

# Risky Business Cycles\*

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## Abstract

We identify a shock that explains the bulk of fluctuations in equity risk premia, and show that the shock also explains a large fraction of the business-cycle comovements of output, consumption, employment, and investment. Recessions induced by the shock are associated with reallocation away from full-time labor positions, and towards part-time and flexible contract workers. We develop a novel real model with labor market frictions and fluctuations in risk appetite, where a “flight-to-safety” reallocation from riskier to safer factors of production precipitate a recession that can explain the data, since the safer factors offer lower marginal products in equilibrium.

**Keywords:** Business Cycles; Risk Premia; Uncertainty.

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# 1 Introduction

Conditional risk premia are highly volatile and counter-cyclical in the data (Cochrane, 2011). Recent macroeconomic research has revived interest in the classic and intuitive idea that these volatile risk premia could be an important source of business cycle fluctuations (Cochrane, 2017). Yet, this research agenda faces the key challenge that in most macroeconomic models aggregate risk or uncertainty shocks have difficulty generating comovement between output, consumption, investment and employment, a hallmark feature of business cycles (Gourio, 2012; Ilut and Schneider, 2014; Basu and Bundick, 2017).

This paper makes two main contributions. First, we perform a model-agnostic empirical analysis, which isolates the shock that drives the bulk of variation in the equity risk premium. We find that the same shock also accounts for much of the variation in the four main macro aggregates, and an even a larger share of their *comovement*, suggesting that there is indeed a direct link between risk premia fluctuations and business cycles in the data. Second, we propose a real model in which a novel investment *reallocation* channel solves the usual comovement challenges, and thus leads risk premium fluctuations to generate business cycles as often intuitively theorized. We estimate our model and show it closely replicates all of the patterns we identify in the data.

Generating comovement via risk premia fluctuations is challenging in models without nominal rigidities because precautionary saving motives push consumption and investment in opposite directions. Our key insight is that, in a world with *multiple* savings vehicles, precautionary motives also determine the *composition* of investment. Specifically an increase in uncertainty leads to a reallocation towards safer investments, which naturally have lower equilibrium returns and marginal products. We show that this reallocation imbues a “flight-to-safety” with real effects, and can result in a recession in which output, employment, consumption and investment all fall. In this way, our model provides a novel, quantitatively successful mechanism for macroeconomic comovement without relying on either nominal rigidities or changes in production technology, both of which Angeletos et al. (2020) argue are not central to business cycles in the data generally.

We begin the paper with an empirical exercise that aims to isolate the connection between risk premia fluctuations and business cycles. Specifically, we use a vector autoregression (VAR) and a maximum-share identification procedure in the tradition of Uhlig (2003) to extract the shock that, by itself, explains the largest possible portion of variation in expected excess equity returns (i.e. the equity risk premium). The shock identified in this way explains around 90% of overall equity risk premium variation. While our analysis cannot uniquely label the structural origin of this “main risk premium” shock, the fact

that a single shock can explain so much of premia fluctuations suggests that innovations to risk premia predominantly follow a common dynamic pattern.

To explore the conditional relationship between risk premia and the broader economy, we examine the response of macroeconomic aggregates to our shock. We find that an increase in the equity risk premium driven by our shock is also associated with substantial and persistent falls in output, consumption, investment, and employment.<sup>1</sup> Moreover, the shock explains a substantial proportion of the overall variation in macro aggregates, and accounts for over half of the unconditional covariances among output, consumption, investment, and employment. Thus, our findings suggest that business cycle comovement is indeed closely related to the source of risk-premium fluctuations.<sup>2</sup>

We go on to explore the effects of our shock on a set of additional variables that could help us better understand the nature of the shock and the likely propagation mechanism. We find that our risk premium shock generates small to insignificant changes in aggregate profits, inflation, risk free rates and also credit spreads. This suggests that the likely structural explanation for our key findings do not rely on direct changes in firm productivity, textbook inflationary demand shocks, or on mechanisms that operate through intertemporal substitution or financial frictions.

Instead, to rationalize our empirical results we propose a novel real model where the risk premium fluctuations themselves generate business cycles and macroeconomic comovement via an investment reallocation channel, without relying on nominal rigidities or standard intertemporal forces. To illustrate our mechanism cleanly, we directly use shocks to risk aversion as the cause of risk premia fluctuations in the model (with stochastic productivity as the underlying source of uncertainty). However, our theory is general, and our novel propagation mechanism would transmit fluctuations in risk premia to the macroeconomy regardless of their source.

In Section 3, we present a stylized two-period model that analytically characterizes our proposed “flight-to-safety” mechanism and illustrates its key intuition. An important feature of our framework is that we allow for search frictions in labor markets. As in Hall (2017), frictions in forming or severing labor relationships imply that labor, like capital, is a long-lived investment good. This effectively gives firms a portfolio choice problem of how much to invest in capital versus long-lived labor positions. We prove that subject to the empirically relevant and common assumption of sticky wages (e.g. Grigsby et al. (2021)),

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<sup>1</sup>In robustness checks, we have found aggregate hours to behave similarly to employment.

<sup>2</sup>Our conditional stock market analysis thus contrasts with the literature that stresses the unconditional predictive power of bond market indicators for real activity (e.g., López-Salido et al., 2017). We also discuss connections with the related approach of Angeletos et al. (2020) in Section 2.3.

labor relationships are relatively riskier for the firm than capital, and hence they carry a higher risk premium in equilibrium.<sup>3</sup> We show that this translates to a relatively low labor demand and hence relatively high marginal product of labor. Moreover, an increase in risk or risk aversion shifts firm investment away from the riskier labor positions, and since the marginal product of labor is high to begin with, this reallocation towards capital investment (and its lower marginal product) lowers output. We prove that this “flight-to-safety” driven recession can indeed be deep enough so that in equilibrium all four macro aggregates fall, including consumption and capital investment.

Having analytically characterized the key forces, we then gauge the potential importance of our novel reallocation channel by estimating a quantitative version of the model in Section 4. Among the additions in the full model, we allow for two types of labor. The first, which we call “full-time,” involves longer-term relationships and sticky real wages. The second, which we call “part-time,” involves shorter employment spells and flexible wages. These assumptions are consistent with the micro data (see [Lariau, 2017](#)).

The introduction of two types of labor improves the empirical realism of the quantitative model in several respects. First, due to their sticky wages and longer duration, “full-time” labor positions carry a higher risk premium than part-time positions, and thus the quantitative model features a second version of our reallocation mechanism, where an increase in risk aversion shifts vacancy postings from full-time to part-time positions. This improves both the quantitative fit and the empirical realism of the model, since we find that in the data there is indeed a strong reallocation of employment from full-time to part-time labor conditional on our risk premium shock.<sup>4</sup> Second, having part-time workers with flexible wages allows the model to match the evidence that aggregate wages are cyclical, despite the fact that wages in our full-time sector are sticky. Third, the short duration of part-time jobs ensures our model does not feature counter-factually long average job duration, avoiding [Borovicka and Borovicková \(2018\)](#)’s critique of [Hall \(2017\)](#).

We estimate the quantitative model with a rich set of empirical targets, featuring both the impulse responses to the risk premium shock we identified in our VAR, and also a bevy of unconditional moments, including asset pricing moments. The model matches all empirical targets very well, generating quantitatively realistic business cycle fluctuations

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<sup>3</sup>And indeed, there is mounting evidence, e.g., [Belo et al. \(2014\)](#), [Favilukis and Lin \(2016\)](#), [Donangelo et al. \(2019\)](#), that labor relationships are in fact priced as risky firm assets in the data.

<sup>4</sup>[Lariau \(2017\)](#), [Mukoyama et al. \(2018\)](#) and [Borowczyk-Martins and Lalé \(2019\)](#) all emphasize that reallocation from full-time to part-time labor is crucial for understanding the counter-cyclicality of part-time labor in the data. In our model, we link it specifically to risk aversion shocks. Reallocation from new to old capital could provide a similar amplification mechanism (see the empirical evidence of [Eisfeldt and Rampini, 2006](#)), though we abstract from it here.

and macroeconomic comovement in response to risk aversion shocks, without implying unrealistically high or volatile risk-premia or labor market fluctuations.<sup>5</sup>

We conclude the paper with a short discussion of why wage rigidities play a different role in our model than they do in [Hall \(2005\)](#). In [Hall \(2005\)](#), sticky wages amplify the volatility of the expected future cash flows associated with labor relationships in response to productivity shocks. By contrast, the key role of sticky wages in our model is to generate a volatile risk-premium wedge between full-time and part-time labor. To make this point, we counterfactually shut down the effect of higher order moments on the demand for full-time labor and we find that while wages remain sticky and all first-order effects are active, the model now delivers very small fluctuations in employment. Thus, our model offers a new way in which wage stickiness increases the volatility of vacancies and helps to resolve the [Shimer \(2005\)](#) puzzle, as a result of fluctuations in risk appetite.

## Related Literature

Recent work has rekindled interest in the idea of uncertainty- or risk-driven macroeconomic fluctuations ([Gilchrist et al., 2014](#)), but this otherwise intuitive research agenda faces difficulty generating full macro comovement. For example, [Bloom \(2009\)](#) proposes a model of the firm where non-convex adjustment costs generate real-option-value effects so that an increase in uncertainty triggers a wait-and-see reaction in firm plans, generating a drop in investment, employment, and output, but not consumption. Some papers, such as [Gourio \(2012\)](#) and [Bloom et al. \(2018\)](#), have therefore complemented risk mechanisms with first-moment shocks to also generate a drop in consumption. In related work, [Arelano et al. \(2019\)](#) exploit financial frictions to obtain drops in output and labor in response to an increase in idiosyncratic risk, but abstract from investment and capital, while [Segal and Shaliastovich \(2021\)](#) rely on persistent capital depreciation to obtain drops in consumption and investment, but abstract from labor implications.

One solution to the comovement challenge is to use models with nominal rigidities, so that output is primarily determined by final goods demand (e.g., [Ilut and Schneider, 2014](#); [Fernández-Villaverde et al., 2015](#); [Basu and Bundick, 2017](#); [Bayer et al., 2019](#); [Caballero and Simsek, 2020](#)). [Christiano et al. \(2014\)](#) further exploits the interaction of nominal rigidities and financial frictions to obtain deep risk-driven recessions. New Keynesian frictions can also help deliver large movements in unemployment following uncertainty

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<sup>5</sup>The model also does not rely on strong cyclicalities of measured final goods markups, avoiding another contentious debate (e.g., [Rotemberg and Woodford, 1999](#) vs [Nekarda and Ramey, 2013](#)).

shocks in models with labor search frictions ([Leduc and Liu, 2016](#); [Challe et al., 2017](#)).<sup>6</sup> All of the above mechanisms rely on endogenous variations in markups driven by sticky prices to deliver simultaneous falls in consumption and investment in response to a risk or uncertainty shock. By contrast, our model does not rely on sticky nominal prices, suboptimal monetary policy, or markup variation to generate business cycle comovement.

Two recent papers, [Di Tella and Hall \(2020\)](#) and [Ilut and Saijo \(2021\)](#), also provide mechanisms that deliver business-cycle comovements via a risk channel without nominal rigidities. They propose models where the marginal product of both capital and labor is uncertain – due to a labor-in-advance choice in the former, and imperfect information about productivity in the latter. In both cases, a rise in uncertainty can generate macro comovement, as long as the risk-driven fall in firms’ investment demand is strong enough to offset the households’ increased desire to save, operating on the usual intertemporal margin that trades off lower risk-adjusted capital returns with precautionary savings.

We differ from this work along two dimensions. First, we propose a new channel for propagating risk and uncertainty fluctuations into macro comovement, which is the reallocation of savings from investments with higher risk premia, and thus higher marginal product, to investments that are safer, but have a lower marginal product. This is a portfolio reallocation story that is conceptually different from existing real mechanisms that operate via fluctuations in the overall desire to save. We are the first to formally model this channel as the source of business cycle comovement, and also argue that it is empirically relevant, and specifically manifests in the data as the reallocation from full-time to part-time labor we document. Second, in the case of [Di Tella and Hall \(2020\)](#), the mechanism relies on variation in *idiosyncratic risk*, and does not generate time variation in the aggregate equity premium, while we document a close empirical link between the counter-cyclicality of the aggregate equity premium and macroeconomic comovement.

Previous research has also sometimes modeled direct shocks to risk appetite as we do in our model, but with the goal of capturing different aggregate phenomena. [Dew-Becker \(2014\)](#) for example, shows that such fluctuations can be useful in New Keynesian contexts to explain the dynamics of the term structure of interest rates. More recently, [Bansal et al. \(2021\)](#) use fluctuations in risk appetite to explain longer run reallocations of investment between R&D intensive and non-intensive industries. The latter authors also propose a different solution to comovement puzzles by assuming that the government sector absorbs demand for lower-risk investments in periods of high risk aversion.

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<sup>6</sup>Occasionally binding downward wage rigidity also amplifies the impact of uncertainty shocks on labor market variables, with or without nominal rigidities ([Cacciatore and Ravenna, 2020](#)).

Hall (2017) argues that the time variation in discount rates that is needed to explain stock market volatility can also rationalize the fluctuations in unemployment. Subsequent papers have built on this general idea to provide a risk-driven explanation of the Shimer (2005) puzzle and other labor market phenomena – see for example Kilic and Wachter (2018), Kehoe et al. (2019), Mitra and Xu (2019), and Freund and Rendahl (2020) among others. These and other models that focus on risk-driven unemployment fluctuations largely abstract from capital accumulation or, when capital is considered, do not focus on the comovement across macro aggregates. In addition, despite their labor market focus, they do not account for the disparate movements in part-time and full-time labor.

## 2 Risk Premium Shocks

This section describes our approach to estimating equity risk premium shocks in the data. Our baseline empirical specification consists of a vector autoregression of the form

$$Y_t = B(L)Y_{t-1} + u_t. \quad (1)$$

In the above,  $Y_t$  is the vector of observed variables,  $B(L)$  contains the weights on past realizations of  $Y_t$ , and  $u_t$  is the vector of residuals.

We estimate equation (1) on US data using the observable set

$$Y_t \equiv [gdp_t, c_t, inv_t, n_t, r_t^s, r_t^b, dp_t]', \quad (2)$$

which consists of the logs of real per-capita output ( $gdp_t$ ), consumption ( $c_t$ ), investment ( $inv_t$ ), employment ( $n_t$ ), cum-dividend real stock log-returns ( $r_t^s$ ), log real ex-post three-month treasury bill rate ( $r_t^b$ ), and the aggregate dividend-price ratio ( $dp_t$ ).<sup>7</sup> Our sample is 1954Q1-2018Q4.<sup>8</sup> The VAR is estimated in levels using OLS, including three lags in the polynomial  $B(L)$ .

### 2.1 Identification Approach

As with most VAR identification schemes, we seek to find a rotation matrix  $A$  that maps the reduced form residual  $u_t$  to a vector of orthogonalized innovations  $\epsilon_t$ :

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<sup>7</sup>Appendix A.1 contains all details on data definitions and sample construction.

<sup>8</sup>A previous version of the paper used data starting in 1985Q1 to avoid a potential structural break at the start of the “Great Moderation.” The results are very similar, hence we use the longer sample in our benchmark analysis. The shorter sample results are reported in Appendix A.2.

$$u_t = A\epsilon_t$$

We follow Uhlig (2003), and use a “max-share” approach to find the matrix  $A$  such that the first element of the resulting vector  $\epsilon_t$  has the highest possible explanatory power over the variation of an endogenous variable from the VAR.

In our application, we specifically look for the shock that has the largest possible contribution to the *expected* equity excess return implied by the VAR, which is constructed as follows. First, the *realized*  $j$ -period cumulative excess return is defined as usual

$$rp_{t,t+j} \equiv [r_{t+1}^s + r_{t+2}^s + \dots + r_{t+j}^s] - [r_{t+1}^b + r_{t+2}^b + \dots + r_{t+j}^b]. \quad (3)$$

We then compute the expectation of this excess return as implied by our VAR. Let  $\tilde{Y}_t = \tilde{B}\tilde{Y}_{t-1} + \tilde{A}\tilde{\epsilon}_t$  be the companion form of the VAR in equation (1) – that is  $\tilde{Y}_t$  is a stacked vector of  $Y_t$  and its three lags, and  $\tilde{\epsilon}_t$  pads  $\epsilon_t$  with zeros at the bottom to be conformable. Taking expectations over (3) and iterating backwards through the VAR system, we can express the expected excess return as a linear function of innovations  $\tilde{\epsilon}_t$

$$\mathbb{E}_t[rp_{t,t+j}] = (e_5 - e_6)(\tilde{B} + \tilde{B}^2 + \dots + \tilde{B}^j)(I - \tilde{B}L)^{-1}\tilde{A}\tilde{\epsilon}_t. \quad (4)$$

where  $e_5$  and  $e_6$  are vectors that select the stock and bond returns from  $\tilde{Y}_t$ , respectively.

