the same approach as Croce (2014) and employ Bansal, Kiku, and Yaron (2010) procedure to decompose IST shocks into orthogonal short-run and long-run risk components by projecting IST shocks on the real risk-free rate and the price-dividend ratio. We use the relative price of the capital good as a measure of IST shocks (see Greenwood, Hercowitz, and Krusell (1997)) and find that the autocorrelation of the persistent component is $\rho_{\mu^z} = 0.86$, and that its volatility, relative to the short-run volatility (σ_{μ^z}/σ_z) is 26%.¹⁵ Therefore, as for TFP shocks, the data suggests that there is a sizable and persistent component in the empirical IST measures. These

¹⁵We also use two alternative measures of IST shocks, one based on the relative growth rate difference in the aggregate investment and consumption (*gIMC*), and the other based on the relative return spread between consumption sector and investment sector (*IMC*). The persistence is 0.80 (0.74) when *gIMC* (*IMC*) is used, and

estimates lend support to our specification (29)–(30) and provide guidance for calibrating the long-run risk components of technology shocks.

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 Sections 4.2 and 4.3.

4.1.1 Parameters

The model parameters belong to three groups: preferences, 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 Table 1.

Preferences. We choose an annual discount factor $\beta^{12} = 0.98$, 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 $\theta = 1.6$, similar to the value used in Jaimovich and Rebelo (2009). The value ψ 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 available time.

Production. We set the labor share of output to $\alpha^C = \alpha^I = 0.60$. The capital adjustment cost parameter is set to $\phi^C = 14$ for the consumption sector, and $\phi^I = 7$ 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 annual depreciation rate under deterministic steady state is set to $12 \times \delta_0 = 10\%$. The other depreciation parameter in (12), δ_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 $\xi^C = 1.1$ for the consumption sector and $\xi^I = 0.6$ 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 ξ implies less flexibility in adjusting capital utilization in equilibrium. We choose a higher value of ξ to match the volatility of capacity utilization variation for the U.S. industrial sector as reported by the Federal Reserve (see Appendix C for details). We choose market power parameters $\nu_C = \nu_I = 4$, which imply a 33% markup for firms in both sectors. This markup value is slightly lower than the 36% markup value calibrated by Bilbiie, Ghironi, and Melitz (2012).

the relative volatility of the persistent component is 18% (9%). The estimates are based on annual data from 1930 to 2012. All three measures of IST shocks are taken from Garlappi and Song (2016).

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 $12 \times \bar{\mu}^a = 0.1\%$ ($\sqrt{12} \times \sigma_a = 1.6\%$), and $12 \times \bar{\mu}^z = 3\%$ ($\sqrt{12} \times \sigma_z = 2.6\%$). 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 annual persistence to $\rho_{\mu^a}^{12} = \rho_{\mu^z}^{12} = 0.77$, which lies within the range of empirical estimates. For the volatility of long-run risks relative to the short-run risks, we set $\sigma_{\mu^j}/\sigma_j = 10\%$, $j = a, z$, which is the same value used by Croce (2014) and also lies within the range of empirical estimates.

4.1.2 Equilibrium policies

Using the parameter values in Table 1, we solve the decentralized equilibrium numerically through value function iteration (details of the algorithm are in Appendix A.4). As we show in Appendices A.1–A.3, a rescaled version of the model is mean and covariance stationary and is described by four state variables: (i) the expected growth of TFP shocks, μ_t^a , (ii) the expected growth of IST shocks, μ_t^z , (iii) the log of the capital ratio in the two sectors, $k_t \equiv \log(K_t^I/K_t^C)$, and (iv) the log of a rescaled composite variable, $\Omega_t \equiv \log\left((N_I)^{\frac{1}{\nu_I-1}} A_t Z_t / (K_t^I)^{\alpha^I}\right)$. We solve the model on a four-dimensional grid $(\mu^a, \mu^z, k, \Omega)$.

Figure 6 reports the equilibrium firm policies—labor, capital utilization rate, and investment rate—for both C- and I-firms as a function of k and Ω , while keeping the other two state variables, μ^a and μ^z , at their unconditional average values. Higher values of k correspond to a smaller C-sector capital, K_t^C , relative to the I-sector capital, K_t^I . Higher values of Ω correspond to states with higher level of I-sector productivity $A_t \cdot Z_t$, for every given level of the I-sector capital, K_t^I . The figure shows that the I-sector labor is increasing in both k and Ω . That is, when the C-sector capital is low or when the I-sector productivity is high, firms in the I-sector demand a higher labor input to produce more capital goods. In contrast, C-sector labor decreases in both k and Ω , confirming that the equilibrium labor in the two sectors negatively comove when preferences for consumption and leisure are of the King, Plosser, and Rebelo (1988) type, as in equation (1). The investment and capital utilization rates in both sectors are increasing in both k and Ω . That is, when the C-sector capital is relatively low or when the I-sector sector productivity is relatively high, firms in both sectors choose to increase the utilization rate of their existing capital and accumulate more capital. Figure 7 reports the equilibrium aggregate consumption, aggregate investment, the equilibrium wages and the price of capital good. The aggregate consumption (investment) reflects closely the behavior of equilibrium labor in the C-sector (I-sector), reported in Figure 6. Wages are increasing in both k and Ω . The price of capital

good is decreasing in both k and Ω . Intuitively, a positive IST shock leads to a higher Ω and therefore a lower capital good price.

4.1.3 Macroeconomic and asset pricing moments

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. Each simulation consists of 100 years of monthly observations. 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. 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 1.5.¹⁶

Overall, the model replicates fairly well the growth rate and volatility of consumption, investment, labor supply, output, equipment price, and capital utilization. Note that the model generates relatively high consumption growth volatility. This is a result of the separation of consumption and investment in our two-sector model, where investment does not absorb the shocks to consumption as it happens in a one-sector model. 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 log risk-free rate of 0.50% vs. 0.54% in the data, and a log equity risk premium of 5.14% in the model vs. 5.48% 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.

We have also solved the model by a second-order local approximation of the policies around the steady state, obtained by using the Dynare software package. While the macroeconomic moments are quite similar to the moments obtained from the value-function iteration (VFI) algorithm, we find that the asset pricing moments can be quite different. For example, the perturbation approach delivers a mean annual log risk-free rate of -2.38% (vs. 0.50% from VFI) and a mean annual log risk premium of 14.36% with 29.84% volatility (vs. 5.14% and 6.08% from VFI). These numbers suggests that the perturbation solution of our model can deliver quite inaccurate asset pricing quantities. Although VFI is much slower than local approximation, its well-known convergence properties makes it a more robust choice to analyze asset prices in a complex model like ours.

¹⁶Our choice of the leverage factor follows Barro (2006) and is conservative compared to Papanikolaou (2011) and Croce (2014) who use a leverage factor of $5/3$ and 2 , respectively.

In our model, the equilibrium risk premium is state-dependent and therefore time-varying. In Table 3 we study return predictability in the model. As it is well known (see, e.g., Kaltenbrunner and Lochstoer (2010) and Petrosky-Nadeau, Zhang, and Kuehn (2015)) dividends can be negative in a production economy like ours. Therefore the table reports long-horizon regression of market excess returns and consumption growth on log price-to-consumption ratio. The left panel shows that, over the sample period 1930–2015, stock prices forecast expected returns but not consumption growth. The regression coefficients from 1- to 5-year return predictability regressions are all negative and significant. In contrast, the coefficient from consumption growth predictability regressions are indistinguishable from zero at all horizon.

The lower panel in Table 3 illustrates that the model fails to capture the return predictability observed in the data. Returns in the model are not predictable while consumption growth is strongly predictable by the log consumption-price ratio. In our model, households can efficiently smooth consumption over time by affecting production and investment. As a consequence, consumption is by construction highly predictable: a high price-to-consumption ratio today implies higher consumption in the future, leading to the high level of consumption growth predictability observed on the lower panel of Table 3.

Finally, using the definition of dividends provided in equation (15), we analyze the properties of aggregate dividend growth in our model.¹⁷ We simulate the model as before under the benchmark calibration of Table 1 and find that a mean annual dividend growth rate of 1.87% and a volatility of 16.22%. In the model, the correlation between dividend growth and output growth is -0.48 . The countercyclical property of dividend is at odds with data but is standard in a production economy with a frictionless labor market like ours. Intuitively, because of consumption smoothing, a frictionless labor market implies that investment is more procyclical than output and therefore dividend must be countercyclical. The literature has pointed out several ways to address this potential shortcoming, such as wage stickiness (Favilukis and Lin (2016)) or search frictions in the labor market (Petrosky-Nadeau, Zhang, and Kuehn (2015)). It is beyond the scope of this paper to investigate these channels.

4.2 Decomposition of the risk premium

To illustrate the quantitative importance of the three channels discussed in Section 3 for the aggregate risk premium, in this subsection we consider alternative parameterizations for the degree of flexibility in capital utilization, market power, and elasticity of intertemporal substitution. For

¹⁷As Kaltenbrunner and Lochstoer (2010) point out, dividends from a production economy like ours cannot be considered as equivalent to the dividends from the aggregate stock market given that publicly traded equity represents only a small component of an economy’s productive capital. In order to construct the dividend growth rate, we consider only the model simulations where the dividend is positive.

each different parameterization, we compute: (i) the “price” of risk, λ , and “quantity” of risk, β , for the short-run shocks, ε_t^a and ε_t^z , and the long-run shocks $\varepsilon_t^{\mu^a}$ and $\varepsilon_t^{\mu^z}$; (ii) the contribution of each shock to the aggregate risk premium. Details of the decomposition procedure are provided in Appendix B.