Let  $\phi(z) \equiv (e_5 - e_6)(\tilde{B} + \tilde{B}^2 + \dots + \tilde{B}^j)(I - \tilde{B}z)^{-1}\tilde{A}$  be the  $z$  transfer-function associated with the MA( $\infty$ ) representation in (4). We can thus express the variance of  $\mathbb{E}_t[rp_{t,t+j}]$  associated with spectra of periodicity  $p \equiv [p_1, p_2]$ , which we label  $\sigma_p^{rp}$ , as

$$\sigma_p^{rp} = \frac{1}{2\pi} \int_{2\pi/p_2}^{2\pi/p_1} \phi(e^{-i\lambda})\phi(e^{-i\lambda})' d\lambda. \quad (5)$$

In turn, we can express the variance of  $\mathbb{E}_t(rp_{t,t+j})$  over those same frequencies, but when only the first element of the shock vector  $\epsilon_t$  is active, as

$$\sigma_p^{rp} \Big|_{\epsilon_t^{(2)}=\epsilon_t^{(3)}=\dots=0} = \frac{1}{2\pi} \int_{2\pi/p_2}^{2\pi/p_1} \phi(e^{-i\lambda})e_1'e_1\phi(e^{-i\lambda})' d\lambda. \quad (6)$$

where again  $e_1$  is a selector vector, this time with 1 in the first position and zeroes everywhere else, and  $\epsilon_t^{(k)}$  is the  $k$ -th element of the shock vector  $\epsilon_t$ .

We can then find the matrix  $A$  by maximizing (6) (recall that  $\phi(z)$  is a function of  $A$ ). This procedure yields a partially identified system, in the sense that the above



maximization problem will uniquely determine the first column of  $A$  and thus the first element of the shock vector of  $\epsilon_t$ , but not the rest. This is okay for our purposes, because we want to focus on just the resulting  $\epsilon_t^{(1)}$ , which is the orthogonal innovation that has the biggest possible contribution to fluctuations in the risk premium  $\mathbb{E}_t(rp_{t,t+j})$ .

Lastly, to implement the procedure, we need to specify the horizon at which excess returns are computed ( $j$ ) and the frequency band of variation we want our procedure to target ( $[p_1, p_2]$ ). As a baseline case we choose  $j = 20$ , consistent with the common practice in the finance literature of emphasizing the predictability in the 5-year excess equity return (e.g., [Cochrane, 2011](#)). Second, we choose  $p = [2, 500]$ , corresponding to fluctuations of periodicity anywhere between 2 and 500 quarters. Practically, this corresponds to targeting unconditional variances in the presence of non-stationary variables, but allows us to perform robustness checks in which the VAR is estimated in VECM form and the lag polynomial  $B(L)$  has a unit root. We have found that our results are robust to estimating the VAR in VECM form so long as we allow for more than two independent trends in the data. Similarly, our results are robust to increasing the lags in our VAR, but for the benchmark results we stick to three lags for degrees of freedom considerations.

## 2.2 Excess Returns Predictability

Before turning to the main empirical results, first we verify that our VAR is indeed able to forecast equity returns, and hence the VAR-implied expected returns  $\mathbb{E}_t(rp_{t,t+j})$  capture the underlying risk premium effectively.

In [Figure 1](#) we plot the expected excess stock return as estimated by our VAR,  $\mathbb{E}_t(rp_{t,t+20})$ , against the realized excess returns over that same forecasting horizon,  $rp_{t,t+20}$ . The Figure shows that both series exhibit substantial variation, and while the ex-post series is more volatile as to be expected since clearly we cannot forecast returns perfectly, the VAR prediction of the excess returns tracks it reasonably well and is highly correlated with it. The  $R^2$  of regressing ex-post returns on our VAR forecast is 0.49, which is both significant and at the same time in line with the previous literature, which has found very similar moderate to high predictability in 5-year returns (e.g., [Cochrane, 2011](#)).

To understand which specific variables in  $Y_t$  are the main predictors our VAR relies on, we investigate the expected excess stock returns  $\mathbb{E}_t(rp_{t,t+j})$  as implied by a sequence of smaller VARs that use only a subset of the 7 variables contained in our main specification.

We start with the smallest VAR that allows us to compute expected excess stock return: the VAR that contains only stock and Tbill returns, that is  $Y_t = [r_t^s, r_t^b]$ . In [Figure 2](#), we plot the forecasted excess return as estimated by this smaller VAR with

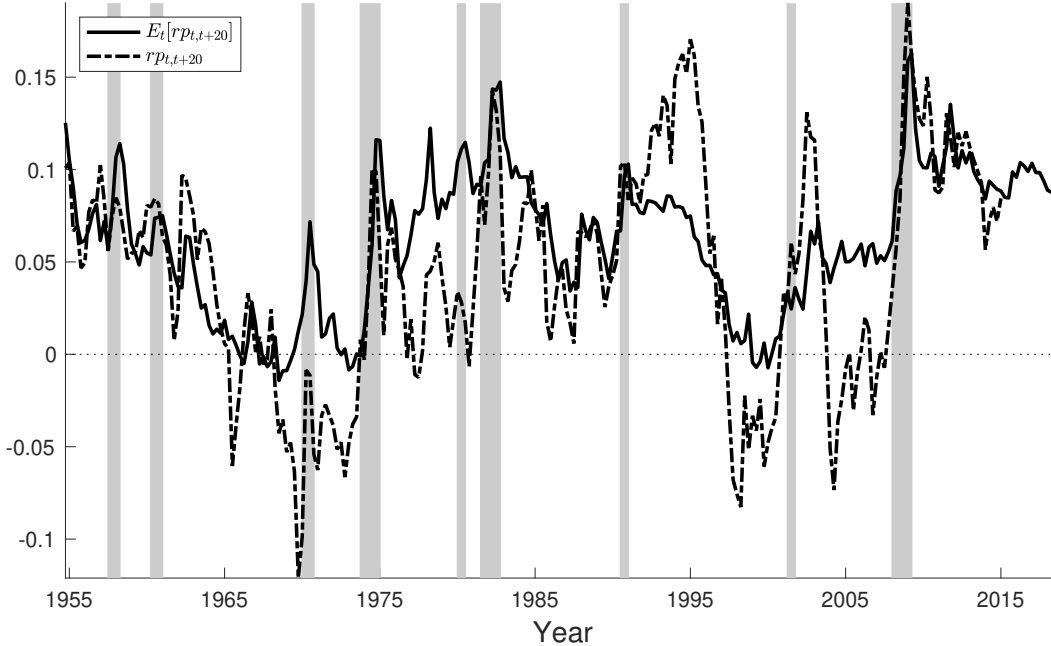


Figure 1: Ex-ante and ex-post excess stock returns.

the light blue line. The Figure shows that stock and bond returns alone are very poor predictors of future excess stock returns, delivering an essentially flat line throughout our sample and an  $R^2$  of expected on realized excess return of only 0.01.

We then sequentially expand the number of variables in the restricted VARs to include more variables from our original set. Doing this exercise in different permutations, we have found that consumption and GDP are particularly important. While including GDP or consumption alone only marginally improves the prediction, the dark blue line in Figure 2 shows that adding them jointly delivers a substantial improvement and raises the  $R^2$  to 0.43, a result in the spirit of [Campbell \(1987\)](#), [Cochrane \(1994\)](#), [Lettau and Ludvigson \(2001\)](#), and [Melone \(2021\)](#). In this case, the VAR-implied expected return exhibits large fluctuations as in the data and is characterized by significant spikes in all recessions in our sample, all followed by a steady decline. In most occasions, including during the Great Recession, these patterns align well with the data. Moreover, no other alternative combination of four variables from our full VAR can deliver similarly large forecastability.

Finally, we have also found that the third most important variable is the dividend-price ratio. Adding  $dp_t$  to the 4-variable VAR with  $c_t$  and  $gdp_t$  further improves predictability and brings the  $R^2$  to 0.46. While this bump in  $R^2$  looks relatively modest, the actual VAR-forecast  $\mathbb{E}_t(rp_{t+j})$  changes in important ways once we add  $dp_t$ . In Figure 2, we can see that this 5-variable VAR's estimate of the conditional risk premium (purple line) is

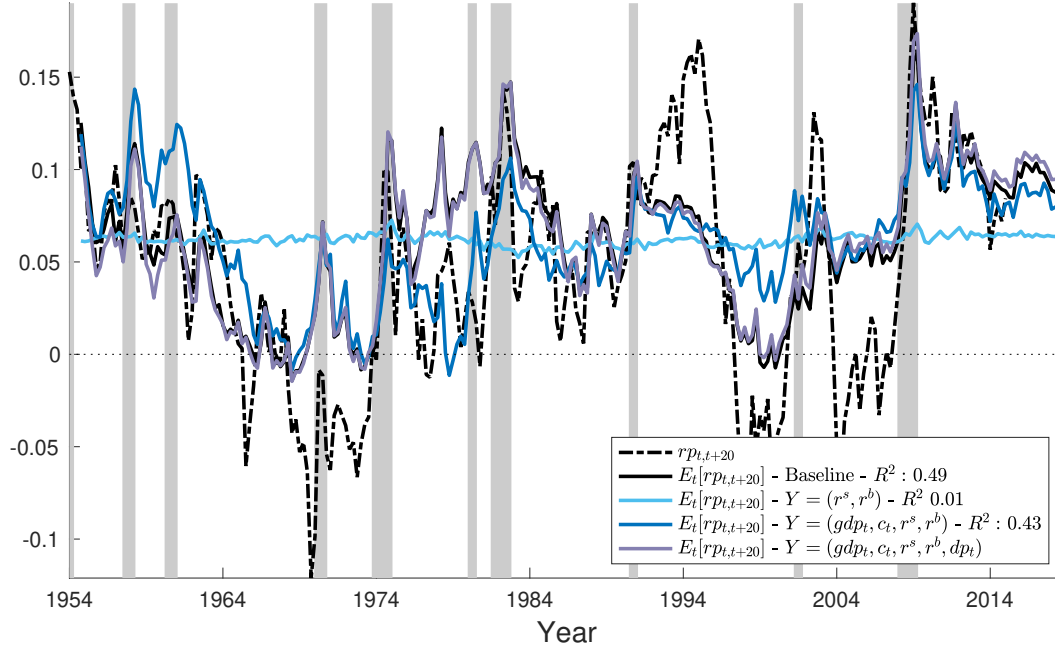


Figure 2: Ex-post and Ex-ante excess stock returns from alternative VARs.

essentially identical to that of our baseline 7-variable VAR (black line). Adding  $dp_t$  is particularly helpful in offering a better return forecast in the late 90s and in the 60s-70s period, as we can see by comparing the dark blue and the purple lines in Figure 2.

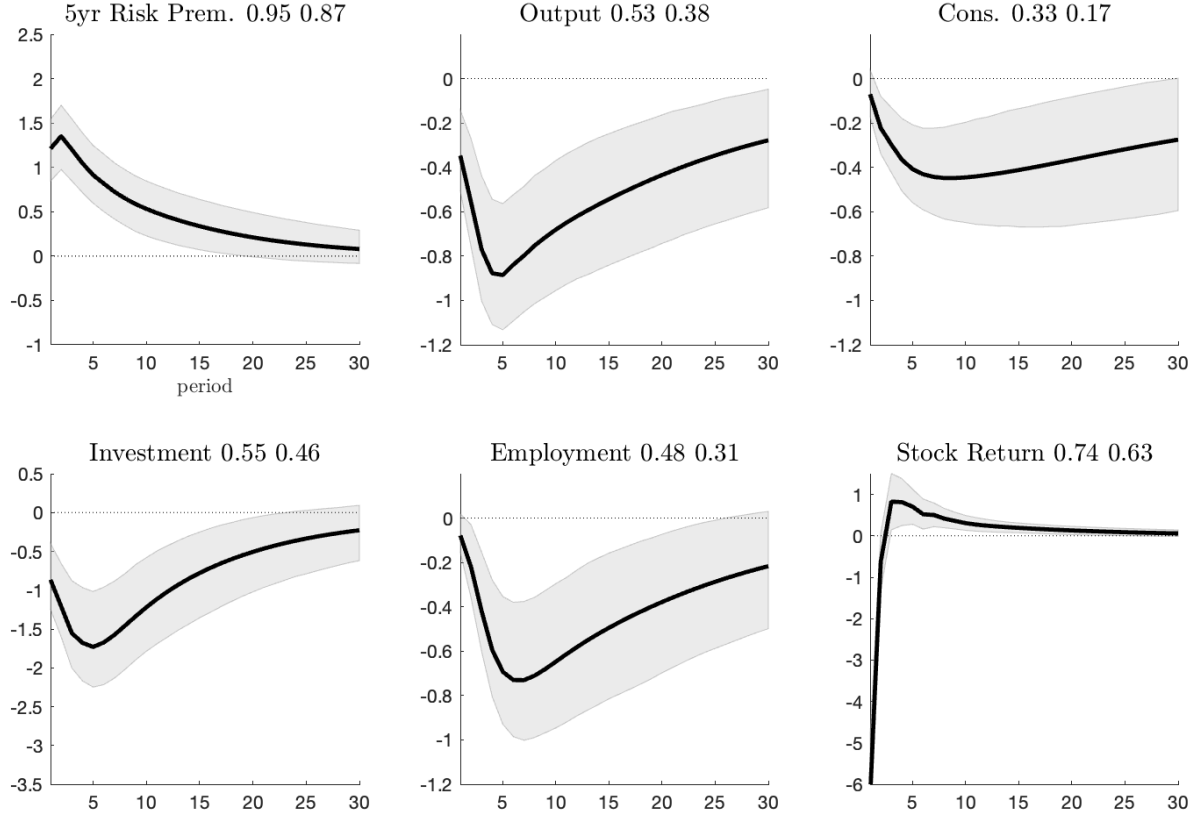
We thus conclude that the joint information in GDP and consumption, and in the dividend-price ratio to a lesser extent, play the most important role in our VAR's ability to predict excess equity returns. As such, our VAR is essentially relying on the information underlying two of the most robust return predictors in the literature – the  $cay_t$  variable of Lettau and Ludvigson (2001) which captures deviations from the long-run mean in the consumption-to-income ratio, and the dividend price ratio (Cochrane, 2011).<sup>9</sup>

## 2.3 Empirical Results

Having established the bona fide of our VAR-based expected equity returns, we apply the identification procedure detailed in Section 2.1, extract the shock that accounts for the bulk of the fluctuations in this expected return, and study its impact.

Figure 3 plots the impulse responses of the major business cycle variables in response to the shock identified by our VAR procedure. The numbers in the panel titles represent the percent of variance of the given variable explained by our shock, either at business

<sup>9</sup>While we do not include  $cay_t$  directly in  $Y_t$ , our VAR nevertheless flexibly captures the same information by implicitly estimating the cointegration relationship between consumption and GDP.



Shaded lines are the 10th- and 90th-percentile bootstrapped responses. Y-axis values are in annualized percentage points for the risk premium and stock return; all other numbers are in percentage deviations. Numbers in subplot titles correspond to the percent of variance explained at the business cycle (6-32 quarters) and unconditional frequencies (2-500 quarters), respectively.

Figure 3: Impulse responses to VAR-identified risk premium shock.

cycle frequency (first number, periodicities between 6 and 32 quarters) or essentially the unconditional variance (second number, periodicities between 2 and 500 quarters).

The first panel plots the response of the equity risk premium itself ( $\mathbb{E}_t rp_{t,t+j}$ ), the target of our max-share procedure. We see that the recovered “risk premium” shock causes a substantial and persistent increase in the 5-year equity risk premium. It jumps up by about 1.25% (annualized) on impact (compared to an average risk premium of 5.4% in our sample), and the impulse response is largely monotonic but decays slowly, with a half-life of 9 quarters. Naturally, we find that this persistent rise in the risk premium is associated with a sharp drop in stock prices on impact (a fall in the ex-post return) – see panel six. This is followed by a prolonged period of higher than average returns, which underlie the elevated expected excess returns  $\mathbb{E}_t(rp_{t,t+j})$ .

Overall, this shock explains 95% of the variation in the risk premium at business cycle frequencies, and 87% of what is effectively its unconditional variance. While we cannot label the structural origin of the shock, the very high share of variance explained by  $\epsilon_t^{(1)}$

Table 1: Business Cycle Covariance Explained - Baseline Procedure

	<b>Output</b>	<b>Cons.</b>	<b>Investment</b>	<b>Employment</b>	<b>Stock Return</b>
Output	0.53				
Cons.	0.49	0.33			
Investment	0.61	0.66	0.55		
Employment	0.55	0.54	0.56	0.48	
Stock Return	0.67	0.87	0.66	0.79	0.74

means that a single factor is sufficient to explain the dynamics of the equity risk premium. For conciseness, we will simply refer to this shock as a “risk premium shock,” with the understanding that we cannot label its deep origins uniquely.

Next, we want to understand what is the footprint that this shock that is seemingly so important to risk premia also leaves in the rest of the economy, and for that we study the impulse responses of the other variables in the VAR. Panels two through five plot the responses of the four main macro aggregates: output, consumption, investment and employment. We find that all of these variables exhibit a substantial and persistent contraction following a risk premium shock, with hump-shaped dynamics. These significant dynamic responses are also reflected in the shock’s importance in terms of variance decomposition. For output, investment, and employment we find that the shock explains roughly half of their variance at business cycle frequencies, and it explains a third of the business cycle variance of consumption. In terms of unconditional variances, the numbers are still substantial, but a bit lower, as could be expected from the fact that the risk premium shock is persistent but clearly stationary (see the first panel).

Moreover, the macro aggregates move together conditional on our risk premium shock. We quantify the importance of the risk premium shock for explaining comovement, a hallmark feature of business cycles, in Table 1. Each entry in the table reports the covariance (at business cycle frequencies) between the variables listed in the row/column, conditional on *only the risk premium shock* being active, relative to the covariance implied by the full estimated system in (1). Thus, the diagonal elements of the table correspond to the standard variance share decomposition, as also reported in the panel titles of Figure 3. By contrast, the off-diagonal elements are a form of “covariance decomposition,” and are not bounded between zero and one: They will take negative values if the covariance implied by the dynamics conditional on our shock has the opposite sign as the corresponding unconditional covariance, and they will be larger than unity when the covariance conditional

on our shock is larger than the unconditional one.

The table shows that, as important as our shock is in terms of variance decomposition, it is just as an important driver of the *covariance* among the variables. The key result is that the off-diagonal entries in Table 1 are bigger than the diagonal elements, and are almost all bigger than 0.5, meaning that our risk-premium shock accounts for more positive comovement than all other shocks in the economy combined. Moreover, our shock appears to be particularly important in driving comovement between consumption and other macro aggregates, and also the stock market, where our shock explained 87% of the covariance between consumption and stock returns. Thus, all other shocks that otherwise drive the remaining two-thirds of consumption volatility in the data cause only mild positive relationship between consumption and stock returns.

In summary, our findings show that the “risk premium” shock is potentially important as a driver of business cycles, both in generating macro fluctuations and in driving the classic observation of macroeconomic comovement. It is interesting to contrast our results with the related but distinct approach in Angeletos et al. (2020), who follow a max-share procedure that isolates the main driver of output (or employment, depending on the specification), and not risk premia as we do.<sup>10</sup> Yet our shock, which targets risk premia, captures a similar portion of business cycles and is correlated – with a coefficient of 0.75 – with the main business cycles shock of Angeletos et al. (2020). If anything, this underscores the close connection between business cycles and risk premia fluctuations that we want to emphasize.

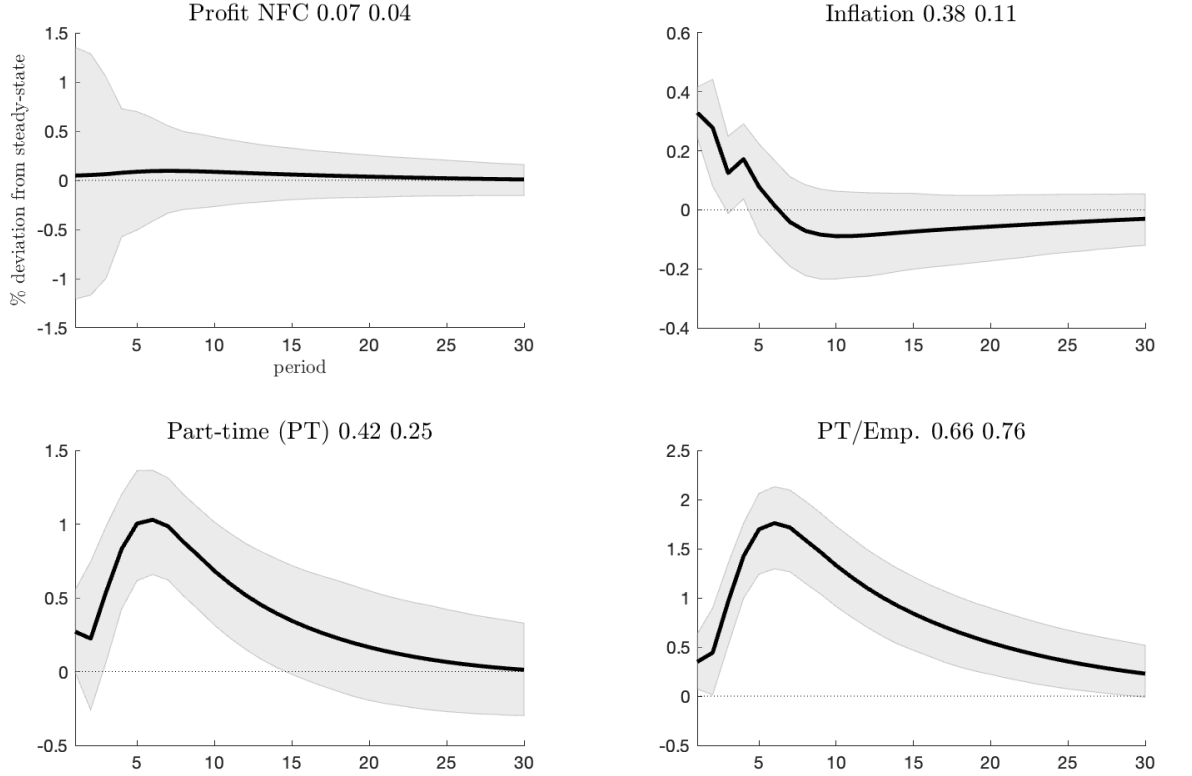
## 2.4 Additional Results

To explore potential interpretations of our shock, we augment our baseline VAR with a set of auxiliary variables,  $S_t$ . These include real profits of non-financial corporations, inflation, the yield on 5-year bonds, and the number of part-time workers in the economy. To save on degrees of freedom (and because not all of the additional variables are available starting in 1954:Q1), we estimate these auxiliary impulse responses by projecting the vector of variables  $S_t$  on current and past observations of our VAR  $Y_t$ :

$$S_t = \Gamma(L)Y_t + v_t, \tag{7}$$

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<sup>10</sup>Another difference is that Angeletos et al. (2020) target business cycle frequencies while we target the unconditional variance. Our results are robust to this change in the targeted frequencies.



Shaded lines are the 10th- and 90th-percentile bootstrapped responses. Numbers in subplot titles correspond to the percent of variance explained at the business cycle (6-32 quarters) and unconditional frequencies (2-500 quarters), respectively.

Figure 4: Impulse responses to VAR-identified risk premium shock for additional variables.

The coefficient matrix  $\Gamma(L)$ , estimated via OLS, contains the same number of lags as the VAR in (1). Using the estimated values of  $\Gamma(L)$ , we can then compute the impulse responses for any auxiliary variable using the responses for  $Y_t$  implied by our VAR in (1).

### Firm Profitability

The literature, summarized by [Cochrane \(2011\)](#), has argued that asset price fluctuations are largely driven by changes in risk premia, rather than changes in expected firm profitability. To demonstrate that these are exactly the sort of fluctuations that our identified shock delivers, the top left panel of Figure 4 plots the response of the present discounted value of expected real non-financial corporate profits to our shock. The time discount we use is the average safe real interest rate over our sample, and the present value of future expected profits is computed by iterating on equation (7). The figure shows that the present value of profits does not move significantly in response to the shock, consistent with the view that the large stock price drop associated with our shock is primarily due to a change in the risky discount rates. An apparent change in the risk appetite of the

economy, without a significant change in cash flows.

## Inflation

This makes us think that rather than a first-moment shock, the data suggests that our empirical results are due to a higher order shock that primarily moves risk-premia. However, risk-premium (or more broadly uncertainty) shocks face significant hurdles in generating macroeconomic comovement in standard models, as uncertainty shocks would typically raise precautionary savings demand and thus increase investment rather than decrease it.

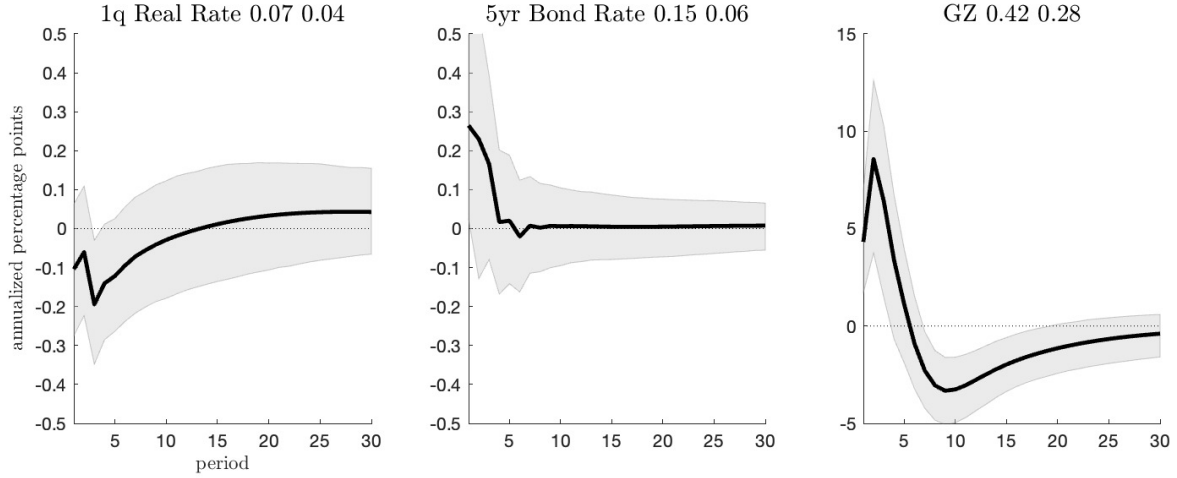
One way of overcoming this challenge is to introduce New Keynesian frictions, in which case the fall in consumption demand can depress aggregate demand enough to cause a broad recession across all four macro aggregates. If this aggregate demand channel were dominant, we would expect the shock to have a negative impact on inflation. However, we find that our risk premium shock is associated with an *increase* in inflation, plotted in the top-right panel of Figure 4. This observation encourages us to consider alternatives to the Keynesian narrative for risk-induced fluctuations.

## Interest Rates and Bond Returns

Alternatively, successful real propagation mechanisms typically rely on tilting intertemporal forces in the right way, so that an increase in uncertainty leads to a drop in the desire to save (e.g. [Di Tella and Hall \(2020\)](#), [Ilut and Saijo \(2021\)](#)), which would imply a rise in real interest rates. Another alternative could potentially be financial frictions, if our equity risk premium shock would also significantly increase credit spreads.

However, in Figure 5 we show that our shock has virtually no effect on interest rates, whether short-term or longer-term (five year) rates. On the other hand, while the excess bond premium of [Gilchrist and Zakrajšek \(2012\)](#) does rise substantially for several quarters after the shock, this effect is much shorter lived than the rise in the equity risk premium and the impact on the real variables we documented earlier. Moreover, we have found that our “risk premium” shock is distinct from the “bond premia” specific shocks in [Gilchrist and Zakrajšek \(2012\)](#) and [Kurmman and Otrok \(2013\)](#), due in part to having very different effects on inflation and real investment. Thus, our shock seems to be something different than a direct shock to credit constraints, and also does not induce strong intertemporal dissaving motives.





Shaded lines are the 10th- and 90th-percentile bootstrapped responses. Numbers in subplot titles correspond to the percent of variance explained at the business cycle (6-32 quarters) and unconditional frequencies (2-500 quarters), respectively.

Figure 5: Impulse responses to VAR-identified risk premium shock for additional variables.

## Part-time Employment

Thus, we want to propose a different potential propagation mechanism, one that relies instead on a “flight-to-safety” effect that is similar in spirit to the intuitive argument in [Cochrane \(2017\)](#). The key intuition relies on a shift towards factors of production that are safer, but also necessarily carry a lower marginal product (i.e. lower return). One potential place in the data this type of reallocation could take place is in the dichotomy between part-time and full-time labor, since full-time arrangements have eight times longer duration and carry less flexible wages (e.g. [Larreau, 2017](#)), which makes the firm profits from full-time workers more cyclical. Thus, we would expect that a risk-premium shock would lead to a reallocation of labor demand from full-time towards part time positions.<sup>11</sup>

Figure 4 shows that part-time employment does indeed rise significantly in response to our shock. This response is persistent, and peaks at an increase of 1% in the number of part-timers, and 1.75% as a share of total employment. This increase in part-time employment happens at the same time as the economy experiences an overall employment *fall* (0.7% at its trough) and a significant rise in the aggregate risk premium.

## Summing up the Evidence

Taken together, we believe our results suggest that flight-to-safety could be central to understanding how shocks to risk premia propagate to the macroeconomy. Both asset

<sup>11</sup>Micro level studies of part-time workers suggest that the labor supply in those markets is relatively rigid, with most cyclical fluctuations driven by changing labor demand shifting workers from full-time to part-time status within the same firm ([Borowczyk-Martins and Lalé, 2019](#)).

pricing returns and, in the case of part-time employment, real input decisions by firms are consistent with a shift toward safety. The same evidence points away from mechanisms that rely on strong first-moment shocks or aggregate demand-driven channels.

An open question is how a reallocation towards safety can result in a simultaneous fall in all of the main macroeconomic aggregates. To build intuition for how the mechanism we propose works, Section 3 formalizes the flight-to-safety argument in an analytically tractable two-period model. To keep things simple, in that model we do not differentiate between part-time and full-time labor, but in Section 4 we quantify the mechanism in a richer version of the model with an infinite horizon and two types of labor.

### 3 Analytical Model and Intuition

In this section, we present a simple real model in which both capital and labor positions are risky investments. We use this model to highlight four key points. First, we show that when both factors are equally risky, precautionary behavior tends to move investment and consumption in opposite directions, making macroeconomic comovement impossible in a standard real model like this. Second, we show that when the two factors have *different riskiness*, in equilibrium the marginal product of the relatively riskier asset is higher than the marginal product of the safer asset. Third, we demonstrate that an increase in risk aversion (or risk) causes a reallocation of investment towards the safer and less productive asset. This causes a fall in output overall. Finally, we derive sufficient conditions under which this reallocation channel is strong enough to generate a simultaneous fall in investment, labor, consumption and output in response to an increase in risk aversion.

The model is a two-period version of a decentralized RBC economy with search and matching in labor markets. Households supply labor inelastically and consume, while the firm purchases capital and hires labor to produce output in two periods  $t \in \{0, 1\}$ . Capital is purchased at the cost of one unit of consumption and does not depreciate. In this section only, we assume there is no time-to-build friction, so that capital becomes productive immediately, and thus has similar timing to labor. This makes the key intuition easier to showcase, but our theorems hold just the same if capital is only productive in the second period, and we also use this more standard timing in the quantitative model.

The main decision maker in our economy are the firms, which determine their capital and labor demand by maximizing profits. Firms hire labor by posting vacancies  $v_0$  at cost  $\varphi$ , and matches are formed according to a standard Cobb-Douglas matching function so

that vacancies are filled with a probability

$$p_0 \equiv \frac{M(v_0, s)}{v_0},$$

where  $M(v, s) = v^\varepsilon s^{1-\varepsilon}$  is the aggregate matching technology in the economy, and  $s$  is the exogenous labor supplied by the household (which we normalize to one). The labor market is only open in period 0 (the first period), and hired workers work both periods, receiving wages  $W_t \geq 0$ . Throughout we suppress time subscripts for variables that are constant over both periods, such as for example capital  $K$  and total hired labor  $N$ .