Panel A in Table 4 reports the decomposition of the risk premium from the benchmark calibration used in Table 2 in which capital utilization is flexible and firms have market power. The entries in Panel A show that in our benchmark calibration, out of the total risk premium of 5.37% (column labeled RP_M)¹⁸, 0.56% comes from the short-run TFP-shock (A), 0.02% from short-run IST shock (Z), 4.17% from the long-run TFP-shock (μ^a), and 0.61% from the long-run IST shock (μ^z). The risk premium mainly comes from the two sources of long-run risks in technology growth which, combined, contribute for 89% of the total market risk premium.

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 the market risk premium. When firms do not have market power, the price of risks are similar to the values in Panel A, but all the four betas decrease, and the two IST betas even become negative. This leads to positive risk premia from the short- and long-run TFP shocks, but negative risk premia from the short- and long-run IST shocks. The aggregate risk premium in this case is -0.62% . Therefore, when capital utilization is flexible, market power increases the aggregate risk premium from -0.62% in Panel B to 5.37% in Panel A. A similar comparison shows that, when capital utilization is fixed, market power increases the aggregate risk premium from -0.26% in Panel D to 6.22% in Panel C. The intuition is similar to 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.

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, flexibility in capital utilization has a mild effect on the risk premium which decreases from 6.22% when utilization is fixed, to 5.37% when utilization is flexible. Similarly, when firms do not have market power, flexible capital utilization decreases the risk premium from -0.26% in Panel D to -0.62% in Panel B. As we discuss below in Subsection 4.3.1, the effect of flexible capital utilization depends on both preferences and types of shocks.

Finally, Panel E reports the risk premium decomposition with flexible capital utilization and market power, as in Panel A, but for a lower level of EIS, equal to 0.75. The entries in the panel

¹⁸Note that the market risk premium (RP_M) reported in Table 4 is slightly higher than the average of the log market excess return (r_M^{ex}) reported in Table 2, due to Jensen’s adjustment: $RP_M = \mathbb{E} \exp(r_M^{ex}) - 1$.

show that EIS has a direct impact on the magnitude of the risk premium. In particular, all the λ 's and β 's are lower with low EIS, and two out of the four betas become negative. The aggregate risk premium decreases from 5.37% when $EIS = 2.0$, to 0.56% when $EIS = 0.75$. Note that the prices of risk are all positive in Panel E because the households still have preference for early resolution of uncertainty. The negative risk loadings under low EIS are due to the strong wealth effect which increases firms' labor cost, thereby causing a drop in firm value upon a positive short-run IST or long-run TFP shock.

In summary, this section shows that in our benchmark calibration, two channels are quantitatively important for the market risk premium: (1) market power can change the risk premium from a large negative value to a large positive value; (2) a high EIS can generate a large and positive risk premium. The flexible capital utilization in our benchmark calibration has a more muted quantitative effect, due to the interaction with market power, preference, and persistence of technology shocks, which we discuss next.

4.3 Inspecting the mechanisms: comparative statics analysis

To fully understand the impact of capital utilization, market power, and EIS, on the market risk premium, in this subsection we vary the intensity of each channel and analyze their effect on the different components of the market risk premium, as discussed in the previous subsection. To interpret the patterns of prices of risk in the results that follow, it is useful to note that, from (3), we can decompose the SDF into two parts: one depending only on the household felicity function which we label "period utility" and one depending on the future utility, which we label "continuation utility". Formally,

$$\mathbb{M}_{t,t+1} = \underbrace{\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \left(\frac{1 - \psi L_{t+1}^\theta}{1 - \psi L_t^\theta} \right)^{1-\rho}}_{\text{Period utility}} \cdot \underbrace{\left(\frac{V_{t+1}}{(\mathbb{E}_t V_{t+1}^{1-\gamma})^{\frac{1}{1-\gamma}}} \right)^{\rho-\gamma}}_{\text{Continuation utility}}. \quad (31)$$

By the definition in equation (20), the price of risk of each shock is the (negative of) the covariance of the SDF with respect to the shock. Hence, from (31) we can decompose the price of risk λ into a component deriving from the period utility and one deriving from continuation utility. This decomposition is useful in understanding the effect of flexibility of capital utilization on the risk premium, as we discuss below in Subsection 4.3.1.

Similarly, to interpret the patterns of betas in the results that follow, it is useful to note that, in our model, the equilibrium firm value is composed of two parts: (1) the "assets in place", whose value is given by the shadow price of capital (or marginal Q) times the installed capital

and (2) the present value of monopoly rents, a quantity that is equal to zero in the case of perfect competition. Formally, from the firm's optimality conditions, we can show that the firm market value is given by:

$$V_{f,t}^J = \underbrace{q_t k_{f,t+1}^J}_{\text{Assets in place}} + \underbrace{\mathbb{E}_t \sum_{s=1}^{\infty} M_{t,t+s} \left[\frac{1}{\nu_J} p_{f,t+s}^J y_{f,t+s}^J \right]}_{\text{Monopoly rents}}, \quad J = C, I, \quad (32)$$

where q_t is marginal Q ,¹⁹ and $y_{f,t+s}^J$ and $p_{f,t+s}^J$ are, respectively, J -firm's output and output price. Equation (32) illustrates that when firms operate in perfectly competitive markets (i.e., $\nu_J \rightarrow \infty$), monopoly rents are zero. In this case the firm value equals the value of assets in place. However, when market power is high, i.e., ν_J is low, the present value of monopoly rent can represent an important component of firm value. Understanding how each component of firm value reacts to technology shocks is important to understand the effect of capital utilization, market power, and EIS on the aggregate risk premium.

4.3.1 The effect of flexible capital utilization

Table 5 focuses on the effects of capital utilization on the market risk premium. Panel A reports the risk premium decomposition for different values of the capital flexibility parameters ξ^C and ξ^I where we impose $\xi^C = \xi^I = \xi$. The remaining parameters are set to the benchmark values presented in Table 1. The results show that the annual risk premium increases from 5.55% when $\xi = 1.0$ to 6.02% when $\xi = 4.0$, and further to 6.20% when $\xi = 50$, where capital utilization is essentially fixed. The prices of risk λ associated to the four shocks are slightly increasing in ξ . The exposures β_M^A and β_M^Z to short-run TFP and IST shocks are hump-shaped in ξ . The exposures $\beta_M^{\mu^a}$ to long-run TFP shocks are monotonically increasing in ξ , while the exposure $\beta_M^{\mu^z}$ is monotonically decreasing in ξ .

In our qualitative analysis of Section 3 we concluded that higher flexibility leads to higher risk premia. The pattern in Panel A shows, instead, that high flexibility leads to lower risk premia. To understand this pattern, it is important to refer to the decomposition (31) of SDF into contributions from period and continuation utility. The qualitative analysis of Section 3 ignores long-run risks in TFP and IST shocks and focuses on the effects of capital utilization flexibility on the determinants of period utility (consumption and labor). However, it is important to note that higher capital flexibility, by allowing households to better smooth consumption overtime, also implies that continuation utility responds less to shocks. Because the price of risk is the response of SDF to shocks (equation (20)), we should then expect that the period utility part of the price

¹⁹Marginal Q is the Lagrange multiplier of the firm's optimization problem described in Appendix A.1.

of risk *decreases* when capital utilization is less flexible, as argued in the qualitative analysis of Section 3, while the continuation-utility part of the price of risk *increases* when utilization is less flexible, because of less effective consumption smoothing. This is exactly the pattern that we observe in Panels B and C of Table 5. Panel B shows that, for all shocks, the prices of risk that come from the period utility component are decreasing as capital utilization becomes less flexible. In contrast, Panel C shows that, for all shocks, the prices of risk that come from the continuation utility component are increasing as capital utilization becomes less flexible. The balance between the two components is dictated by the type of preferences and the natures of shocks. When preference are time-separable, or when shocks do not contain long-run risks the continuation utility part is either irrelevant or less important, and the patterns of price of risk are dictated by the period utility effect. In contrast, when household has recursive preference with a high value of EIS and shocks contain a persistent component, the pattern from the continuation utility part can dominate and undo the patterns in the period utility part, as it happens in our benchmark calibration of Panel A.

Finally, to understand the patterns in betas observed in Panel A, we consider, in Panel D, the case of perfect, instead of monopolistic, competition. In this case the firm value (32) consists only of assets-in-place. This case allows us to identify the different nature of TFP and IST shocks in our model. The negative values of β_M^Z and $\beta_M^{\mu^z}$ indicate that an IST shock is similar to a “supply” shocks to the capital sector and results in lower prices of capital q_t . A TFP shock, instead, affects both the consumption and the investment sector and is similar to a “demand” shocks for the capital sector, resulting in an increase in the price of capital. Flexibility in the use of capital amplifies IST shocks (betas are larger in absolute value and negative for low ξ) while they dampen TFP shocks (betas are smaller for low ξ). The latter effect is similar to that of adjustment costs: a more flexible capital utilization is equivalent to lower adjustment costs and results in lower betas, all else equal. Comparing the betas in Panel D with those in Panel A, we see that monopoly rents can qualitatively change the effect of capital flexibility on the exposure to the shocks. This is particularly evident for the case of β_M^Z and $\beta_M^{\mu^z}$ that are negative and increasing in ξ , for the case of perfect competition in Panel D, but positive and decreasing (or hump shaped) for the case with market power in Panel A.