Since vacancies  $v_0$  can be expressed as  $v_0 = N/p_0$ , and firms are competitive in labor markets and take the matching probability  $p_0$  as given, we can express the firm's problem as a choice over labor and capital,  $N$  and  $K$ , both of which are hired once and for all in the initial period and operate in both periods. The firm maximizes the sum of its expected profits discounted by the household's stochastic discount factor  $M_{0,1}$  (defined below):

$$\max_{N, K} \pi_0 + E_0[M_{0,1}\pi_1], \quad (8)$$

subject to  $N \geq 0, K \geq 0$ , and the expressions for firm profits

$$\pi_0 = K^\alpha N^{1-\alpha} - W_0 N - \varphi \frac{N}{p_0} - K, \quad (9)$$

$$\pi_1 = Z_1 K^\alpha N^{1-\alpha} - W_1 N, \quad (10)$$

The firm operates a standard Cobb-Douglas technology, where  $Z_1$  is a stochastic second-period productivity that represents the only source of risk in the economy. We assume that  $\log(Z_1) \sim N(-\frac{1}{2}\sigma_z^2, \sigma_z^2)$ , so that  $E_0[Z_1] = 1$ .

The household has Epstein-Zin preferences,

$$V_0 = \max \left[ (1 - \beta)C_0^{1-1/\psi} + \beta(E_0 C_1^{1-\gamma})^{\frac{1-1/\psi}{1-\gamma}} \right]^{\frac{1}{1-1/\psi}}, \quad (11)$$

owns the representative firm, and maximizes utility subject to the constraints

$$C_0 = \pi_0 + W_0 N,$$

$$C_1 = \pi_1 + W_1 N,$$

where  $\pi_t$  are the profits of the firm and  $W_t N$  is the household's labor income. The household supplies labor inelastically and consumes the resulting proceeds of firm profits

and labor income. The household's stochastic discount factor is

$$M_{0,1} \equiv \left( \frac{\partial V_0 / \partial C_1}{\partial V_0 / \partial C_0} \right) = \beta \left( \frac{C_1}{C_0} \right)^{-1/\psi} \left( \frac{C_1}{(\mathbb{E}_0 C_1^{1-\gamma})^{\frac{1}{1-\gamma}}} \right)^{1/\psi-\gamma}. \quad (12)$$

The intertemporal elasticity of substitution is denoted by  $\psi$ , and risk aversion by  $\gamma$ . In order to transparently illustrate the basic mechanism through which risk premia propagate to the broader economy in our setup, we directly consider changes in risk-aversion. However, our results suggest that the same mechanism would propagate changes in risk premia that originate from other sources (e.g., changes in volatility) in the same way.

To close the model, we need to specify a wage determination process, and we consider two options. The first is a flexible wage which is renegotiated each period via Nash bargaining with household bargaining weight  $\eta = 1 - \varepsilon$ . This calibration eliminates the congestion externalities in the labor search market, so that the Nash-wage economy delivers efficient equilibrium allocations. For simplicity we assume that workers have an outside option of zero, so the wage is a pro-rata share of the marginal product of labor:

$$W_0^{Nash} = (1 - \varepsilon)(1 - \alpha) \left( \frac{K}{N} \right)^\alpha, \quad W_1^{Nash} = (1 - \varepsilon)Z_1(1 - \alpha) \left( \frac{K}{N} \right)^\alpha. \quad (13)$$

Using (13) we can define the average per-period wage, which turns out to also be equal to the time-0 wage, and thus also next period's expected wage:  $W^{avg} \equiv W_0^{Nash} = \mathbb{E}_0(W_1^{Nash})$ .

The second alternative we consider is a rigid wage  $W_0 = W_1 = W$ , the level of which we take as an arbitrary constant within the bargaining set. As we show below, rigid wages make labor the riskier factor of production, giving rise to our novel reallocation channel.

### 3.1 Analytical Results

We start by analyzing the standard, flexible wage economy. Proposition 1 shows that there are two offsetting effects of an increase in risk aversion. First, an increase in risk aversion lowers the certainty equivalent of future consumption, and thus generates an incentive for agents to save more, via both higher  $K$  and  $N$ . Second, the increase in risk aversion increases the risk premia associated with the uncertain returns of these two saving vehicles, giving agents a reason to lower  $K$  and  $N$ . Which forces dominates depends on the value of the intertemporal elasticity of substitution  $\psi$ .

**Proposition 1.** *In the economy with flexible Nash wages:*

1. *The risk premia on capital and labor investment are the same;*

2.  $(C_0, K, N)$  cannot all move in the same direction in response to a change in risk aversion,  $\gamma$ . In particular, an increase in  $\gamma$  causes  $C_0$  to rise while  $K$  and  $N$  both fall when the intertemporal elasticity  $\psi > 1$ . The converse happens when  $\psi < 1$ .

*Proof.* We sketch the intuition here, and provide the details in Appendix B.  $\square$

The key intuition for part (1) of Proposition 1 can be seen in the firm's optimality conditions, which equate the marginal costs of each investment – simply one for capital and equal to the vacancy cost needed to hire 1 unit of  $N$  ( $\frac{\varphi}{p_0} = \varphi N^{\frac{1-\varepsilon}{\varepsilon}}$ ) for labor – with the expected present discounted value of the stream of their respective marginal products:

$$1 = \left[ 1 + \frac{1}{R_f} + \beta \text{Cov}(M_{0,1}, Z_1) \right] \alpha \left( \frac{K}{N} \right)^{\alpha-1} \quad (14)$$

$$\varphi N^{\frac{1-\varepsilon}{\varepsilon}} = \left[ 1 + \frac{1}{R_f} + \beta \text{Cov}(M_{0,1}, Z_1) \right] \left( (1-\alpha) \left( \frac{K}{N} \right)^{\alpha} - W^{avg} \right), \quad (15)$$

Since the firm owns the capital, the present discounted value of capital returns is simply  $\alpha \left( \frac{K}{N} \right)^{\alpha-1} + E_0(M_{0,1} \alpha Z_1 \left( \frac{K}{N} \right)^{\alpha-1})$  which equals the right hand side of equation (14) above. In terms of labor, the firm also needs to net out wage payments. Utilizing the previously defined average level of wages  $W^{avg}$ , we can rewrite the optimality condition in a way parallel to that of capital, and obtain equation (15).

Combining these two optimality conditions we can conclude that the ratios of the expected cumulative payoffs to the equilibrium cost of an installed unit of capital and a unit of labor are equal to one another:

$$\alpha \left( \frac{K}{N} \right)^{\alpha-1} = \frac{(1-\alpha) \left( \frac{K}{N} \right)^{\alpha} - W^{avg}}{\varphi N^{\frac{1-\varepsilon}{\varepsilon}}} \quad (16)$$

Thus, investment in both factors of production is subject to the same equilibrium required return and risk premium. Therefore a change in risk aversion will have the same impact on both, and hence variation in risk aversion could increase or decrease overall desired savings, but not the relative attractiveness between the two investment vehicles.

The specific impact of risk aversion on overall savings depends on the value of  $\psi$ , the intertemporal elasticity of substitution. To see this, first observe that the term  $\left[ \frac{1}{R_f} + \beta \text{Cov}(M_{0,1}, Z_1) \right]$ , which appears in both (14) and (15), can be expressed as

$$\frac{1}{R_f} + \beta \text{Cov}(M_{0,1}, Z_1) = \beta \left( \frac{K^{\alpha} N^{1-\alpha}}{C_0} \right)^{-\frac{1}{\psi}} \exp \left\{ \gamma \left( \frac{1}{\psi} - 1 \right) \frac{\sigma_z^2}{2} \right\}, \quad (17)$$

using (12). Combining (17) with the optimality conditions (14) and (15), it is clear that when  $\psi = 1$  changes in risk tolerance have no impact on total savings (or allocations). When  $\psi$  is greater than one, however, an increase in risk aversion lowers the present discounted value of risky future cashflows, which leads investment in both capital and labor to fall. Intuitively, when the intertemporal elasticity is high, the household is primarily worried that the available saving vehicles are risky, overpowering the countervailing precautionary savings motive due to the lower certainty equivalent of future consumption, and thus investment (in both durable factors) falls.

Finally, to understand the implication of risk aversion changes for comovement, it is helpful to observe that since both capital and labor investments have positive net present value, they must also have positive resource costs at the margin today. Meaning that while the lower desire to save decreases output today (as both  $K$  and  $N$  fall), this actually increases the resources available for current consumption and  $C_0$  rises. This argument establishes the impossibility of comovement in part (2) of Proposition 1.<sup>12</sup>

Proposition 2 shows that these results change when the wage is fixed. The key intuition is that a rigid wage makes labor a more risky investment option relative to capital. Consequently, an increase in risk aversion leads to a *reallocation* of savings from labor to capital. It is a story of flight-to-safety, and does not depend on whether overall desired savings go up or down. Thus, to isolate our reallocation mechanism we state the theorem for the case of  $\psi = 1$ , which shuts down the standard intertemporal forces and fluctuations in overall desired savings.

**Proposition 2.** *Given  $\psi = 1$  and wages  $W_0 = W_1 = W$  fixed within the bargaining set:*

1. *The risk premium on labor is higher than the risk premium on capital.*
2. *An increase in risk aversion leads both  $K$  and  $N$  to fall, but  $N$  falls by more.*
3. *There is a threshold  $\bar{\gamma}$ , such that if  $\gamma > \bar{\gamma}$  then all of  $(C_0, K, N)$  fall with  $\gamma$ .*

*Proof.* Proved in the Appendix. □

To understand parts (1) and (2) of Proposition 2, notice that the capital optimality condition remains the same as in eq. (14), but the vacancy posting condition becomes:

$$\varphi N^{\frac{1-\varepsilon}{\varepsilon}} = \left( (1-\alpha) \left( \frac{K}{N} \right)^\alpha - W \right) \left[ 1 + \frac{1}{R_f} \right] + (1-\alpha) \left( \frac{K}{N} \right)^\alpha \beta Cov(M_{0,1}, Z_1). \quad (18)$$

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<sup>12</sup>Notice from (17) that  $\gamma$ ,  $\beta$ , and  $\sigma_z^2$  all move discounting in the same way, and thus shocks to any of these parameters would generate exactly the same comovement patterns.

The key difference relative to (15) is that the covariance term  $\beta Cov(M_{0,1}, Z_1)$  on the right hand side now multiplies the full marginal product of labor,  $(1 - \alpha) \left(\frac{K}{N}\right)^\alpha$ , and not just the marginal product net of wages. This means that the risk-premium channel on vacancies is amplified. Intuitively, whereas the Nash-bargained wage rises and falls with  $Z_1$ , and thus partially insulates the firm from productivity changes, the rigid wage we study here leaves the firm fully exposed to  $Z_1$  fluctuations. As a result, the risk-premium on vacancy postings is both higher on average and is also more sensitive to changes in  $\gamma$ .

This higher sensitivity to risk on the part of labor generates a flight-to-safety effect. An increase in risk aversion leads to a reallocation of investment from vacancies to capital, as the risk premium on labor rises by more than that of capital. In equilibrium, this fall in labor demand leads to a fall in capital demand as well, because lower  $N$  also lowers the marginal product of capital (i.e., it affects the first moment of the return on capital). Thus, the reallocation desire leads to  $N$  and  $K$  to both fall in equilibrium.

Finally, notice that (18) implies there is a wedge in the equilibrium returns to capital and labor, as naturally the riskier labor investment must offer a higher average payoff relative to its cost of investment, that is

$$\alpha \left(\frac{K}{N}\right)^{\alpha-1} < \frac{(1 - \alpha) \left(\frac{K}{N}\right)^\alpha - W}{\varphi N^{\frac{1-\varepsilon}{\varepsilon}}}. \quad (19)$$

Effectively, this means that in this economy the marginal product of labor is higher than that of capital, and thus a reallocation of a unit of investment from vacancies to capital decreases output even without changing the overall level of investment. As described above, however, in equilibrium both  $N$  and  $K$  also fall, so there is also a fall in overall savings which could free up some resources for current consumption as in Proposition 1. The key to part (3) of Proposition 2 is then that if the wedge in the returns on capital and labor in equation (19) is sufficiently big, then the fall in output due to the flight-to-safety reallocation effect can dominate, ensuring that in equilibrium  $C_0$  falls. The proof of Proposition 2 shows that this wedge in the returns to capital and labor is increasing in  $\gamma$ , and thus when  $\gamma$  is large enough all macro aggregates fall together.

## 4 Quantifying the Mechanism

We quantify the potential importance of our novel mechanism by estimating an extended version of the model via an impulse-response matching exercise, where we match the model-implied response to a risk-aversion shock,  $\gamma_t$ , to the empirical impulse responses to

the “risk premium” shock we identified in Section 2. We use a direct shock to the risk aversion coefficient in order to conservatively gauge whether our propagation mechanism, by itself and without any fundamental changes in the economy, can account for our empirical finding. In our estimation, we also further discipline the model by matching a number of unconditional moments in the data, in addition to the impulse responses.

## 4.1 Extended Model

The model consists of a representative household and a representative firm. The household consumes, supplies labor inelastically, and invests in firm equity, and in corporate and government debt instruments. The firm produces final goods and invests in capital and in two types of labor (via labor search markets) in order to maximize shareholder value.

### Households

The economy is populated by a representative household with a continuum of members of unit measure. In period  $t$ , the household chooses aggregate consumption ( $C_t$ ), government bond holdings ( $B_{t+1}$ ), corporate bond holdings ( $B_{t+1}^c$ ), and holdings of equity shares in the firms ( $X_{t+1}$ ), to maximize lifetime utility. Preferences are given, as in Section 3, by:

$$V_t = \max \left[ (1 - \beta) C_t^{1-1/\psi} + \beta (\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1-1/\psi}{1-\gamma_t}} \right]^{\frac{1}{1-1/\psi}}, \quad (20)$$

subject to the budget constraint, denoted in terms of the consumption numeraire,

$$C_t + P_t^e X_{t+1} + Q_t^c (B_{t+1}^c - dB_t^c) + \frac{1}{R_t^r} B_{t+1} \leq (D_t^e + P_t^e) X_t + B_t^c + B_t + E_t^l + T_t.$$

In the above,  $Q_t^c$  is price of a multi-period corporate bond,  $R_t^r$  is the one-period safe real interest rate,  $P_t^e$  is the price of a share of the representative firms that pays a real dividend  $D_t^e$ , and  $E_t^l$  is the household’s total labor earnings (detailed below).  $T_t$  denotes lump-sum transfers. We model corporate bonds following [Gourio \(2012\)](#), and assume they repay a constant fraction  $1 - d$  of the principal each period. These bonds are only needed to create an empirically relevant amount of financial leverage in firms, since we will eventually match the average equity risk premium in the data. The government bonds are in zero net supply, and only serve to define the safe real rate.

The Epstein-Zin preferences in equation (20) imply the following stochastic discount



factor between  $t$  and  $t + 1$ :

$$M_{t,t+1} \equiv \left( \frac{\partial V_t / \partial C_{t+1}}{\partial V_t / \partial C_t} \right) = \beta \left( \frac{C_{t+1}}{C_t} \right)^{1-1/\psi} \left( \frac{C_t}{C_{t+1}} \right) \left( \frac{V_{t+1}}{(\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1}{1-\gamma_t}}} \right)^{1/\psi-\gamma_t}. \quad (21)$$

In parallel with the analytical model, our main shock of interest is an exogenous change to risk aversion, hence  $\gamma_t$  is allowed to vary over time.

Households supply labor inelastically, but labor markets are subject to search and matching frictions in the spirit of [Mortensen and Pissarides \(1994\)](#). We fix labor supply in order to focus on the labor demand mechanism that is at the heart of our mechanism.

There are two types of labor positions households can match to. Full-time positions involves longer-term relationships and sticky wages,  $W_{1,t}$ , while part-time labor involves shorter employment spells and flexible wages,  $W_{2,t}$ . Both of these features – the difference in duration and wage rigidity – is consistent with micro data as we discuss below.

We normalize the total mass of workers to 1 and denote with  $N_{1,t}$  and  $N_{2,t}$  the masses of labor currently working under the full-time and part-time contracts, respectively. The mass of unemployed workers in period  $t$  is therefore  $U_t = 1 - N_{1,t} - N_{2,t}$ . While employment status may vary across workers, their consumption is equalized because the household provides perfect consumption insurance for its members.