In summary, the effect of flexible capital utilization on the market risk premium depends crucially on both the preference specification and the degree of competition among firms. With the particular choice in our benchmark calibration in Table 1, the quantitative effect of flexibility in capital utilization on the market risk premium is relatively small.

4.3.2 The effect of firms' market power

Panel A of Table 6 reports the effect of market power on the market risk premium under the case of a high EIS = 2.0, as in the benchmark calibration. We consider five different values of the market power parameters ν^C and ν^I where we impose $\nu^C = \nu^I = \nu$. A smaller value of ν corresponds to stronger market power. The results show that the market risk premium is monotonically increasing with market power. For example, the risk premium is -0.62% in competitive markets, it increases to 2.80% with a 10% markup ($\nu = 11$), and further to 6.08% when the markup is 50% ($\nu = 3$). Under competitive markets, firm values are composed uniquely of assets in place. A positive IST shock results in lower price of capital and hence lower firm values. Since the price of risks are all positive under the preference specification, negative betas for the short- and long-run IST shocks lead to negative risk premium.

Panel B reports the same results as in Panel A, but with a lower EIS of 0.75. Comparing with the results in Panel A, a lower EIS leads to negative betas for long-run TFP shocks even when firms have strong market power. Therefore, the negative contribution of the risk premium attributable to TFP shocks lowers the overall level of the market risk premium. When EIS is relatively low, the strong wealth effect reduces households' willingness to supply labor in response to a positive IST or TFP shock, leading to higher labor costs and hence lower firm values. This explains why the market risk premium is low in Panel B, irrespective of the level of market power.

In summary, the results from Panels A and B confirm our qualitative analysis in Section 3.1.2. Specifically: (i) market power has relatively little effect on the market prices of risk, and (ii) low market power decreases firms' exposures to shocks.

4.3.3 The effect of the elasticity of intertemporal substitution

Panel C of Table 6 reports the effect of EIS on the market risk premium, with all other parameters kept at the same values as in the benchmark calibration. A higher EIS, for a given level of relative risk aversion, means that the household dislikes more the uncertainty related to future utility and therefore demands a lower price to hold risky assets. This leads to a higher risk premium. For example, the risk premium increases from 0.56% when EIS = 0.75, to 3.94% when EIS = 1.5, and further to 5.90% when EIS = 2.25. Note, finally that the betas of the Z and μ^z shocks can be negative for low level of EIS. When households have low EIS, the wealth effect reduces the willingness to supply labor in response to a positive IST shock. As a result, all else equal, firms suffer a higher increase in labor costs which leads to a drop in firm value and hence to negative betas.

In summary, this section shows that the three channels studied in this paper have important quantitative effect on the risk premium. In particular, market power can change the risk premium from a large negative value to a large positive value, and a strong preference for early resolution of uncertainty can generate a large and positive risk premium. The effect of flexible capital utilization depends on both the market power and preference. Combining these three channels, our model can generate asset returns and macroeconomic quantities that match those observed in the data.

5 Conclusion

In this paper we show that capital utilization and firms' market power have an important effect on the market price of risk and risk premia of investment shocks. Under fixed capital utilization, the current consumption drops upon a positive investment 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 investment shocks to positively impact firm's value.

We identify three main mechanisms that drive the connection between investment shocks and asset prices. First, market power affects the sign of risk premium associated with investment shocks 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 investment shocks when EIS is low. Finally, the EIS affects both the market price of risk and risk premium of investment 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. Section A.1 describes the original problem. Section A.2 illustrates the construction of a growth-stationary version of the model that allows the derivation of the deterministic steady state. Section A.3 describes the construction of a rescaled version of the model that is both mean and co-variance stationary. Section A.4 describes the value function iteration algorithm we use for solving the model.

A.1 Original problem

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

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

The firms' problem is given by (14), which we reproduce here:

$$\begin{aligned} V_{f,t}^J &= \max_{\{l_{f,s}^J, i_{f,s}^J, u_{f,s}^J\}_{s=t}^{\infty}} \mathbb{E}_t \sum_{s=t}^{\infty} \mathbb{M}_{t,s} d_{f,s}^J, \\ \text{s.t. } d_{f,s}^J &= p_{f,s}^J y_{f,s}^J - W_s l_{f,s}^J - P_s^I \varphi(i_{f,s}^J) k_{f,s}^J, \quad J = C, I. \end{aligned}$$

Each firm takes the aggregate prices and quantities as given and makes optimal decisions on hiring ($l_{f,s}^J$), investment ($i_{f,s}^J$), and capital utilization intensity ($u_{f,s}^J$). Note that, according to equation (6), $p_{f,t}^J = (y_{f,t}^J / Y_t^J)^{-1/\nu_J} P_t^J$ with $y_{f,t}^J$ given by equations (7) and (8).

The market clearing conditions for the C- and I-sectors, and the labor market are:

$$C_t = A_t (N^C)^{\frac{1}{\nu_C - 1}} (u_t^C K_t^C)^{1 - \alpha^C} (L_t^C)^{\alpha^C} \quad (\text{A1})$$

$$\sum_{f=1}^{N^C} \varphi(i_t^C) k_{f,t}^C + \sum_{f=1}^{N^I} \varphi(i_t^I) k_{f,t}^I = A_t (N^I)^{\frac{1}{\nu_I - 1}} Z_t (u_t^I K_t^I)^{1 - \alpha^I} (L_t^I)^{\alpha^I} \quad (\text{A2})$$

$$L_t = \sum_{f=1}^{N^C} l_{f,t}^C + \sum_{f=1}^{N^I} l_{f,t}^I. \quad (\text{A3})$$

The above equations can be rewritten in terms of aggregate quantities by using the symmetry among firms in each sector (see equation (18)). We choose the final consumption good as the numeraire and hence set the price $P^C \equiv 1$.

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. The market clearing condition for the final consumption good in (A1) gives the growth rate of consumption:

$$g_c = g_a(g_{k^C})^{1-\alpha^C}, \quad \text{where } g_a = e^{\bar{\mu}^a}.$$

The market clearing condition for the final capital good in (A2) implies that the balanced growth rate of capital in the two sectors is the same and given by

$$g_{k^C} = g_{k^I} = (g_a g_z)^{\frac{1}{\alpha^I}}, \quad \text{where } g_z = e^{\bar{\mu}^z}.$$

Since consumption equals the sum of wages 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,

$$g_w = g_c, \quad g_{p^I} = g_c/g_{k^C}, \quad \text{and } g_u = g_c.$$

The original problem then can be written in terms of these detrended variables (e.g., the detrended consumption $\hat{C}_t = C_t/g_c^t$). The deterministic steady state of the detrended problem can be obtained by the corresponding first order conditions.

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 , and $V_t^{C,I}$ by $A_t (N^C)^{\frac{1}{\nu_C-1}} (K_t^C)^{1-\alpha^C}$;
2. P_t^I by $\frac{A_t (N^C)^{\frac{1}{\nu_C-1}} (K_t^C)^{1-\alpha^C}}{A_t (N^I)^{\frac{1}{\nu_I-1}} Z_t (K_t^I)^{1-\alpha^I}}$;
3. K_t^I by K_t^C .

The rescaled problem is fully described by the following four stationary state variables: μ_t^a and μ_t^z , whose evolution is given by (29) and (30), and

$$k_t \equiv \log\left(\frac{K_t^I}{K_t^C}\right), \quad \text{and} \quad \Omega_t \equiv \log\left(\frac{(N^I)^{\frac{1}{\nu_I-1}} A_t Z_t}{(K_t^I)^{\alpha^I}}\right), \quad (\text{A4})$$

whose evolution is given by

$$k_t = k_{t-1} + \log(1 + i_{t-1}^I - \delta(u_{t-1}^I)) - \log(1 + i_{t-1}^C - \delta(u_{t-1}^C)). \quad (\text{A5})$$

$$\Omega_t = \Omega_{t-1} - \alpha^I \log(1 + i_{t-1}^I - \delta(u_{t-1}^I)) + \bar{\mu}^a + \bar{\mu}^z + \mu_{t-1}^a + \mu_{t-1}^z + \varepsilon_t^a + \varepsilon_t^z. \quad (\text{A6})$$

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

$$V_t^J = A_t (N^C)^{\frac{1}{\nu_C-1}} (K_t^C)^{1-\alpha^C} v_t^J(\mu_t^a, \mu_t^z, k_t, \Omega_t), \quad J = C, I, M, \quad (\text{A7})$$

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

A.4 Value function iteration algorithm

Because we allow for market power, the second welfare theorem does not hold and we need to solve for a decentralized equilibrium. We solve the model through a value function iteration algorithm consisting of three steps:

1. *Step 1:* given prices (wage, capital good price and SDF) and aggregate policies (labor, investment, and capital utilization), we solve for the firm's dynamic programming problem via value function iteration. In this optimization, firms are price takers. We initialize the firm value for the dynamic programming routine to be a constant over the entire state space.
2. *Step 2:* use the firms' policies from Step 1 to verify the market clearing conditions, and update the wage, capital good price and SDF accordingly.
3. *Step 3:* repeat Steps 1–2 until prices and aggregate policies converge.

Value function and optimal decision rules are solved on a four-dimensional grid $(\mu^a, \mu^z, k, \Omega)$ in a discrete state space. We use an evenly spaced grid with 30 points each for the state variables k , and Ω . The expected growth rates μ^a and μ^z are defined on a continuous state space which we transform into a discrete state space following the quadrature procedure in Rouwenhorst (1995). Specifically, we use a grid of 5 points each for μ^a and μ^z . Finally, we approximate the continuous

i.i.d. shocks ε_t^a and ε_t^z via a Gauss-Hermite quadrature routine with 5 points for each shock. We verify that the results are robust to finer grids.

To test the accuracy of our solution, we compute the Euler equation errors in the model, obtained from the two sectoral intertemporal first order conditions for optimal investment and from the definition of recursive utility. For the benchmark calibration of Table 1, the maximum Euler equation error is 1.97% on the state space and 0.59% in simulations. The average absolute errors in the simulations are below 0.09%.

B Model simulation and return decomposition

We simulate our model at the monthly frequency. To minimize the effect of the initial values, we simulate 200 years of time series and only use the second half of the series in our analysis. For each simulation, we first aggregate the monthly observations to annual numbers, and then we compute the moments based on the annual data. In order to obtain the distribution of the moments across samples, we repeat the 100 years of monthly time series for 1,000 samples.

In order to decompose the risk premium into contributions from each shock, we compute: the “price” of risk, λ , and “quantity” of risk, β , for the short run shocks, ε_t^a and ε_t^z , and the long-run shocks $\varepsilon_t^{\mu^a}$ and $\varepsilon_t^{\mu^z}$. Note that the long-run risks $\varepsilon_t^{\mu^a}$ and $\varepsilon_t^{\mu^z}$ in equations (29) and (30) are treated in the same way as the short-run risks ε_t^a and ε_t^z in equations (19) and (21). Therefore, similar to the short-run risks, the long-run risks also contribute to the risk premium in equations (22) and (23).

To obtain the risk premium decomposition, we first calculate the conditional λ 's in (20) and β 's in (24) on each grid point of the 4-dimensional state space. We then interpolate these values for off-grid points in the simulation and calculate the unconditional average of λ 's and β 's. In order to estimate the risk premium contribution from long-run risks, we carry out the return decomposition at the monthly frequency and report the annualized values.

C 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.

IST measures. We take the three measures of IST shocks, *Ishock*, *IMC* and *gIMC* from Garlappi and Song (2016).

Asset prices. 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 $t - 1$. The price dividend ratio is from Robert Shiller's online data repository: <http://www.econ.yale.edu/shiller/data.htm>.

Table 1: Parameter values

Parameter values used in the benchmark monthly calibration of Section 4.

Group	Description	Symbol	Value
Preferences	Time discount rate	β^{12}	0.98
	Relative risk aversion	γ	10.0
	EIS	$1/\rho$	2.0
	Degree of labor disutility	θ	1.6
	Sensitivity of labor disutility	ψ	2.957 ^a
Production	Depreciation rate constant	$12 \times \delta_0$	0.10
	Depreciation rate slope	δ_1	0.0134 ^b
	Labor share of output for C-sector	α^C	0.60
	Labor share of output for I-sector	α^I	0.60
	Degree of capital adjustment cost for C-sector	ϕ^C	14.00
	Degree of capital adjustment cost for I-sector	ϕ^I	7.00
	Elasticity of marginal depreciation for C-sector	ξ^C	1.10
	Elasticity of marginal depreciation for I-sector	ξ^I	0.60
	Constant elasticity of substitution for C-sector	ν_C	4.00
	Constant elasticity of substitution for I-sector	ν_I	4.00
Financial leverage	...	1.50	
Shocks	Growth rate of TFP shock	$12 \times \bar{\mu}^a$	0.10%
	Volatility of TFP shock	$\sqrt{12} \times \sigma_a$	1.60%
	Volatility of long-run TFP risk	$\sqrt{12} \times \sigma_{\mu^a}$	0.16%
	Persistence of long-run TFP risk	$\rho_{\mu^a}^{12}$	0.77
	Growth rate of IST shock	$12 \times \bar{\mu}^z$	3.00%
	Volatility of IST shock	$\sqrt{12} \times \sigma_z$	2.60%
	Volatility of long-run IST risk	$\sqrt{12} \times \sigma_{\mu^z}$	0.26%
	Persistence of long-run IST risk	$\rho_{\mu^z}^{12}$	0.77

^a Chosen such that the fraction of working hours is 23% of available time in the deterministic steady state.^b Chosen such that capital utilization equals to 1 in the deterministic steady state.

Table 2: Model versus data: macroeconomic and asset pricing moments

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 (Δc), investment (Δi), total output (Δy) are adjusted for inflation and population. The log growth rate of labor (Δl) is adjusted for population. The growth rate of relative price of investment good (Δp^I) is adjusted for quality. The log growth rate in capital utilization (Δu) 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_M^{ex} is the log market excess return, 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. Each simulation consists of a time series of 100 years, constructed from a monthly series. Further details on the data constructions are provided in Appendix C.

Variable	Data		Model	
	Mean	Volatility	Mean	Volatility
Panel A. Macroeconomic quantities				
Δc	2.01 [1.53, 2.50]	2.22 [1.92, 2.62]	2.19 [-0.67, 4.96]	3.91 [2.96, 5.11]
Δi	2.19 [-0.77, 5.15]	13.58 [11.78, 16.02]	2.14 [-1.30, 5.35]	13.67 [10.47, 20.57]
Δl	-0.02 [-0.67, 0.63]	2.62 [2.23, 3.17]	-0.00 [-0.21, 0.20]	2.10 [1.70, 2.45]
Δy	1.93 [0.71, 3.15]	5.58 [4.84, 6.58]	2.13 [-0.68, 4.99]	5.11 [4.03, 6.34]
Δp^I	-3.45 [-4.25, -2.65]	3.65 [3.17, 4.31]	-3.08 [-5.27, -0.67]	4.02 [3.16, 5.08]
Δu	-0.26 [-1.53, 1.00]	4.21 [3.49, 5.32]	0.00 [-0.47, 0.44]	3.12 [2.51, 3.81]
Panel B. Asset prices				
r_f	0.54 [-0.09, 1.17]	2.85 [2.47, 3.36]	0.50 [-0.32, 1.33]	1.08 [0.79, 1.48]
r_M^{ex}	5.48 [1.14, 9.82]	19.87 [17.24, 23.46]	5.14 [3.22, 7.35]	6.08 [4.98, 7.20]

Table 3: Predictability of returns and consumption growth rates

This table reports the results of the long-horizon predictability of future excess returns and consumption growth rates. The long-horizon predictive regression of excess return is $\sum_{h=1}^H [\log(1 + R_{M,t+h}) - \log(1 + R_{f,t+h})] = \alpha_R + \beta_R \log(P_t/C_t) + \epsilon_{t+h}^R$, where H is the forecasting horizon in years, $R_{M,t}$ is the real stock market return and $R_{f,t}$ is the real risk free rate, P_t is the real S&P500 stock market index, and C_t is real consumption. The long-horizon predictive regression of log consumption growth is $\sum_{h=1}^H \log(C_{t+h}/C_t) = \alpha_C + \beta_C \log(P_t/C_t) + \epsilon_{t+h}^C$. Real consumption is defined as real per capita nondurables plus services from NIPA Table 7.1. The real S&P500 stock market index is obtained by deflating the nominal index from CRSP. Return data are from Kenneth French's website. The entries for the model are the average estimates based on 1,000 simulations each with 1,200 monthly observations that are time-aggregated to an annual frequency. The slopes and R^2 s are in percent. We report in brackets the 95%-confidence interval for the slopes. In constructing the confidence intervals in the data, the standard errors are Newey and West (1987) corrected with $2(H - 1)$ lags.

U.S. annual data, 1930-2015					
H	1y	2y	3y	4y	5y
β_R	-11.96 [-20.80, -3.12]	-19.18 [-32.96, -5.40]	-28.65 [-44.62, -12.67]	-37.63 [-55.02, -20.24]	-43.79 [-65.52, -22.06]
R_R^2	7.12	9.79	16.95	22.94	25.45
β_C	-0.57 [-1.43, 0.29]	-1.21 [-3.09, 0.66]	-1.77 [-4.61, 1.08]	-2.05 [-5.90, 1.80]	-2.02 [-6.82, 2.78]
R_C^2	1.36	2.52	3.84	4.03	3.34
Model					
H	1y	2y	3y	4y	5y
β_R	8.28 [-10.24, 20.43]	14.37 [-19.11, 38.14]	18.39 [-31.36, 54.81]	20.86 [-42.11, 71.08]	22.00 [-56.01, 84.78]
R_R^2	3.52	4.99	5.66	5.99	6.13
β_C	35.61 [30.89, 40.76]	66.86 [56.72, 75.66]	93.38 [76.12, 106.67]	115.95 [89.08, 135.55]	135.01 [97.84, 162.77]
R_C^2	67.66	75.08	75.66	73.04	68.99

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 two short-run shocks, ε_t^a , ε_t^z , and the two long-run shocks, $\varepsilon_t^{\mu^a}$, and $\varepsilon_t^{\mu^z}$. Panel A represents the benchmark calibration in Table 2 with flexible capital utilization and market power. In Panel B, capital utilization is flexible and firms are perfectly competitive. In Panel C, capital utilization is fixed and firms have market power. In Panel D capital utilization is fixed and firms are perfectly competitive. In Panel E, EIS has a low value of 0.75. All the other parameters are kept to their benchmark levels contained in Table 1. For each combination of alternative parameters, we simulate the model in the same way as in the benchmark calibration of Table 2, and use the full simulation population to estimate the following variables: (i) price of risk, λ^x , (ii) market return loading, β_M^x , and (iii) leveraged risk premium, $1.5 \times \beta_M^x \lambda^x$, for each shock and the summation of all shocks, which is the market risk premium, RP_M . Both the price of risk and risk premium are in percentage terms.