Workers search sequentially. Specifically, every worker seeking a job in period  $t$  first tries to find a full-time job. If the search is unsuccessful, the worker searches for a part-time job within the same period.<sup>13</sup> A job-seeker who is unsuccessful in both searches will be unemployed in period  $t$ . In addition, at the end of a period, workers experience exogenous separation from full-time and part-time positions with probabilities  $\rho_1$  and  $\rho_2$ , respectively. The mass of searchers for the two types of contracts are then given by:

$$S_{1,t} = U_{t-1} + \rho_1 N_{1,t-1} + \rho_2 N_{2,t-1} \quad (22)$$

$$S_{2,t} = S_{1,t} - N_{1,t} + (1 - \rho_1) N_{1,t-1}. \quad (23)$$

Equation (22) states that the mass of searchers for full-time jobs in period  $t$ ,  $S_{1,t}$ , is given by the workers who were unemployed in period  $t - 1$ ,  $U_{t-1} = 1 - N_{1,t-1} - N_{2,t-1}$ , plus the full-time and part-time workers that separated from firms at the end of period  $t - 1$ ,  $\rho_1 N_{1,t-1} + \rho_2 N_{2,t-1}$ . The mass of searchers for part-time jobs in period  $t$ ,  $S_{2,t}$ , is

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<sup>13</sup>This behavior is optimal if the expected value of searching sequentially in the full-time and part-time sector exceeds the value of searching only in the part-time sector. We verify this condition *ex post*. Appendix C.5 provides full details on this procedure.

simply  $S_{1,t}$  minus the job-seekers that find full-time job in period  $t$ ,  $N_{1,t} - (1 - \rho_1)N_{1,t-1}$ .

Having distinct full-time and part-time positions creates some subtle issues regarding how workers are compensated in case they are unemployed or “under-employed.” Unemployed workers, those who find no employment in either sector, receive a benefit  $b_{2,t}$  that corresponds to monetary unemployment benefits as well any other time-use benefits they might accrue from not working. In addition, a worker employed in the part-time sector receives not just a wage, but also a flow  $\kappa_t$  that corresponds to the benefits (e.g., of home production) from the additional time made available by part-time work. Both  $b_{2,t}$  and  $\kappa_t$  are time-varying because they are cointegrated with the stochastic trend in our economy (to ensure a balanced growth path), but they are not subject to any shocks themselves.

Thus, aggregate household earnings each period are given by:

$$E_t^l = W_{1,t}N_{1,t} + (W_{2,t} + \kappa_t)N_{2,t} + b_{2,t}(1 - N_{1,t} - N_{2,t}). \quad (24)$$

## Firms

The representative firm has cash flows,

$$D_t = Y_t - W_{1,t}N_{1,t} - W_{2,t}N_{2,t} - I_t - \varphi_{1,t}v_{1,t} - \varphi_{2,t}v_{2,t}. \quad (25)$$

It maximizes profits by choosing employment for the two types of contracts,  $N_{1,t}$  and  $N_{2,t}$ , vacancies,  $v_{1,t}$  and  $v_{2,t}$ , capital,  $K_{t+1}$ , and investment,  $I_t$ . The variables  $W_{i,t}$  and  $\varphi_{i,t}$  denote the real wage and the vacancy posting cost for the labor contract of type  $i \in \{1, 2\}$ , all of which the firm takes as given.

The firm discounts cash flows using the stochastic discount factor of the household. Its objective is to maximize

$$\mathbb{E}_t \sum_{s=0}^{\infty} M_{t,t+s} D_{t+s}, \quad (26)$$

subject to a production function with labor-augmenting technology  $Z_t$

$$Y_t \leq K_t^\alpha (Z_t N_t)^{1-\alpha}, \quad (27)$$

a CES labor aggregator that combines the inputs of the full-time and part-time workers,

$$N_t = \left( (1 - \Omega) N_{1,t}^{\frac{\theta-1}{\theta}} + \Omega N_{2,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad (28)$$

a capital accumulation equation with quadratic capital adjustment costs,

$$K_{t+1} = \left(1 - \delta - \frac{\phi_K}{2} \left(\frac{I_t}{K_t} - \delta\right)^2\right) K_t + I_t, \quad (29)$$

and the laws of motion for employment as perceived by the firm,

$$N_{1,t} = (1 - \rho_1)N_{1,t-1} + \Theta_{1,t}v_{1,t}, \quad (30)$$

$$N_{2,t} = (1 - \rho_2)N_{2,t-1} + \Theta_{2,t}v_{2,t}, \quad (31)$$

where  $\Theta_{i,t}$  is the probability of filling a type- $i$  vacancy.

Equations (27), (28), and (30)-(31) imply that workers engage in production as soon as they are hired. Following [Christiano et al. \(2016\)](#), we adopt this timing assumption because the time period in our model is one quarter and it would be implausible to assume a whole quarter's delay between a worker-firm match and the start of employment.

We assume that the representative firm can raise capital by issuing equity shares and debt. Specifically, we follow [Jermann \(1998\)](#) by assuming the representative firm finances a percentage of its physical capital stock each period through debt. As in [Gourio \(2012\)](#), this financing occurs with multi-period riskless bonds. Firm debt evolves according to

$$B_{t+1}^c = dB_t^c + L_t, \quad (32)$$

where the parameter  $d \in [0, 1)$  is the portion of outstanding debt that does not mature in the current period, and hence determines the effective duration of a bond as  $\frac{1}{1-d}$  quarters. The net amount of new borrowing each period,  $Q_t^c L_t = \xi K_{t+1}$ , is proportional to the quantity of capital owned by the firm. Under these assumptions, the steady-state leverage ratio of the firm is given by  $B^c/K \equiv \nu = \xi/(1-d)$ . This is a parameter we will estimate. The price of the multi-period bond ( $Q_t^c$ ) is determined by the pricing equation

$$Q_t^c = \mathbb{E}_t [M_{t,t+1}(dQ_{t+1}^c + 1)]. \quad (33)$$

Total firm cash flows are divided between payments to bond holders and equity holders as follows:

$$D_t^E = D_t - B_t^c + \xi K_{t+1}. \quad (34)$$

Since in our model there are no distortionary taxes, agency costs, or asymmetric information, the [Modigliani and Miller \(1958\)](#) theorem holds: financial policies such as

leverage decisions do not affect firm value or optimal firm decisions. Leverage does, however, affect the volatility of cash flows to shareholders and, therefore, the price of equity and its risk premium. The introduction of leverage allows us to map equity returns from the model to the data, where firms carry significant financial leverage.

### Wage-setting

We make a set of assumptions about wage determination that simplify our equilibrium computations and serve as a realistic baseline for examining the quantitative importance of our mechanism.

First, we assume that wages for the full-time sector are sticky, and equal each period to their previous value plus an adjustment for the change in the level of productivity. The initial value of the wage is the Nash-bargained wage that would emerge in a non-stochastic steady-state with  $Z = 1$ :

$$W_1 = \eta_1 \left[ (1 - \Omega)(1 - \alpha) \left( \frac{K}{N} \right)^\alpha \left( \frac{N}{N_1} \right)^{\frac{1}{\theta}} + \varphi_1 \theta_1 \right] + (1 - \eta_1) b_1, \quad (35)$$

where  $\eta_1 \in [0, 1]$  and  $\theta_1 = \frac{v_1}{S_1}$  denote the worker's bargaining power and the steady-state labor market tightness in the full-time sector, while  $b_1$  is the value of the worker's outside option when negotiating for a wage.

Given the sequential nature of the search in the two sectors, the steady-state outside option for the full-time sector is

$$b_1 \equiv P_2^m (W_2 + \kappa) + (1 - P_2^m) b_2, \quad (36)$$

A worker who declines a full-time job finds a part-time job with probability  $P_2^m$ , earns a steady-state wage  $W_2$ , and enjoys  $\kappa$  units of additional home production made possible by part-time work. With probability  $(1 - P_2^m)$ , the worker becomes unemployed and earns formal unemployment benefits plus home production with a total value of  $b_2$ .

Wages in the part-time sector are flexible, and equal to the Nash wage that would emerge in every period in this sector:

$$W_{2,t} = \eta_2 \left[ \Omega(1 - \alpha) Z_t \left( \frac{K_t}{Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} + \varphi_{2,t} \theta_{2,t} \right] + (1 - \eta_2) b_{2,t}. \quad (37)$$

where  $\eta_2 \in [0, 1]$  and  $\theta_{2,t}$  denote the workers' bargaining power and the labor market

tightness in the part-time sector.

This wage-setting setup is flexible and also conforms with the micro data, where the part-time positions indeed display more flexible wages than full-time positions, as documented by [Lariau \(2017\)](#). Moreover, the same paper as well as [Borowczyk-Martins and Lalé \(2021\)](#) also document that part-time positions have separation rates that are eight times higher than full-time positions. We will therefore calibrate  $\rho_2 > \rho_1$ .

## Government

The government finances a stream of expenditures, which are exogenous but slowly adjust to the trend growth of the economy. The initial value of the government expenditure in a non-stochastic steady-state with  $Z = 1$  is

$$G = \bar{g}Y. \quad (38)$$

Government expenditures and the pecuniary component of unemployment benefits are financed using lump-sum taxes. As a result, government bonds are always in zero-net supply:  $B_t = 0$ , for all  $t$ .

## Market Clearing

At the aggregate level, the labor workforce at time  $t$  in the two sectors is:

$$N_{1,t} = (1 - \rho_1)N_{1,t-1} + \mathcal{M}_{1,t}, \quad (39)$$

$$N_{2,t} = (1 - \rho_2)N_{2,t-1} + \mathcal{M}_{2,t}, \quad (40)$$

where  $\mathcal{M}_{1,t}$  and  $\mathcal{M}_{2,t}$  are the matches from the Cobb-Douglas matching functions of the full-time and part-time sectors, respectively. These matching functions take the form:

$$\mathcal{M}_{i,t} = \chi_i v_i^{\epsilon_i} S_i^{1-\epsilon_i}, \quad (41)$$

for  $i \in \{1, 2\}$ . The corresponding job-finding and vacancy-filling probabilities as a function of the labor markets tightness  $\theta_{i,t} = \frac{v_{i,t}}{S_{i,t}}$  are respectively:  $P_{i,t}^m = \chi_i \theta_{i,t}^{\epsilon_i}$  and  $\Theta_{i,t} = \chi_i \theta_{i,t}^{\epsilon_i-1}$ .

Finally, the aggregate resource constraint in the economy is given by

$$Y_t = C_t + I_t + \varphi_{1,t}v_{1,t} + \varphi_{2,t}v_{2,t} + G_t. \quad (42)$$

In order to ensure our model satisfies the national accounting identity, we follow [den Haan](#)

and Kaltenbrunner (2009) by including job posting costs in defining our model analogue to measured investment, i.e.,  $\tilde{I}_t \equiv I_t + \varphi_{1,t}v_{1,t} + \varphi_{2,t}v_{2,t}$ .

## Exogenous Processes

The economy is perturbed by two exogenous disturbances. The first is technology,  $Z_t$ , which we assume follows a random walk, as is the case for utilization-adjusted US TFP data of Fernald (2014):

$$\ln(Z_t) = \ln(Z_{t-1}) + \sigma_z \epsilon_t^z \quad (43)$$

The second is risk aversion,  $\gamma_t$ , with dynamics governed by an AR(1) process in logs:

$$\log(\gamma_t/\gamma_{ss}) = \rho_\gamma \log(\gamma_{t-1}/\gamma_{ss}) + \sigma_\gamma \epsilon_t^\gamma. \quad (44)$$

Because our economy has a unit root in productivity, we impose additional assumptions to ensure that the model has a balanced growth path. In particular, we assume that the cost of vacancy posting, the workers' outside options, the sticky full-time wage, and government expenditure are all cointegrated with technology, with a common error-correction rate of  $\omega$ . Specifically, for each variable  $X \in \{\varphi_{1,t}, \varphi_{2,t}, b_{1,t}, b_{2,t}, W_{1,t}, G_t\}$ , we assume that  $X_t = \Gamma_t \bar{X}$  where  $\bar{X}$  is the deterministic steady-state value, and

$$\Gamma_{t+1} = \Gamma_t^\omega Z_t^{1-\omega}. \quad (45)$$

When the parameter  $\omega \in [0, 1)$  is close to one, which turns out to be the case in our estimation, the variables “catch-up” with the (non-stationary) changes in productivity slowly, but are nevertheless cointegrated with productivity.

In particular, the process for the full-time wage is given by

$$W_{1,t} = \left( \frac{Z_{t-1}}{\Gamma_{t-1}} \right)^{1-\omega} W_{1,t-1}. \quad (46)$$

Thus, the full-time wage is sticky in the sense it only partially adjusts for the change in productivity, to the extent to which  $\omega > 0$ . If  $\omega = 1$ , then the wage is perfectly rigid at its steady state value, and if  $\omega = 0$ , it adjusts immediately to changes in productivity.

We solve the model using a third-order perturbation, and compute impulse responses by comparing the path of the economy over an extended period in which the realizations of all shocks are identically zero to the counterfactual path in which a single one-standard deviation shock to  $\gamma_t$  is realized. We preset the details of the model's solution and the

Table 2: Calibrated Parameters

Name	Description	Value
$\beta$	Discount rate	0.994
$\phi_k$	Capital Adj. Cost	10.000
$\psi$	Intertemporal elasticity of substitution	2.500
$\alpha$	Capital share	0.300
$\delta$	Capital depreciation rate	0.025
$\bar{g}$	Steady-state G/Y	0.200
$d$	Corporate bond duration	0.975
<b>Labor Markets</b>		
$\rho_1$	Separation Rate - FT	0.042
$\rho_2$	Separation Rate - PT	0.335
$\eta_1$	HH's bargaining power - FT	0.500
$\eta_2$	HH's bargaining power - PT	0.500
<b>Exogenous Processes</b>		
$\sigma_z$	Std. dev. of tech shock	0.008

resulting set of conditions that describe the equilibrium in Appendix C.

## 4.2 Calibrated Parameters and Steady-State Targets

To begin, we calibrate a set of standard parameters to values that are consistent with the literature and summarized in Table 2. We set  $\beta = 0.994$  as in Basu and Bundick (2017). We fix the depreciation rate to  $\delta = 0.025$  and the capital share parameter to  $\alpha = 0.3$ . Because the estimated model includes risk, this will imply an unconditional capital income share that is slightly less than 0.3. We fix the long-run share of share government expenditures to GDP to 20% and the bond duration parameter  $d = 0.975$  as in Gourio (2012), which implies corporate debt has a 10-year maturity.

Estimates of capital adjustment costs vary considerably in the literature, and range from values around 2 in macro contexts (e.g., Basu and Bundick, 2017) to values of 18 or higher in micro studies (e.g., Galeotti and Schiantarelli, 1991). We set our adjustment cost parameter  $\phi_K = 10$  in the middle of this range and in line with the value obtained by the recent paper Belo et al. (2022) which estimates neoclassical investment models on a rich dataset of market value data of U.S. publicly-traded firms.

We set the elasticity of intertemporal substitution to  $\psi = 2.5$ , which is in line with the typical macro-finance practice of picking IES higher than one (Schorfheide et al., 2018). This value is relatively high compared to the macro literature that focuses on quantities

only, but overall the quantitative fit of the model does not rely on any particular restriction on  $\psi$ , and works just as well for  $\psi < 1$ . To illustrate this, in Appendix F we reestimate the model assuming  $\psi = 0.5$ , and find that the overall difference in fit with our benchmark is very small. Mainly, with  $\psi = 0.5$ , the model overshoots the empirical response of safe interest rates somewhat more than does our baseline estimation, but otherwise the model delivers just as good of a fit in all other directions, including on comovement.

In terms of labor markets, the key calibrated parameters are the separation rates,  $\rho_1$  and  $\rho_2$ . We pick these values to satisfy two features of the data. First, we fix  $\rho_2/\rho_1 = 8$ , matching recent estimates of the relative difference in separation rates of part-timers to full-timers from the longitudinal dimension of the U.S. Current Population Survey (CPS) (Lariau, 2017; Borowczyk-Martins and Lalé, 2021). Second, we fix the level of separations in the full-time sector ( $\rho_1$ ) so that the average separation rate across both labor sectors equals the aggregate quarterly rate in the US economy of 10% (Yashiv, 2008). We also fix the Nash bargaining parameters to  $\eta_1 = \eta_2 = 0.5$ , but have found that alternative choices for these parameters make very little difference.

Finally, we use the Basu et al. (2006) utilization adjustments to U.S. TFP, as implemented in quarterly data by Fernald (2014), to calibrate the process for productivity. Over our sample period, productivity is an almost perfect random walk with standard deviation in growth rates of  $\sigma_z = 0.008$ .

The remaining parameters are estimated by matching the impulse responses to a risk-aversion shock to the empirical responses from Section 2.1 along with the eight additional unconditional moments reported in Table 3. Our approach is to place extremely high weight on the unconditional moment targets in the estimation procedure to force the model to match these moments perfectly, and then see how the model does in terms of conditional dynamics.

Among these unconditional moments, the average equity premium, the share of part-time workers, and the average unemployment rate are directly observed in the data, and we match their average values over our sample period. The targeted average vacancy rate of 3.5% comes from the full-sample average of the JOLTS dataset (which starts in 2000). In line with Blanchard and Galí (2010), we target a ratio of hiring costs to GDP is 1%.