	Shock (X)				Total RP_M
	Short-run		Long-run		
	ε_t^a	ε_t^z	$\varepsilon_t^{\mu^a}$	$\varepsilon_t^{\mu^z}$	
Panel A. Flexible capital utilization and market power					
λ^x	0.349	0.245	0.140	0.090	
β_M^x	1.070	0.065	19.816	4.524	
$1.5 \times \beta_M^x \lambda^x$	0.559	0.024	4.172	0.611	5.366
Contribution	10.4%	0.4%	77.8%	11.4%	100%
Panel B. Flexible capital utilization and perfect competition					
λ^x	0.334	0.207	0.135	0.077	
β_M^x	0.492	-0.510	3.906	-12.962	
$1.5 \times \beta_M^x \lambda^x$	0.246	-0.158	0.788	-1.501	-0.624
Contribution	-39.5%	25.3%	-126.3%	240.5%	100%
Panel C. Fixed capital utilization and market power					
λ^x	0.362	0.280	0.147	0.106	
β_M^x	1.102	0.097	22.003	4.658	
$1.5 \times \beta_M^x \lambda^x$	0.598	0.041	4.837	0.743	6.219
Contribution	9.6%	0.7%	77.8%	12.0%	100%
Panel D. Fixed capital utilization and perfect competition					
λ^x	0.351	0.252	0.142	0.096	
β_M^x	0.571	-0.431	6.201	-11.887	
$1.5 \times \beta_M^x \lambda^x$	0.301	-0.163	1.319	-1.714	-0.257
Contribution	-117.0%	63.5%	-513.4%	667.0%	100%
Panel E. Low EIS					
λ^x	0.338	0.218	0.136	0.095	
β_M^x	0.754	-0.250	-2.169	4.906	
$1.5 \times \beta_M^x \lambda^x$	0.382	-0.082	-0.442	0.701	0.559
Contribution	68.4%	-14.6%	-79.2%	125.4%	100%

Table 5: Asset pricing implications of capital utilization flexibility

This table reports the risk premium, RP_M , and its decomposition under different degree of flexibility in capital utilization. We set $\xi^C = \xi^I = \xi$. Panel A reports results when all the other parameters are set to the benchmark values in Table 1. In Panels B and C we apply the decomposition of SDF in Equation (31) to the prices of risk reported in Panel A. Specifically, Panel B reports the component of price of risk that derives from period utility. Panel C reports the component of price of risk that derives from continuation utility. The risk exposures (β 's) in Panels B and C are the same as those in Panel A. Panel D reports results when firms are perfectly competitive. Both the price of risk and risk premium are in percentage terms.

	ξ	RP_M	Price of risk				Exposure			
			λ^A	λ^Z	λ^{μ^a}	λ^{μ^z}	β_M^A	β_M^Z	$\beta_M^{\mu^a}$	$\beta_M^{\mu^z}$
Panel A. Market power and recursive preferences										
Flexible:	1.0	5.550	0.351	0.251	0.141	0.093	1.091	0.087	20.067	4.933
	2.0	5.846	0.356	0.265	0.144	0.099	1.100	0.096	20.869	4.838
	4.0	6.021	0.359	0.272	0.145	0.103	1.103	0.098	21.383	4.768
	10.0	6.134	0.361	0.276	0.146	0.105	1.103	0.098	21.747	4.719
Fixed:	50.0	6.199	0.361	0.278	0.146	0.106	1.103	0.097	21.958	4.683
Panel B. Market power and recursive preferences: Risk premia from period utility										
Flexible:	1.0	0.031	0.014	0.003	-0.000	0.002	1.091	0.087	20.067	4.933
	2.0	0.027	0.014	0.002	-0.000	0.001	1.100	0.096	20.869	4.838
	4.0	0.024	0.013	0.001	-0.000	0.001	1.103	0.098	21.383	4.768
	10.0	0.022	0.013	0.000	-0.000	0.000	1.103	0.098	21.747	4.719
Fixed:	50.0	0.021	0.013	-0.000	-0.000	0.000	1.103	0.097	21.958	4.683
Panel C. Market power and recursive preferences: Risk premia from continuation utility										
Flexible:	1.0	5.518	0.337	0.248	0.142	0.091	1.091	0.087	20.067	4.933
	2.0	5.819	0.343	0.263	0.144	0.098	1.100	0.096	20.869	4.838
	4.0	5.997	0.346	0.271	0.145	0.102	1.103	0.098	21.383	4.768
	10.0	6.112	0.348	0.276	0.146	0.104	1.103	0.098	21.747	4.719
Fixed:	50.0	6.177	0.349	0.279	0.146	0.106	1.103	0.097	21.958	4.683
Panel D. Perfect competition and recursive preferences										
Flexible:	1.0	-0.610	0.338	0.216	0.136	0.081	0.516	-0.485	4.051	-12.720
	2.0	-0.578	0.344	0.233	0.139	0.088	0.534	-0.467	4.726	-12.687
	4.0	-0.472	0.348	0.243	0.140	0.092	0.549	-0.452	5.316	-12.420
	10.0	-0.343	0.350	0.248	0.141	0.094	0.562	-0.440	5.823	-12.087
Fixed:	50.0	-0.273	0.351	0.251	0.142	0.096	0.569	-0.433	6.117	-11.924

Table 6: Asset pricing implications of market power and EIS

This table reports the risk premium, RP_M , and its decomposition under different level of market power and EIS. Panels A and B report the comparative statics for the effect of market power under high (2.0) and low (0.75) EIS, respectively. We set $\nu^C = \nu^I = \nu$. Panel C reports the comparative statics for the effect of EIS. All other parameters are set to the benchmark values in Table 1. Both the price of risk and risk premium are in percentage terms.

		Price of risk				Exposure				
RP_M		λ^A	λ^Z	λ^{μ^a}	λ^{μ^z}	β_M^A	β_M^Z	$\beta_M^{\mu^a}$	$\beta_M^{\mu^z}$	
Panel A. Effect of market power: EIS = 2.0										
	ν									
Monopolistic:	3	6.084	0.352	0.254	0.142	0.093	1.130	0.125	21.426	6.310
	4	5.366	0.349	0.245	0.140	0.090	1.070	0.065	19.816	4.524
	11	2.802	0.339	0.220	0.137	0.082	0.836	-0.168	13.414	-2.589
	21	1.538	0.337	0.214	0.136	0.080	0.712	-0.291	9.986	-6.362
Competitive:	10^4	-0.624	0.334	0.207	0.135	0.077	0.492	-0.510	3.906	-12.962
Panel B. Effect of market power: EIS = 0.75										
	ν									
Monopolistic:	3	0.657	0.341	0.226	0.136	0.096	0.824	-0.179	-2.338	5.382
	4	0.559	0.338	0.218	0.136	0.095	0.754	-0.250	-2.169	4.906
	11	-0.634	0.331	0.201	0.135	0.091	0.547	-0.456	-4.399	0.883
	21	-1.437	0.330	0.196	0.134	0.090	0.442	-0.561	-6.186	-1.803
Competitive:	10^4	-2.993	0.328	0.191	0.134	0.089	0.254	-0.747	-9.785	-7.008
Panel C. Effect of EIS										
	EIS									
Low:	0.75	0.559	0.338	0.218	0.136	0.095	0.754	-0.250	-2.169	4.906
	1.0	1.953	0.341	0.226	0.136	0.093	0.847	-0.158	4.139	5.185
	1.5	3.944	0.346	0.237	0.138	0.091	0.982	-0.023	13.324	4.965
	2.0	5.366	0.349	0.245	0.140	0.090	1.070	0.065	19.816	4.524
High:	2.25	5.898	0.349	0.245	0.141	0.089	1.101	0.096	22.332	4.209

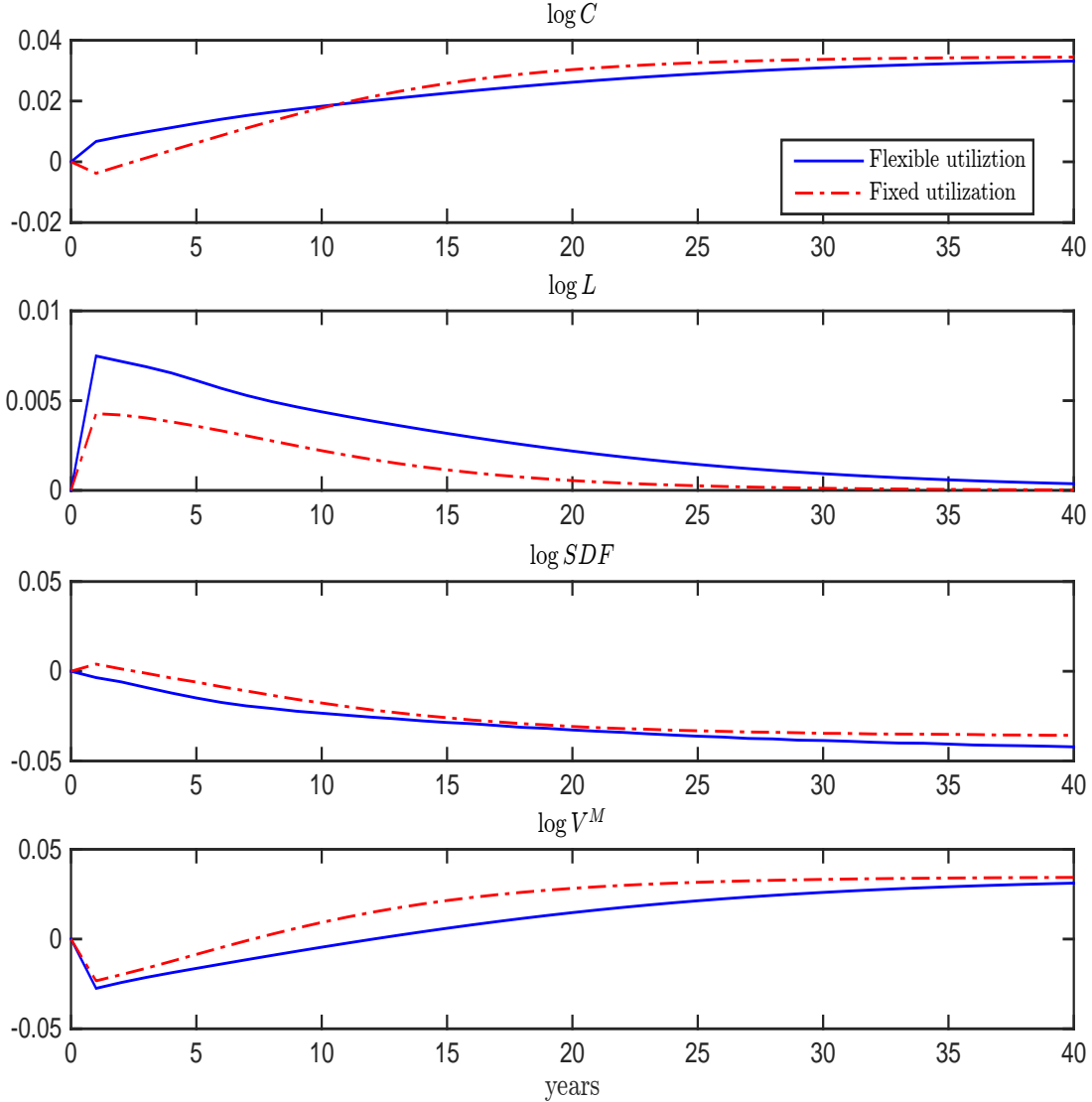


Figure 1: The effect of flexible capital utilization

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 ($\nu_C = \nu_I = 10000$). For each variable, the figure reports the IRFs under two parameterizations: (i) capital utilization is flexible ($\xi^C = \xi^I = 0.3$), solid line; (ii) capital utilization is fixed ($\xi^C = \xi^I = 3000$), dashed line. The capital adjustment cost parameter $\phi^C = \phi^I = 2$. All the other parameter values are the same as the annualized values in Table 1.

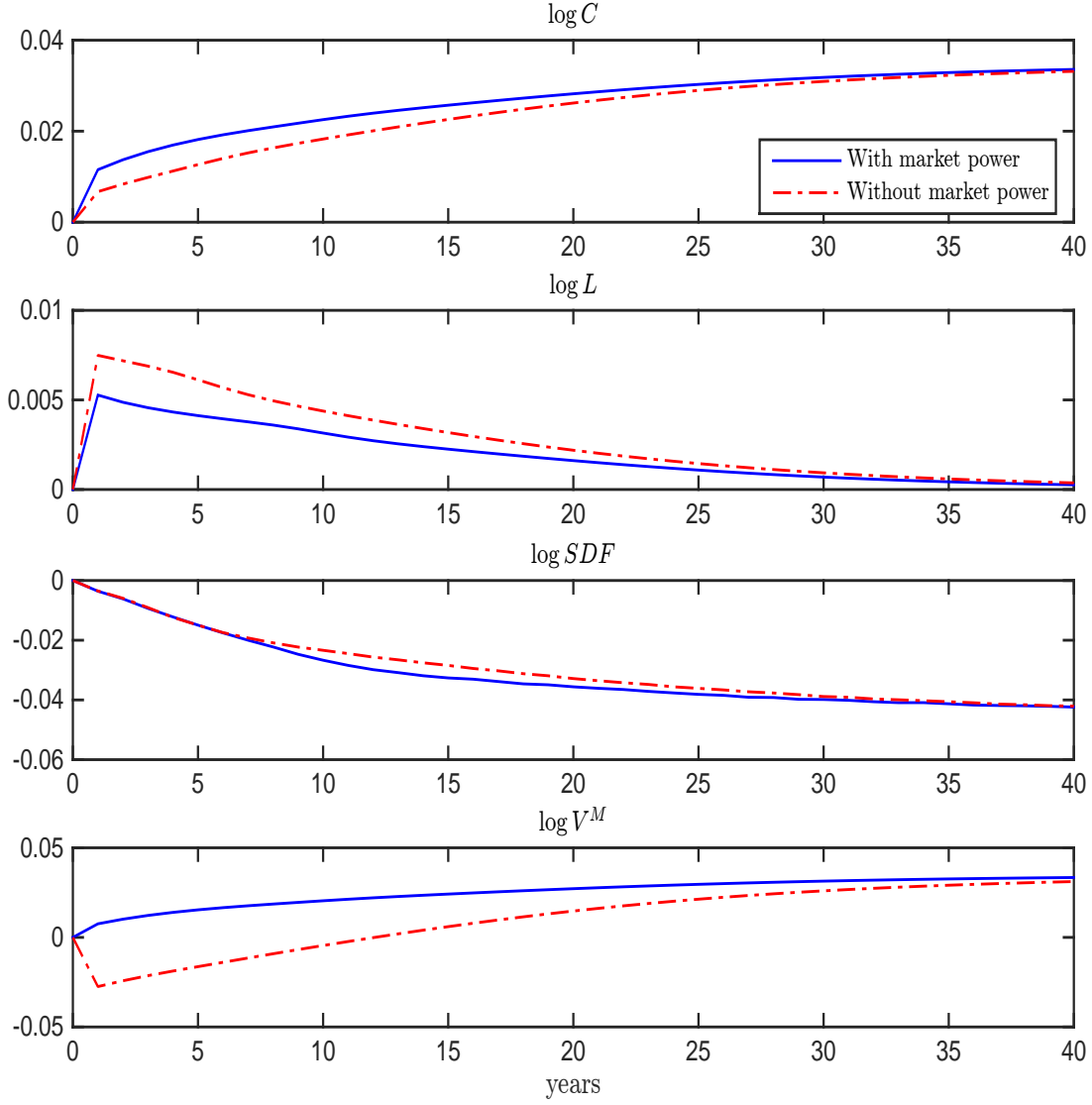


Figure 2: The effect of market power

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 parameterizations: (i) firms have market power ($\nu_C = \nu_I = 4$), solid line; (ii) firms are perfectly competitive ($\nu_C = \nu_I = 10000$), dashed line. The capital adjustment cost parameter $\phi^C = \phi^I = 2$. All the other parameter values are the same as the annualized values in Table 1.