We also target the standard deviations of (HP-filtered) employment and vacancies (using the series created by Barnichon, 2010), in order to ensure that the model delivers a Beveridge curve in line with the data. We also note that, since it successfully matches both of these moments, our model is not subject to the Shimer critique. As we explain below, this is due to a novel channel – the fluctuating risk aversion generates movements



Table 3: Unconditional Target Moments

Description	Value
Equity risk premium	0.054
Share of part-time	0.198
LR unemployment	0.059
Vacancy Rate	0.035
Hiring cost/GDP	0.010
PT earn./FT earn.	0.375
Std. HP log(Emp/Pop)	0.013
Std. HP log(vacan.)	0.138

in employment that are not driven by productivity shocks.

Finally, we target a ratio of part-time to full-time earnings of 0.375. We arrive at this ratio by assuming that part-time workers work one-half the number of hours of full-time workers (in line with CPS averages), and earn an hourly wage that is 25% lower than similar full-time workers ( $0.375 = 0.5 \times 0.75$ ), in line with studies on this wage penalty (Aaronson and French (2004), Bick et al. (2022)).<sup>14</sup> In any case, we have found that our results change very little even if we make substantially different assumptions about the part-time wage penalty.

### 4.3 Estimation Procedure

Aside from the additional long-run target moments in Table 3, our impulse response matching exercise is standard. The estimation targets are the impulse responses of output, consumption, investment, total employment, part-time employment, equity returns, and the real interest rate. The set of estimated parameters, denoted by  $\Pi$ , includes the steady-state risk aversion parameter  $\gamma$ , the aggregate leverage ratio  $\nu$ , the vacancy posting costs,  $\varphi_1$  and  $\varphi_2$ , the value of outside options  $b_1$  and  $b_2$ , the production share of part-time labor  $\Omega$ , the elasticity of substitution between the two types of labor  $\theta$ , the four parameters governing the aggregate matching technologies, the cointegration parameter  $\omega$ , and the parameters of the risk aversion shock,  $\rho_\gamma$  and  $\sigma_\gamma$ .

Let  $\hat{\Psi}$  denote the column vector stacking the point estimates of each impulse response variable across all horizons along with our unconditional target moments, and let  $\Psi(\Pi)$  denote the corresponding theoretical responses and model-implied unconditional moments.

<sup>14</sup>See also: <https://www.epi.org/publication/part-time-pay-penalty>.

Table 4: Estimated Parameters

Name	Description	Point Est.	Std Err.
$\gamma_{ss}$	Steady-state risk aversion	42.263	8.064
$\nu$	Leverage Ratio	0.792	0.019
<b>Labor Markets</b>			
$\varphi_1$	Vacancy posting cost - FT	1.087	0.139
$\varphi_2$	Vacancy posting cost - PT	0.058	0.022
$b_1$	Value if no perm posit.	1.088	0.030
$b_2$	Value if unemployed	0.497	0.010
$\Omega$	Labor contrib. of PT	0.199	0.010
$\theta$	Elas. between FT & PT	3.547	0.542
$\epsilon_1$	Matching elasticity - FT	0.492	0.032
$\epsilon_2$	Matching elasticity - PT	0.975	0.034
$\chi_1$	Matching technology - FT	0.646	0.039
$\chi_2$	Matching technology - PT	2.661	0.243
$\omega$	Gradual wage adj.	0.966	0.007
<b>Risk Aversion Process</b>			
$\rho_\gamma$	AR(1) risk av. shock	0.935	0.023
$\sigma_\gamma$	Std. dev. of risk av. shock	0.465	0.096

*Note:* Standard errors computed via bootstrap, by reestimating model parameters targeting N=100 different (bias-corrected) impulse responses drawn from the VAR bootstrap procedure.

The objective function of our estimation is then given by

$$\mathcal{L}(\Pi) \equiv (\hat{\Psi} - \Psi(\Pi))'W(\hat{\Psi} - \Psi(\Pi)). \quad (47)$$

The matrix  $W$  is a diagonal weighting matrix consisting of the inverse of the bootstrapped variances of each impulse response in  $\hat{\Psi}$ , plus very large weights for our unconditional target moments. Given the extreme weights on our 8 unconditional targets, we are essentially targeting  $7 \times 30 = 210$  impulse response moments with just 7 degrees of freedom.

## 4.4 Estimation Results and Model Fit

The estimation procedure finds a global interior optimum, and in Table 4 we report the estimated parameters  $\hat{\Pi}$  along with their corresponding standard errors.

Our estimate of  $\gamma \approx 42$  is similar to or lower than the values used by other quantitative papers focused on matching risk premia facts in business cycle models (e.g., Piazzesi and Schneider, 2006; Rudebusch and Swanson, 2012; Basu and Bundick, 2017; Caggiano et al., 2021). That this estimate remains “high” relative to microeconomic estimates of risk

Table 5: Unconditional and Asset Pricing Moments

Moment	Model	Data	Moment	Model	Data
Std( $Y$ )	1.53	1.49	$E[r_t^b]$	1.84	1.53
Std( $C$ )	1.12	0.82	Std( $r_t^b$ )	1.20	2.54
Std( $I$ )	3.25	3.18	$E[rp_{t,t+1}^1]$	5.37	5.40
Std( $N$ )	1.33	1.31	Std( $rp_{t,t+1}^1$ )	28.24	33.41
Std( $N_1/N$ )	2.30	2.21	Ann. Sharpe Ratio	0.37	0.33

*Note:* Unconditional model moments based on a single simulation of 5000 periods. Data moments based on data from our empirical sample period. All real variables are logged and then HP-filtered with a penalty parameter  $\lambda = 1600$ . Asset pricing moments are annualized percentages and are not filtered. Standard deviations are in percent. Sharpe ratio is for annualized equity returns.

aversion is a manifestation of the well-known “equity premium” puzzle. One can increase the effective quantity of risk in the model by introducing habit formation (Campbell and Cochrane, 1999), augmenting the shock process with either long-run risk (Bansal and Yaron, 2004) or rare disasters (Barro, 2006), or introducing parameter or model uncertainty (Weitzman, 2007; Barillas et al., 2009). The macro finance literature has not yet converged on a consensus explanation, and most papers that do not focus on explaining the deep reasons for the large risk premium, but want to match it quantitatively, simply rely on a high risk aversion coefficient. We do so too, in order to put the focus on our novel mechanism, rather than on the particular way we generate high average risk premia.

Moving to the main results, Figure 6 shows that the impulse responses implied by the estimated model (blue-dot lines) match the data quite well, and in particular generate the key aggregate comovement patterns that traditionally define the business cycle. On the macroeconomic side, the changes in output, consumption and employment track the data quite closely. Investment and output undershoot modestly, but the model-implied responses are substantial and remain for the most part within the standard error bands of the data.

The estimated model also captures two central conditional features of asset prices. First, the model closely matches the persistent increase in the 5-year equity risk premium. Second, it matches the steep fall in stock returns on impact and the subsequent long period of above-average returns. Thus, the model generates variation in asset prices primarily due to changes in expected excess returns, and not changes in cash-flows, as in the data.<sup>15</sup>

To further assess the external validity of our estimated model, we ask how well it reproduces key unconditional macroeconomic and asset pricing moments in the data that

<sup>15</sup>Moreover, Figure D.1 in Appendix D reports the IRF of the safe-discounted value of profits for the model and data together, and shows the model matches the very small effect on profits found in the data.

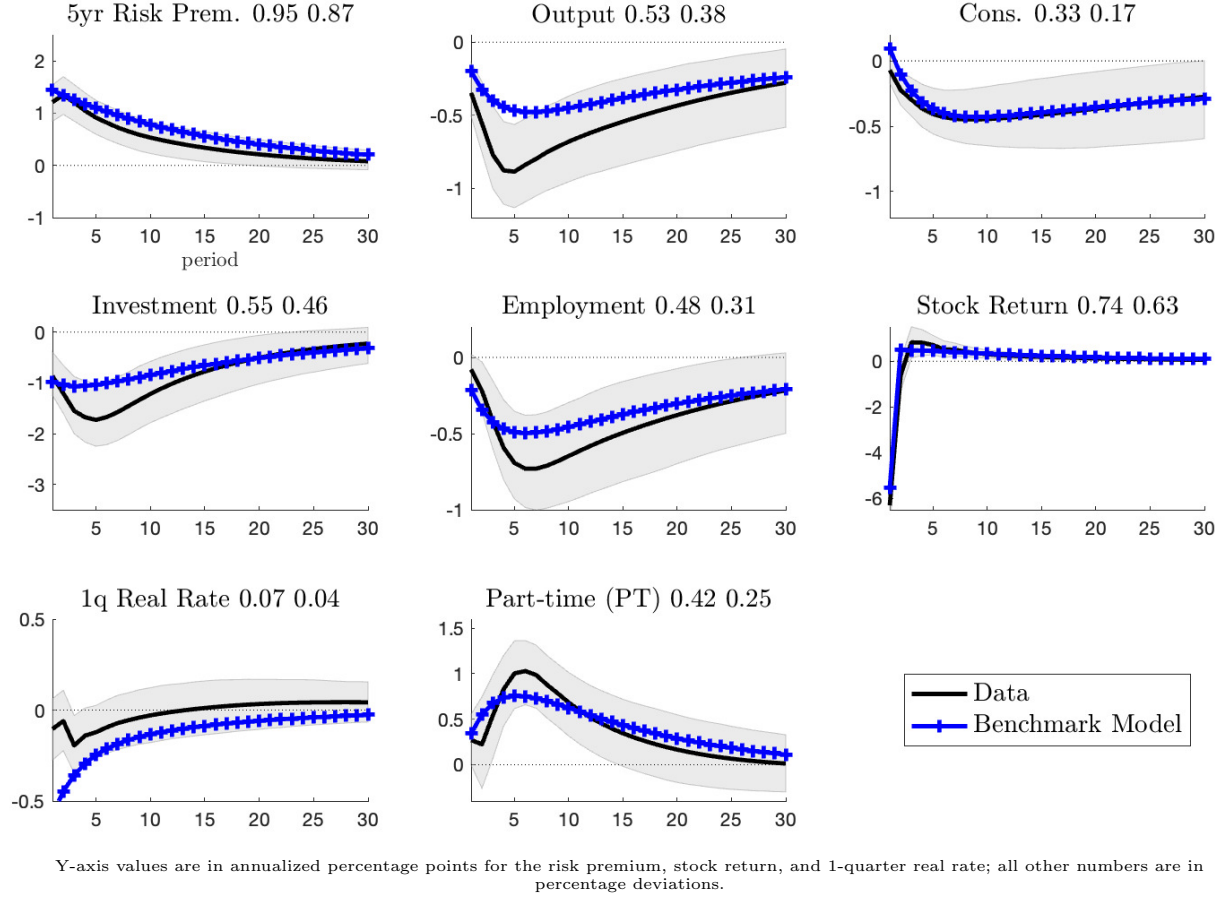


Figure 6: Impulse responses to VAR-identified risk premium shock along with model-implied responses.

were not directly targeted by our estimation procedure. The left panel of Table 5 shows that our model matches the unconditional volatility of output, investment, employment and the part-time employment share. The model slightly over-predicts the volatility of consumption but correctly predicts that consumption is less volatile than output.

The right panel of the table shows that the models also succeeds in replicating several untargeted unconditional asset pricing moments. Our model predicts an unconditionally low and stable risk-free rate in line with the data. Besides reproducing the unconditional levels of risk premia that we targeted in estimation, our model also implies realistic unconditional variability of excess returns, which was not targeted. Indeed, the model's unconditional standard deviation of the (annualized) 1-quarter risk premium of 28.41% is quite close to the empirical counterpart of 33.41%. Moreover, the annualized Sharpe (1994) ratio, calculated using quarterly returns as  $SR = \frac{E[\log(R_{t+1}^E/R_t^b)]}{std[\log(R_{t+1}^E/R_t^b)]}$ , implied by our model is 0.37, which is quite close to the empirical value of 0.33 in our sample.

Overall, the model captures both the conditional business cycle comovements and the counter-cyclical risk premium that we found in the data, while being consistent with many untargeted unconditional macroeconomic and asset pricing moments.

## 4.5 The Flight-to-Safety Channel in the Quantitative Model

Our analytical results in Section 3 suggest that reallocations across savings vehicles with different riskiness and different average returns are central for achieving macroeconomic comovement, and our quantitative model features two potential types of reallocations. The first, between labor as a whole and capital, mirrors the mechanism of the simple model in Section 3. The second potential reallocation concerns shift in hiring between the two labor types. In this section, we explore the quantitative importance of these two reallocation channels in our estimated model.

### Disaggregated Risk Premia

What are the quantitative differences in average risk premia in our model? To measure this, we need to define premia for each of the three savings vehicles in the economy. Capital returns reflects the net cash flow of a capital unit, equal to its marginal product ( $MPK_{t+1}$ ) plus the change in the market price net of depreciation and adjustment costs,

$$\tilde{R}_{t+1}^K \equiv \frac{MPK_{t+1} + q_{t+1}(1 - \delta - adj.costs)}{q_t},$$

and the capital risk premium is defined as  $KP_t \equiv \mathbb{E}_t [\tilde{R}_{t+1}^K / R_t^R]$ . Similarly, the return to investing a dollar in labor of type  $i$  can be written

$$R_{i,t+1}^L \equiv \frac{(MPL_{i,t} - W_{i,t})R_t^R + (1 - \rho_i)\frac{\varphi_{i,t+1}}{\Theta_{i,t+1}}}{\varphi_{i,t}/\Theta_{i,t}},$$

and the premium by  $LP_{i,t} = \mathbb{E}_t [R_{i,t+1}^L / R_t^R]$ . The definition of  $R_{i,t+1}^L$  reflects the net cash flow from a filled vacancy, i.e., the marginal product of labor in sector  $i$  ( $MPL_{i,t}$ ) minus the wage plus the change in the value of a job. The latter equals the vacancy cost,  $\varphi_{i,t}$ , times the duration of the typical vacancy,  $\frac{1}{\Theta_{i,t}}$ . In contrast to capital, which becomes productive with a one-period delay, both labor types generate cash flow immediately, so the first term in the numerator of the labor returns is multiplied by  $R_t^R$ .

Table 6 reports the (annualized) stochastic steady state premia implied by our model. Our estimation implies a full-time labor premium of around 11% and a part-time labor

Table 6: Disaggregated Risk Premia

<b>Moment</b>	<b>Value (%)</b>
Full-time labor premium	10.91
Part-time labor premium	0.18
Capital premium	0.53

*Note:* Unconditional premia are annualized percentages based on a single simulation of 5000 periods.

premium of just 0.2%. This reflects the key differential features of part-time jobs – flexible wages and shorter duration – both of which make part-time labor relatively less risky. Thus, part-time labor becomes an attractive alternative to full-time positions during periods of heightened risk aversion. The average capital premium of the model is also fairly low, around 0.5%, meaning full-time labor vacancies are the riskiest savings vehicle in our model.

While direct empirical counterparts of these objects do not exist, the recent literature has found both that “installed” labor is an important priced component of the value of US publicly traded firms (Belo et al., 2022), and that cross-sectional risk premia are higher for firms with more rigid wages (Favilukis and Lin (2016), Donangelo et al. (2019)) and higher labor adjustment frictions (Belo et al. (2014), Kuehn et al. (2017)). All of these observations are consistent with the implications of our model, where the stickier full-time labor positions with rigid wages are the riskiest ones for the firm.

Moreover, in the model the return differences in Table 6 also correspond to differences in marginal products per dollar invested, and those underlie the real effects of the flight-to-safety reallocation mechanism. Upon an increase in risk aversion the full-time labor risk premium rises more than the risk premium on both physical capital and part-time labor (see Figure 7). The consequence is twofold. First, as in the analytical model in Section 3 firms shift away from full-time labor towards investment in physical capital, which lowers contemporaneous output. Second, now there is also a shift in vacancy postings from full-time to part-time positions, which manifests as a fall in the composite labor aggregate  $N_t$  that exceeds the fall in total employment  $N_{1,t} + N_{2,t}$ , as part-timers have lower marginal product. The fall in  $N_t$  further decreases output, and also lowers the marginal product of capital, which depresses the incentive to invest. The result of both of these reallocations is that all four main macro aggregates fall (Figure 6), without a change in technology.

Thus, part-timers amplify the quantitative effects of our mechanism. Moreover, matching the empirical response of the reallocation towards part-time labor helps discipline the estimation of our flight to safety mechanism overall.