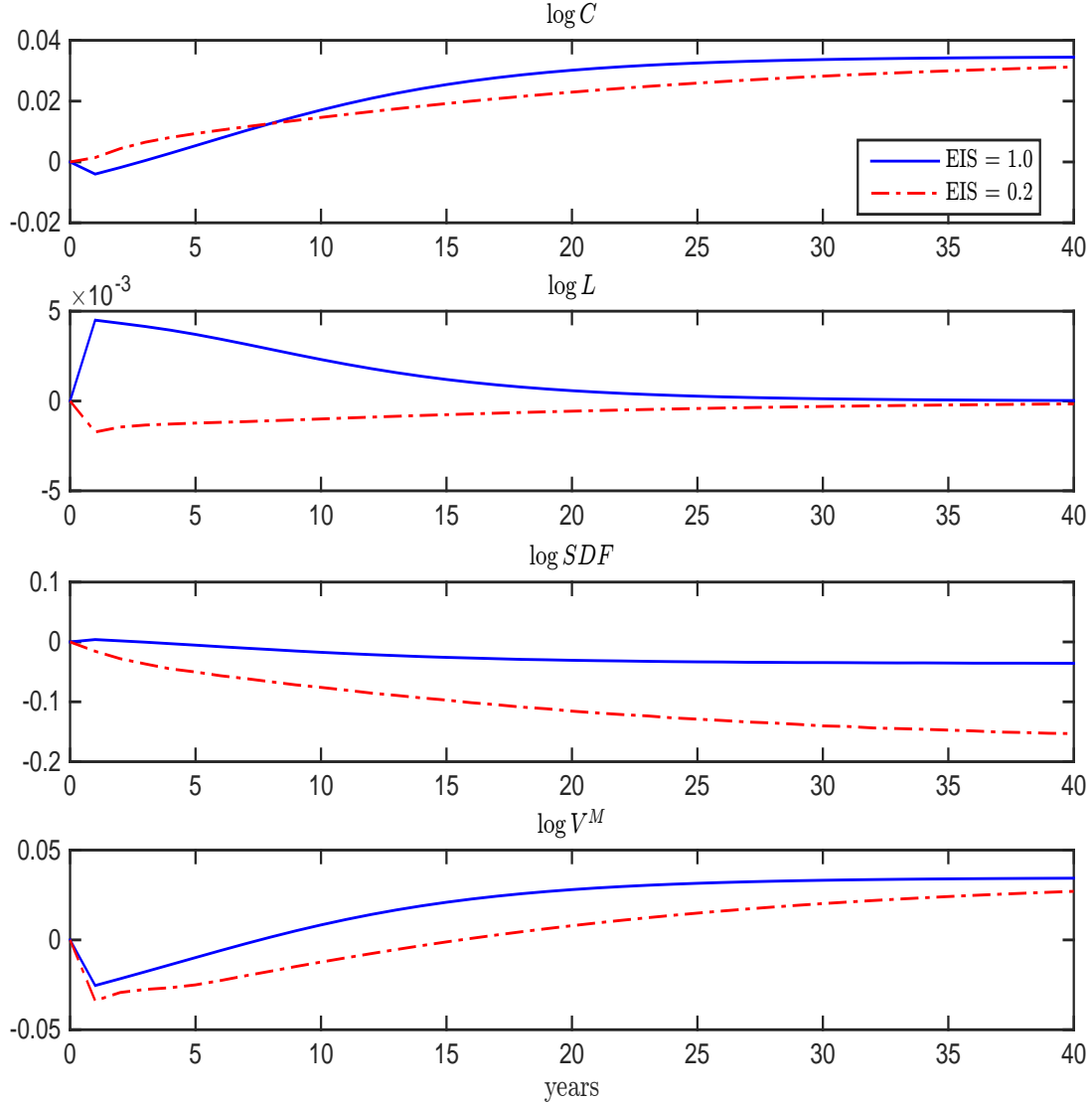


Figure 3: The effect of EIS

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 ($\gamma = 1/\text{EIS}$), capital utilization is fixed ($\xi^C = \xi^I = 3000$), and firms are perfectly competitive ($\nu_C = \nu_I = 10000$). For each variable, the figure reports the IRFs under two parameterizations: (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 the annualized values in Table 1.

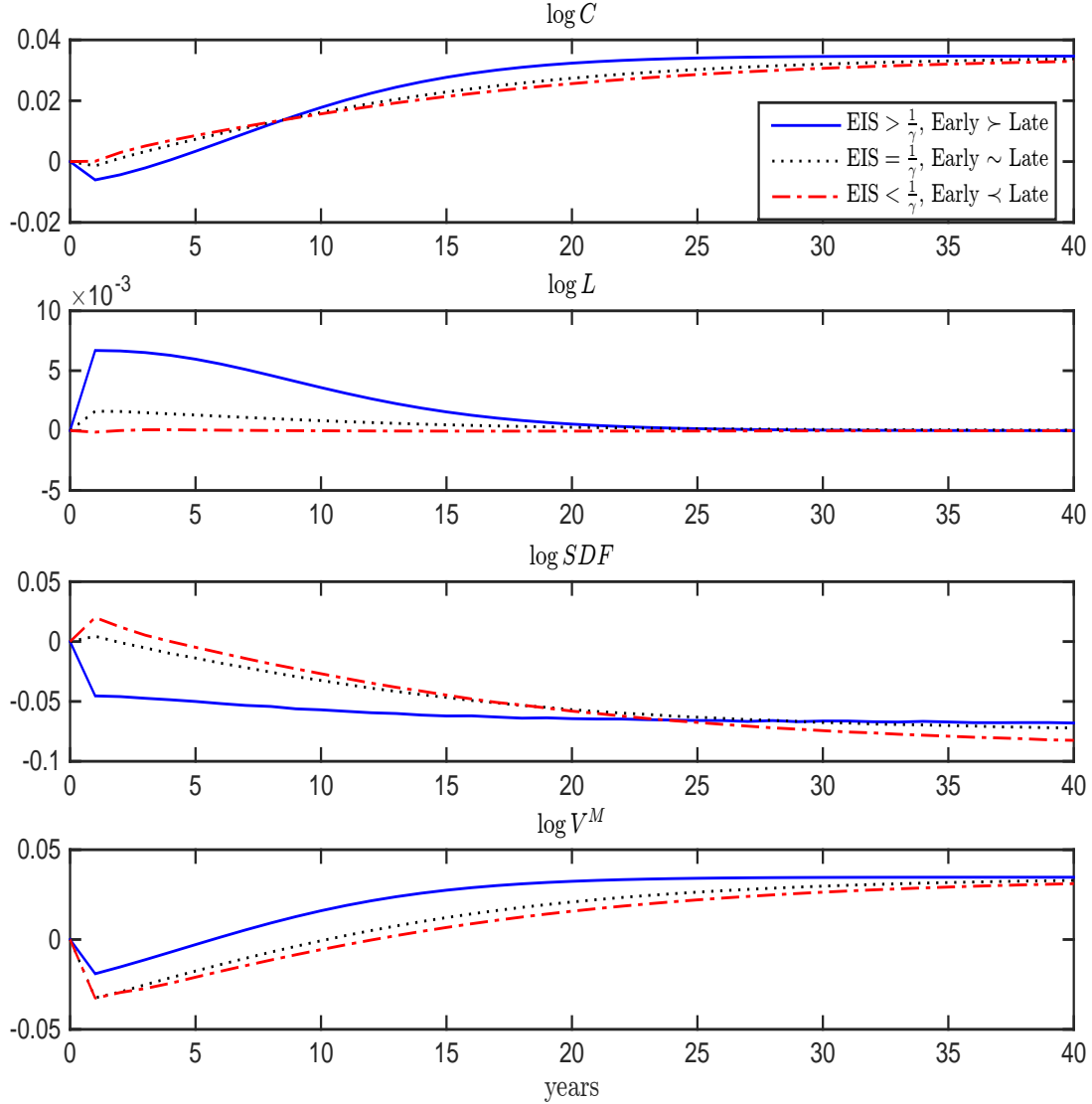


Figure 4: The effect of preference towards temporal resolution of uncertainty

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 ($\nu_C = \nu_I = 10000$). For each variable, the figure reports the IRFs under three parameterizations: (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 the annualized values in Table 1.

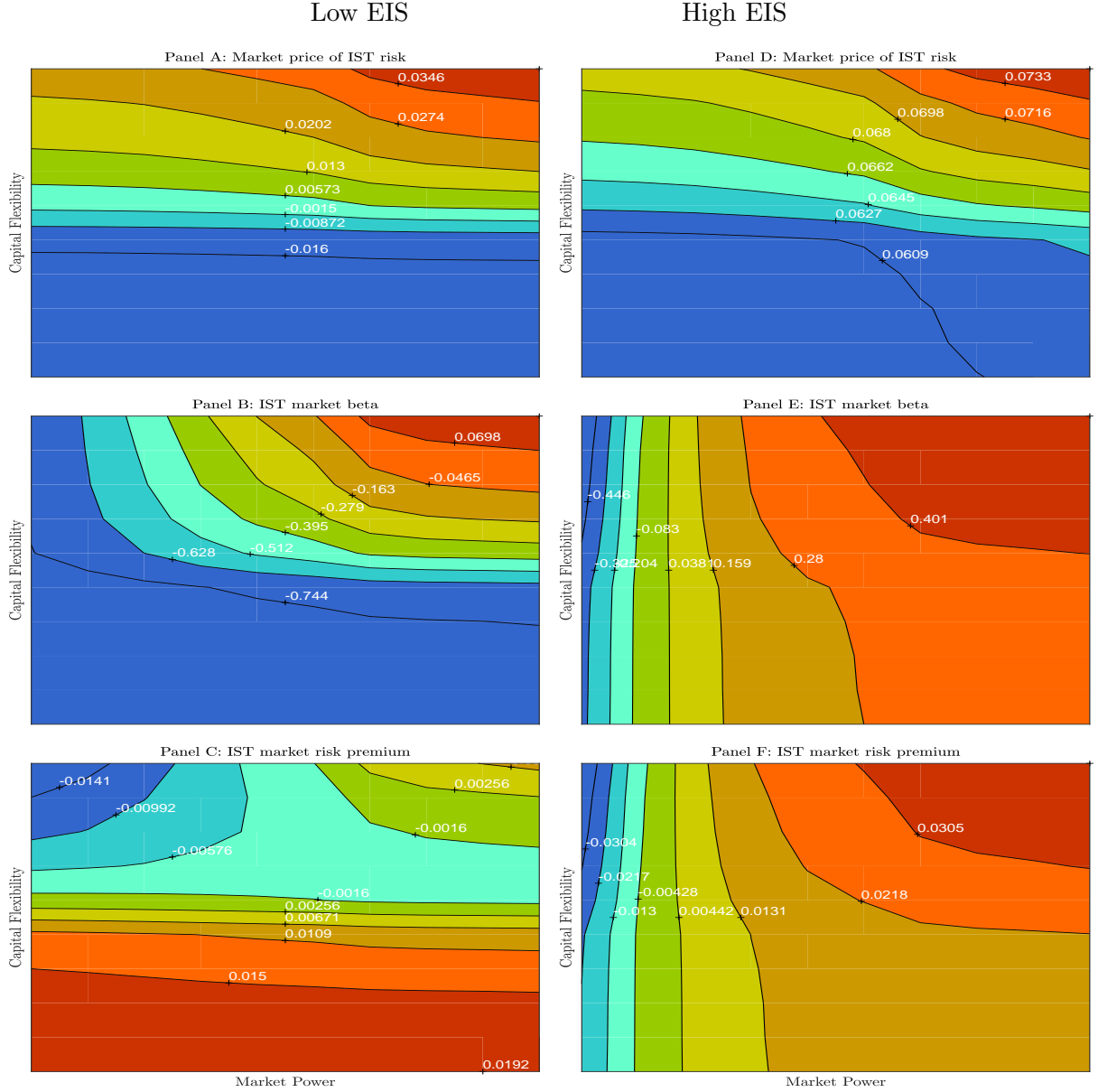


Figure 5: Asset pricing implications of capital flexibility, market power, and EIS

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, λ^z , in percent, (ii) IST market beta, β_M^z , and (iii) IST risk premium, RP_M^z , in percent. 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 $\xi^C = \xi^I$ in the interval $[0.1, 1000]$, and the market power parameter $\nu^C = \nu^I$ in the interval $[1.1, 1000]$. The capital adjustment cost parameter in both sectors is set to $\phi^C = \phi^I = 2$. All the other parameter values are the same as the annualized values in Table 1.