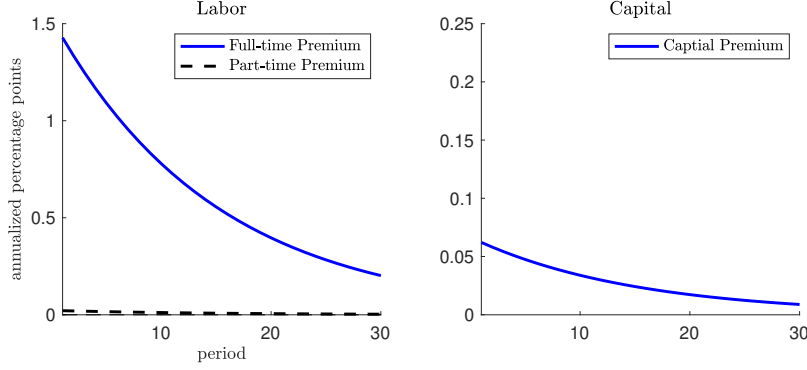


Figure 7: Impulse responses of risk premia in the model following a risk appetite shock.

### Role of Sticky Wages

In our model, sticky wages play a role that is complementary to, but distinct from, their role in most prior literature. To see this, consider the value of a type- $i$  labor match for a firm,  $J_{i,t}$ , in equilibrium given by:

$$J_{i,t} = MPL_{i,t} - W_{i,t} + (1 - \rho_i)\mathbb{E}_t \{M_{t,t+1}J_{i,t+1}\}. \quad (48)$$

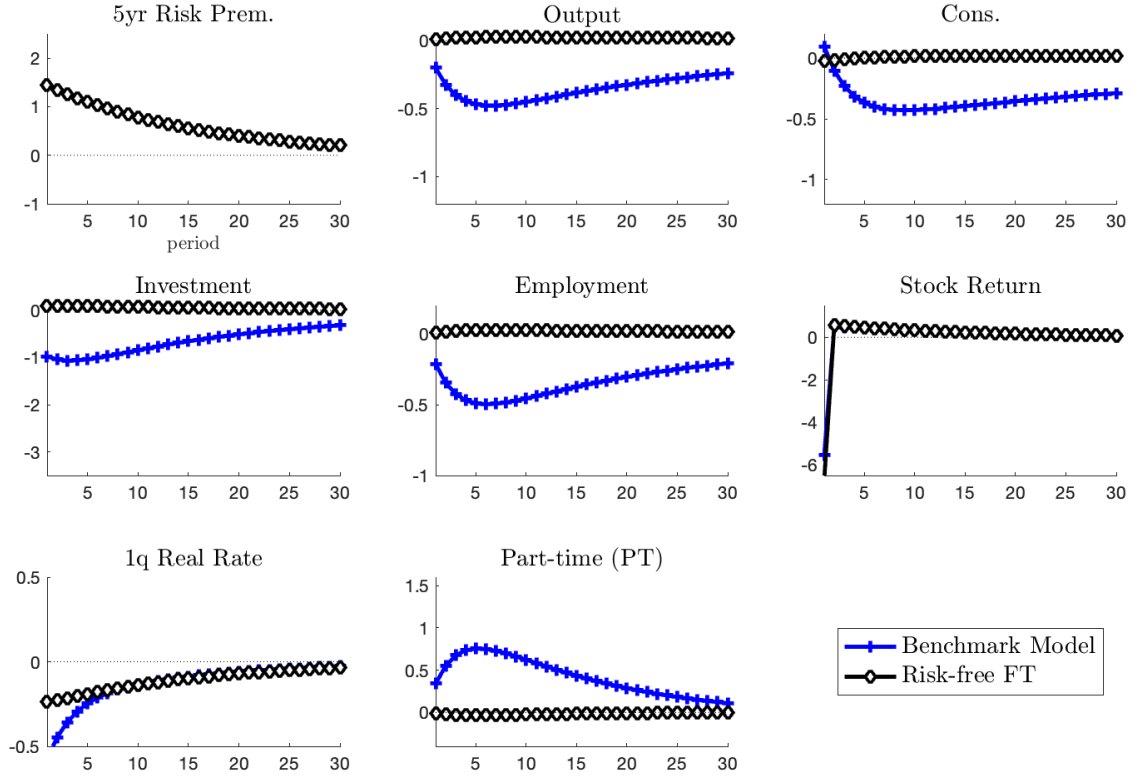
Equation (48) states that the value of a match is equal to the firm's cash flows, given by the marginal product of the worker ( $MPL_{i,t}$ ) net of the wage payment, plus the discounted continuation value if the worker does not separate from the firm. Solving this equation forward, we can rewrite the value of a match as:

$$J_{i,t} = \underbrace{\sum_{j=0}^{\infty} \frac{(1 - \rho_i)^j \mathbb{E}_t(MPL_{i,t+j} - W_{i,t+j})}{R_{t,t+j}^R}}_{\text{cash flows}} + \underbrace{\sum_{j=1}^{\infty} (1 - \rho_i)^j Cov_t(M_{t,t+j}, MPL_{i,t+j} - W_{i,t+j})}_{\text{risk premium}}, \quad (49)$$

where we have imposed the transversality condition that  $\lim_{j \rightarrow \infty} \mathbb{E}_t[M_{t,t+j}J_{i,t+j}] = 0$ .

Equation (49) expresses the value of a match as the sum of two terms. The first is the present value of firms' cash flows, discounted with the risk-free rate  $R_{t,t+j}^R = \mathbb{E}_t[M_{t,t+j}]^{-1}$ . The second is a risk adjustment. Labor matches for which firms' cash flows covary more negatively with the stochastic discount factor carry higher risk premia.

In the prior literature, (e.g., [Hall, 2005](#)) sticky wages serve to drive fluctuations in the expected cash flows associated with hiring (the first term above). In our model, sticky wages serve to amplify the risk premium of full-time labor, by magnifying the negative covariance between the firm's cash flows and the stochastic discount factor (the second term above). Sticky wages still do drive fluctuations in expected cash flows in response



Y-axis values are in annualized percentage points for the risk premium, stock return, and 1-quarter real rate; all other numbers are in percentage deviations.

Figure 8: Model responses without risk premia.

to productivity shocks as well, but without a risk-premium employment does not move much in response to risk aversion changes.

To demonstrate the quantitative importance of this channel, Figure 8 shows the responses to a risk aversion shock in a counterfactual economy in which we keep the full-time wage sticky as estimated, but eliminate the risk-premium term from the firm's full-time vacancy posting condition (49). The figure shows that this model fails to reproduce the empirical patterns. Consumption and investment move in opposite directions, which is the typical challenge that our reallocation channel (which is now shutdown) solves, and moreover, the size of real responses are tiny compared to our baseline model. This is despite the full-time wages remaining sticky, which highlights that the strong effects on labor we find in our baseline model are indeed due to sticky wages increasing the risk premia of labor matches, and not due to the standard real rigidity mechanisms. Thus, our model offers a distinct resolution to the [Shimer \(2005\)](#) puzzle, as arising from labor's



sensitivity to risk aversion shocks.

Lastly, while the full-time sector wages in our model are rigid and thus adjust slowly to shocks, the *aggregate* wage can adjust flexibly along two dimensions. First, the wages of existing part-time workers are flexible and they fall in response to the shock. Second, the share of part time workers grows in the model as a share of total employment: since those workers have lower earnings, this also reduces earnings-per-worker. To showcase the resulting level of adjustment in aggregate wages, in Figure D.1 (and associated discussion in Appendix D), we plot the impulse response of earnings-per-worker both in the model and the data, to a risk aversion shock. The figure shows that earnings-per-worker fall modestly in response to the shock both in the data and in the model. We conclude from this figure that, while our assumptions about wages are probably an oversimplification, the overall implications for the aggregate earnings-per-worker are not strongly counterfactual.

## 5 Conclusions

This paper shows that fluctuations in risk premia can be major drivers of macroeconomic fluctuations. Our empirical analysis suggests the possibility of a major causal pathway flowing from risk premia to macroeconomic fluctuations, and our theory embodies one such a pathway. In our model, heightened risk premia cause recessions because they drive reallocation of saving towards safer stores of value, which simultaneously have low instantaneous marginal products. Thus, our theory puts risk premia and their effects on precautionary saving at the center of macroeconomic propagation. In this respect, our model bridges a gap between the tradition of risk-driven business cycles à la Keynes and the central lessons of modern macro-finance summarized in Cochrane (2017), all within a real framework.

To focus attention on our novel propagation mechanism, we abstract throughout from many other ingredients that may contribute to risk-driven macroeconomic comovement, including nominal rigidities (Basu and Bundick, 2017), financial frictions (Christiano et al., 2014), uninsurable idiosyncratic risk (Di Tella and Hall, 2020), information frictions (Ilut and Saijo, 2021), and heterogeneous asset valuations (Caballero and Simsek, 2020). All of these features likely play a role in the world. Nevertheless, our quantitative analysis demonstrates that the savings reallocation channel is sufficiently powerful to drive a substantial portion of macroeconomic fluctuations on its own.

Our theory emphasizes the labor market implications of savings reallocation primarily because our empirical results suggest a flight-to-safety in those markets. Nevertheless, the

same patterns likely apply to other forms of saving available in the economy (risky private investments versus safe government bonds, foreign investment for open economies, etc.). Reallocation from new to old capital could also provide a similar amplification mechanism for which there is already intriguing empirical evidence (e.g., [Eisfeldt and Rampini, 2006](#)). Future research should continue to explore the business cycle consequences of such alternative applications of our basic mechanism, both theoretically and empirically.

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# Online Appendix

## A Empirical Appendix

### A.1 Data Construction

Our baseline VAR specification consists of output, consumption, investment, employment, ex-post real stock returns, ex-post real bond returns, and the dividend price ratio. Our auxiliary series include measures of part-time employment, hours-per-worker, bond returns, and bond-risk premia.

Quantity variables were downloaded from the FRED database of the St. Louis Federal Reserve Bank and are included in seasonally-adjusted, real, per-capita terms. Our population series is the civilian non-institutional population ages 16 and over, produced by the BLS. We convert our population series to quarterly frequency using a three-month average and smooth it using an HP-filter with penalty parameter  $\lambda = 1600$  to account for occasional jumps in the series that occur after census years and CPS rebasing (see [Edge and Gürkaynak, 2010](#)). Our deflator series is the GDP deflator produced by the BEA national accounts.

For output, we use nominal output produced by the BEA. Our investment measure is inclusive: we take the sum of nominal gross private domestic investment, personal expenditure on durable goods, government gross investment, and the trade balance (i.e. investment abroad). Consumption consists of nominal personal consumption expenditures on non-durables and services.

Our measure of employment is Total Nonfarm Employees (FRED code: PAYEMS) produced by the BLS and divided by population. The measure of part-time employment is the number of people “employed, usually part-time work” (FRED code: LNS12600000) produced by the BLS and again divided by our population series. This series includes a large discrete jump in the first month of 1994, associated with a reclassification of part-time work. We splice the series by assuming there was no change in employment between 1993M12 and 1994M1. Our measure of hours is Non-farm Business Sector: Hours of All Persons (FRED code: HOANBS). Finally, our measure of profits is Corporate Profits with inventory valuation adjustments: Nonfinancial Domestic Industries (FRED code: A399RC1Q027SBEA) and our measure of inflation is the log change in the GDP deflator (FRED code: GDPDEF).

Our asset return series are all based on quarterly NYSE/AMEX/NASDAQ value-



weighted indexes from CRSP. Asset returns are computed inclusive of dividends, and are also deflated by the GDP deflator. Our measure of bond risk premia comes from Moody's corporate bond yield relative 10-year treasury bonds (FRED code: BAA10YM).

## A.2 Short-sample results

An earlier version of this paper was based on a shorter sample, starting in 1985Q1. Figure A.1 below shows our baseline VAR results, recomputed using that shorter sample. All results are qualitatively the same. The main difference is that the persistence of the increased risk premium is higher.

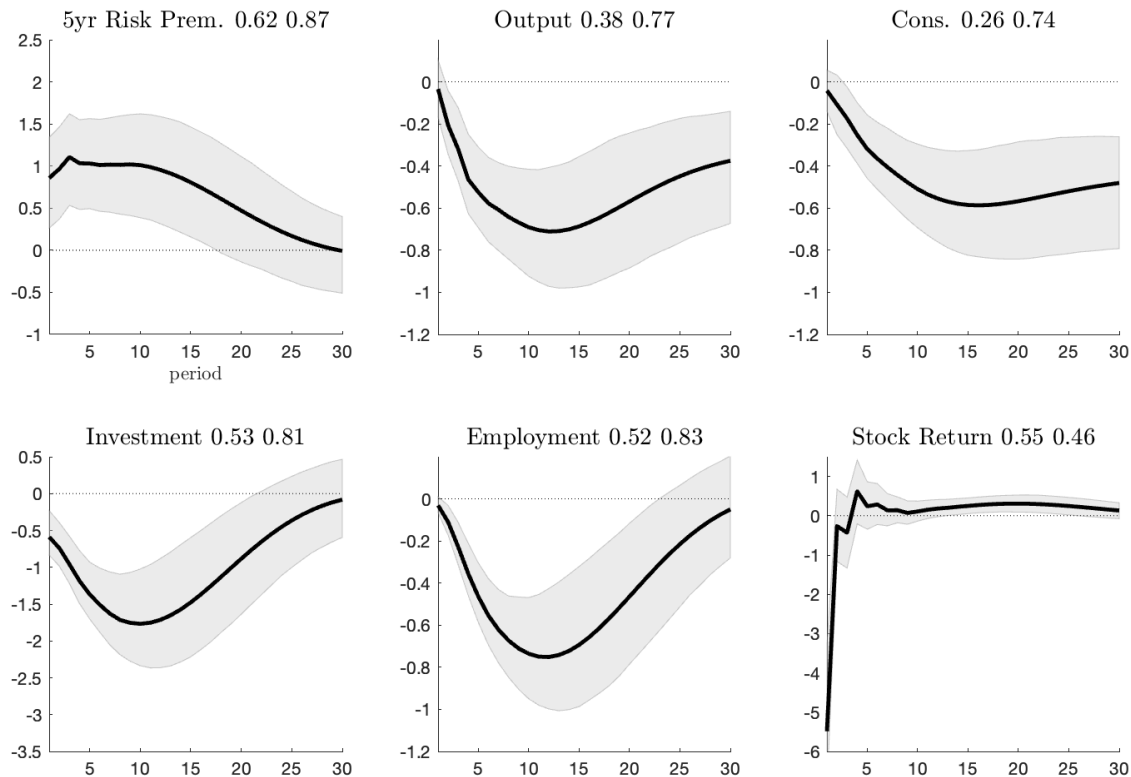


Figure A.1: VAR results based on the 1985 - 2018 sub-sample.

## A.3 Excess Stock Return Predictability

Figure decomposing the VAR's stock return forecast.

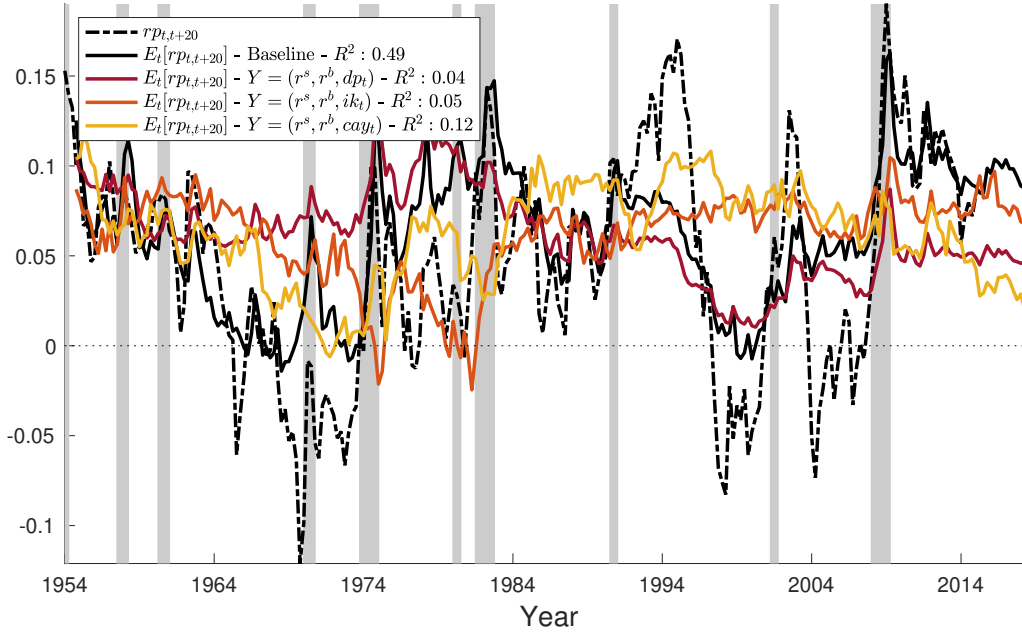


Figure A.2: Ex-ante excess stock returns from a sequence of VARs.