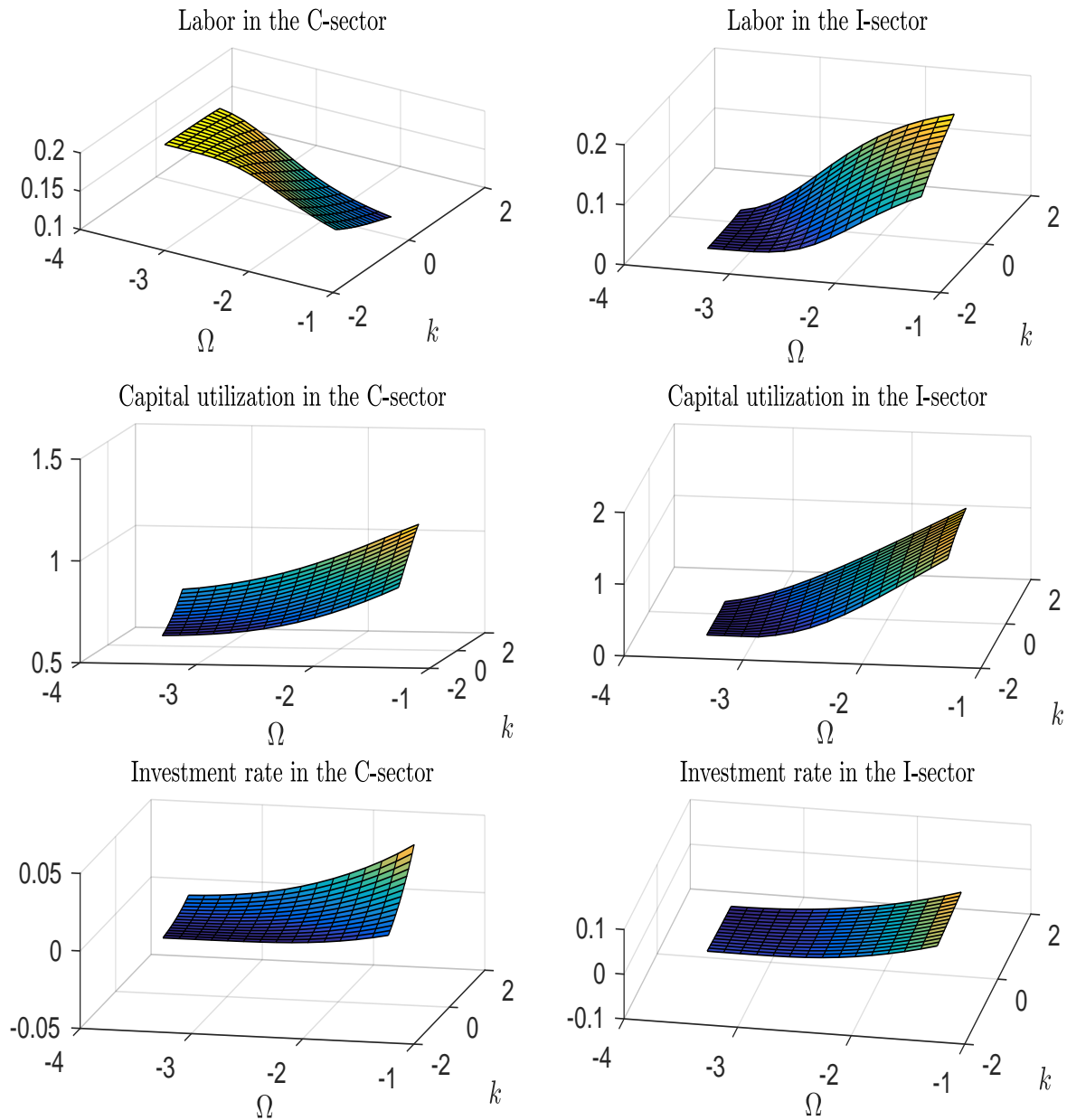


Figure 6: Equilibrium firm policies

The figure plots the equilibrium labor, investment rate and capital utilization in the C- and I-sectors, as a function of the state variables k and Ω defined in (A4). The expected growth rates μ^a and μ^z are set at their respective unconditional averages. Parameter values are given in Table 1.

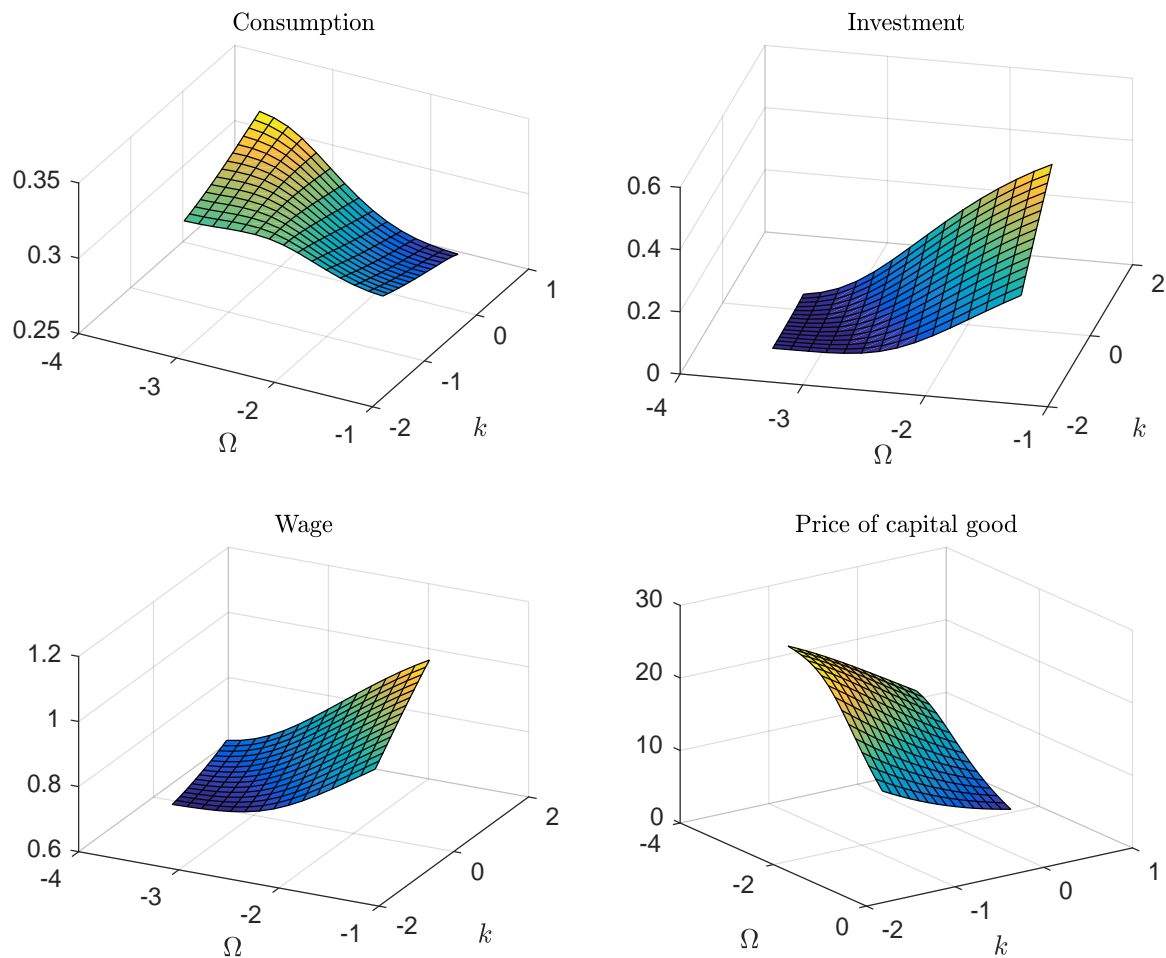


Figure 7: Equilibrium aggregate policies

The figure plots the equilibrium consumption, investment, wages, and price of capital good, as a function of the state variables k and Ω defined in (A4). Note that consumption, investment, and wage are rescaled by $A_t(N^C)^{1/(\nu_C-1)}(K_t^C)^{1-\alpha^C}$, and the capital good price is rescaled by $A_t(N^C)^{1/(\nu_C-1)}(K_t^C)^{-\alpha^C}$. The expected growth rates μ^a and μ^z are set at their respective unconditional averages. Parameter values are given in Table 1.

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