## B Analytical Model: Proofs of Propositions

**Proof of Proposition 1.** Let  $x = \frac{K}{N}$  be the capital-labor ratio. We have two Euler equations. First, there is the capital Euler equation:

$$\begin{aligned}
 1 &= \alpha x^{\alpha-1} + \mathbb{E}_0(M_{0,1} Z \alpha x^{\alpha-1}) \\
 &= \alpha x^{\alpha-1} + \alpha x^{\alpha-1} (\mathbb{E}_0(M_{0,1}) \mathbb{E}_0(Z) + Cov(M_{0,1}, Z)) \\
 &= \alpha x^{\alpha-1} \left[ 1 + \frac{1}{R_f} + Cov(M_{0,1}, Z) \right]
 \end{aligned} \tag{B.1}$$

where in the second line we use the fact that  $E(XY) = E(X)E(Y) + Cov(X, Y)$ , and in the third line we use the fact that the risk-free rate is the inverse of the expected SDF:  $R_f = \frac{1}{\mathbb{E}_0(M_{0,1})}$ .

Then we have the labor optimality condition:

$$\begin{aligned}
 \varphi N^{\frac{1-\varepsilon}{\varepsilon}} &= (1 - \alpha)x^\alpha - W_0 + \mathbb{E}_0[M_{0,1}(Z(1 - \alpha)x^\alpha - W_1)] \\
 &= (1 - \alpha)x^\alpha - W_0 + ((1 - \alpha)x^\alpha - \mathbb{E}_0(W_1))\mathbb{E}_0[M_{0,1}Z] \\
 &= ((1 - \alpha)x^\alpha - W^{avg}) \left[ 1 + \frac{1}{R_f} + Cov(M_{0,1}, Z) \right]
 \end{aligned} \tag{B.2}$$

where in the second line we use the formula for the period-1 Nash wage  $W_1 = (1 - \varepsilon)Z(1 -$

$\alpha)x^\alpha$ , and in the third line we simply break down the expectation  $\mathbb{E}_0(M_{0,1})$  as we did with the capital Euler equation above, and then combine the terms and use the notation

$$W^{avg} \equiv (1 - \varepsilon)(1 - \alpha)x^\alpha = W_0 = \mathbb{E}_0(W_1)$$

This gives us the Euler equations from the main text, and it directly follows that

$$\alpha x^{\alpha-1} = \frac{(1 - \alpha)x^\alpha - W^{avg}}{\varphi N^{\frac{1-\varepsilon}{\varepsilon}}} \quad (\text{B.3})$$

To establish the first result of the proposition, note that the cost of a unit of investment in capital is 1 and the cost of a unit of investment in labor is  $\varphi N^{\frac{1-\varepsilon}{\varepsilon}}$ . Defining the returns  $R^K$  and  $R^N$  as the respective cumulative payoffs, capitalized to time 1, and divided by their respective cost of investment we have:

$$\begin{aligned} R^K &= \alpha x^{\alpha-1} R_f + Z \alpha x^{\alpha-1} \\ R^N &= \frac{((1 - \alpha)x^\alpha - W_0) R_f + (Z \alpha x^{\alpha-1} - W_1)}{\varphi N^{\frac{1-\varepsilon}{\varepsilon}}} \end{aligned}$$

Taking expectations, subtracting the risk-free rate and using equations (B.1) and (B.2)

$$\begin{aligned} \mathbb{E}(R^K) - R_f &= -R_f \alpha x^{\alpha-1} \text{Cov}(M, Z) \\ \mathbb{E}(R^N) - R_f &= -\frac{R_f((1 - \alpha)x^\alpha - W^{avg})}{\varphi N^{\frac{1-\varepsilon}{\varepsilon}}} \text{Cov}(M, Z) \end{aligned}$$

By the relation in equation (B.3) these excess returns are equivalent, which proves the first result in the Proposition.

For the second result, we need to characterize the full equilibrium in  $C_0, N, K$  and  $Y_0$ . To do so, we will substitute the expression for the stochastic discount factor  $M_{0,1}$  in the Euler equations above, and evaluate expectations in closed-form using properties of the log-normal distribution.

We start by rewriting the economy resource constraints for consumption in period 0 and 1 as

$$\begin{aligned} C_0 &= K^\alpha N^{1-\alpha} - K - \varphi N^{\frac{1}{\varepsilon}} \\ C_1 &= Z K^\alpha N^{1-\alpha} \end{aligned}$$

where we have subbed out  $p_0$  using the fact that in equilibrium employed labor equals the

number of matches,  $N = M(v, 1) = v^\varepsilon$ , and that the equilibrium job-filling probability  $p_0 = \frac{M(v, 1)}{v} = v^{\varepsilon-1}$ .

Using those expressions and utilizing properties of the log-normal distribution we have:

$$\begin{aligned}\mathbb{E}_0(M_{0,1}Z) &= \beta \mathbb{E}_0 \left[ \left( \frac{C_1}{C_0} \right)^{-\frac{1}{\psi}} \left( \frac{C_1}{\mathbb{E}_0(C_1^{1-\gamma})^{\frac{1}{1-\gamma}}} \right)^{\frac{1}{\psi}-\gamma} Z \right] \\ &= \beta \mathbb{E}_0 \left[ \left( \frac{C_1}{C_0} \right)^{-\frac{1}{\psi}} \left( \frac{Z}{\mathbb{E}_0(Z)^{\frac{1}{1-\gamma}}} \right)^{\frac{1}{\psi}-\gamma} Z \right] \\ &= \beta \mathbb{E}_0 \left[ \left( \frac{x^\alpha}{x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}}} \right)^{-\frac{1}{\psi}} \exp\left(\gamma\left(\frac{1}{\psi} - 1\right)\frac{\sigma_z^2}{2}\right) \right]\end{aligned}$$

which allows us to boil down the two optimality conditions to

$$1 = \alpha x^{\alpha-1} \left( 1 + \beta \left( \frac{x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}}}{x^\alpha} \right)^{\frac{1}{\psi}} \exp\left(\gamma\left(\frac{1}{\psi} - 1\right)\frac{\sigma_z^2}{2}\right) \right) \quad (\text{B.4})$$

$$\varphi N^{\frac{1-\varepsilon}{\varepsilon}} = \varepsilon(1 - \alpha)x^\alpha \left( 1 + \beta \left( \frac{x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}}}{x^\alpha} \right)^{\frac{1}{\psi}} \exp\left(\gamma\left(\frac{1}{\psi} - 1\right)\frac{\sigma_z^2}{2}\right) \right) \quad (\text{B.5})$$

From these equations, it directly follows that

$$\alpha \varphi N^{\frac{1-\varepsilon}{\varepsilon}} = \varepsilon(1 - \alpha)x \quad (\text{B.6})$$

Plugging this back into the capital Euler equation (B.1),

$$1 = \alpha x^{\alpha-1} \left( 1 + \beta \left( 1 - x^{1-\alpha} \frac{\alpha + \varepsilon(1 - \alpha)}{\alpha} \right)^{\frac{1}{\psi}} \exp\left(\gamma\left(\frac{1}{\psi} - 1\right)\frac{\sigma_z^2}{2}\right) \right) \quad (\text{B.7})$$

which can be re-arranged as

$$1 - \alpha x^{\alpha-1} = (\alpha x^{\alpha-1})^{1-\frac{1}{\psi}} \beta \left( \alpha x^{\alpha-1} - (\alpha + \varepsilon(1 - \alpha)) \right)^{\frac{1}{\psi}} \exp\left(\gamma\left(\frac{1}{\psi} - 1\right)\frac{\sigma_z^2}{2}\right) \quad (\text{B.8})$$

From here, we can see that

$$1 - \alpha x^{\alpha-1} > 0 \iff \alpha x^{\alpha-1} - (\alpha + \varepsilon(1 - \alpha)) > 0 \quad (\text{B.9})$$

However, since  $\alpha + \varepsilon(1 - \alpha) < 1$

$$\alpha x^{\alpha-1} - (\alpha + \varepsilon(1 - \alpha)) > \alpha x^{\alpha-1} - 1$$

In this case, if  $\alpha x^{\alpha-1} - 1 > 0$ , then  $\alpha x^{\alpha-1} - (\alpha + \varepsilon(1 - \alpha)) > 0$ , and thus equation (B.8) cannot hold as the LHS is negative but the RHS is positive. Thus, it must be the case that  $\alpha x^{\alpha-1} - 1 < 0$ , which also implies that

$$1 - x^{1-\alpha} \frac{\alpha + \varepsilon(1 - \alpha)}{\alpha} > 0 \quad (\text{B.10})$$

Note that this result together with eq. (B.7) implies that  $x > 0$ .

With these results in hand, use equation (B.8) to define the function

$$F = \alpha x^{\alpha-1} \left( 1 + \beta(1 - x^{1-\alpha} \frac{\alpha + \varepsilon(1 - \alpha)}{\alpha})^{\frac{1}{\psi}} \exp(\gamma(\frac{1}{\psi} - 1)\frac{\sigma_z^2}{2}) \right) - 1 \quad (\text{B.11})$$

Taking derivatives

$$\begin{aligned} \frac{\partial F}{\partial x} &= \alpha(\alpha - 1)x^{\alpha-2} \left( 1 + \beta(1 - x^{1-\alpha} \frac{\alpha + \varepsilon(1 - \alpha)}{\alpha})^{\frac{1}{\psi}} \exp(\gamma(\frac{1}{\psi} - 1)\frac{\sigma_z^2}{2}) \right) \\ &\quad + (\alpha - 1)\alpha x^{\alpha-1} \frac{\beta}{\psi} (1 - x^{1-\alpha} \frac{\alpha + \varepsilon(1 - \alpha)}{\alpha})^{\frac{1}{\psi}-1} x^{-\alpha} \frac{\alpha + \varepsilon(1 - \alpha)}{\alpha} \exp(\gamma(\frac{1}{\psi} - 1)\frac{\sigma_z^2}{2}) < 0 \\ \frac{\partial F}{\partial \gamma} &= \alpha x^{\alpha-1} \beta (1 - x^{1-\alpha} \frac{\alpha + \varepsilon(1 - \alpha)}{\alpha})^{\frac{1}{\psi}} \exp(\gamma(\frac{1}{\psi} - 1)\frac{\sigma_z^2}{2}) (\frac{1}{\psi} - 1) \frac{\sigma_z^2}{2} > 0 \iff \psi < 1 \end{aligned}$$

Since  $F = 0$  in equilibrium, by the implicit function theorem

$$\frac{\partial x}{\partial \gamma} = - \frac{\frac{\partial F}{\partial \gamma}}{\frac{\partial F}{\partial x}} = \begin{cases} > 0 \text{ if } \psi < 1 \\ = 0 \text{ if } \psi = 1 \\ < 0 \text{ if } \psi > 1 \end{cases} \quad (\text{B.12})$$

Using this, and combined with the fact that  $N$  moves in the same direction as  $x$  (by equation (B.6)), we can conclude that

$$\frac{\partial x}{\partial \gamma} \begin{cases} > 0 \Rightarrow \frac{\partial N}{\gamma} > 0 \text{ and } \frac{\partial K}{\gamma} > 0 \text{ if } \psi < 1 \\ = 0 \Rightarrow \frac{\partial N}{\gamma} = 0 \text{ and } \frac{\partial K}{\gamma} = 0 \text{ if } \psi = 1 \\ < 0 \Rightarrow \frac{\partial N}{\gamma} < 0 \text{ and } \frac{\partial K}{\gamma} < 0 \text{ if } \psi > 1 \end{cases} \quad (\text{B.13})$$

Lastly, consider the impact on consumption. Using market clearing at time 0:

$$C_0 = K^\alpha N^{1-\alpha} - K - \varphi N^{\frac{1}{\varepsilon}}$$

differentiate with respect to  $\gamma$

$$\begin{aligned} \frac{\partial C_0}{\partial \gamma} &= (\alpha K^\alpha N^{1-\alpha} - K) \frac{\partial \ln(K)}{\partial \gamma} + ((1-\alpha)K^\alpha N^{1-\alpha} - \frac{\varphi}{\varepsilon} N^{\frac{1}{\varepsilon}}) \frac{\partial \ln(N)}{\partial \gamma} \\ &= N \left( (\alpha x^\alpha - x) \frac{\partial \ln(K)}{\partial \gamma} + ((1-\alpha)x^\alpha - \frac{\varphi}{\varepsilon} N^{\frac{1-\varepsilon}{\varepsilon}}) \frac{\partial \ln(N)}{\partial \gamma} \right) \\ &= N \left( x(\alpha x^{\alpha-1} - 1) \frac{\partial \ln(K)}{\partial \gamma} + ((1-\alpha)x^\alpha - \frac{1-\alpha}{\alpha} x) \frac{\partial \ln(N)}{\partial \gamma} \right) \\ &= N \left( x(\alpha x^{\alpha-1} - 1) \frac{\partial \ln(K)}{\partial \gamma} + \frac{1-\alpha}{\alpha} x(\alpha x^{\alpha-1} - 1) \frac{\partial \ln(N)}{\partial \gamma} \right) \end{aligned}$$

Thus, since  $\alpha x^{\alpha-1} - 1 < 0$  and  $x > 0$  it follows that

$$\frac{\partial C_0}{\partial \gamma} \begin{cases} < 0 \text{ if } \psi < 1 \\ = 0 \text{ if } \psi = 1 \\ > 0 \text{ if } \psi > 1 \end{cases}$$

which is the opposite direction of the move in  $K$  and  $N$ . So there can be no comovement.  $\square$

### ***Proof of Proposition 2.***

**Equilibrium:** For an equilibrium in our economy to exist the fixed wage  $W$  must be in the bargaining set, meaning that the present discounted value of wages is lower than the total surplus of a labor match (so firms have an incentive to participate), but also wages must be positive (for households to have an incentive to participate; recall the household has zero outside option). This means that  $W$  must satisfy this condition:

$$0 \leq \bar{W} \left(1 + \frac{1}{R_f}\right) < (1-\alpha)x^\alpha (1 + \mathbb{E}_0(M_{0,1}Z)) \quad (\text{B.14})$$

As we show below, for a given set of structural parameters  $\{\gamma, \alpha, \varepsilon, \beta, \varphi, \sigma_z^2\}$ , there exists a threshold  $\bar{W}$  such that condition (B.14) is satisfied if and only if  $W \in [0, \bar{W}]$ .

### Part 1: risk premia

For a given set of parameters and  $W$  inside the relevant bargaining set, using the log-normal formulas to evaluate expectations, we have the capital Euler and the labor Euler equations as follows (note the only one that changes substantially is the labor one, the capital optimality condition is the same as (B.4) above, but evaluated at  $\psi = 1$ ):

$$1 = \alpha x^{\alpha-1} \left( 1 + \beta \left( \frac{x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}}}{x^\alpha} \right) \right) \quad (\text{B.15})$$

$$\varphi N^{\frac{1-\varepsilon}{\varepsilon}} = (1-\alpha)x^\alpha \left( 1 + \beta \left( \frac{x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}}}{x^\alpha} \right) \right) - \bar{W} \left( 1 + \beta \left( \frac{x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}}}{x^\alpha} \right) \exp(\gamma \sigma_z^2) \right) \quad (\text{B.16})$$

From here it follows that in this version of the economy we have

$$\alpha x^{\alpha-1} < \frac{(1-\alpha)x^\alpha - \bar{W}}{\varphi N^{\frac{1-\varepsilon}{\varepsilon}}}$$

and thus,

$$\begin{aligned} \mathbb{E}(R^N) - R_f &= -\frac{R_f((1-\alpha)x^\alpha - \bar{W})}{\varphi N^{\frac{1-\varepsilon}{\varepsilon}}} \text{Cov}(M, Z) \\ &> -R_f \alpha x^{\alpha-1} \text{Cov}(M, Z) \\ &= \mathbb{E}(R^K) - R_f \end{aligned}$$

which proves the first part of the proposition.

### Part 2: $N$ and $K$ both fall, but $N$ falls by more

Assume  $W$  is within the bargaining set, hence condition (B.14) is satisfied. Using the capital Euler equation, notice that

$$\beta \left( \frac{x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}}}{x^\alpha} \right) = \frac{x^{1-\alpha}}{\alpha} - 1$$

Using this relationship and the closed-form for the stochastic discount factor, the condition that wages are within the bargaining set can be expressed as

$$0 \leq W \left( 1 + \left( \frac{x^{1-\alpha}}{\alpha} - 1 \right) \exp(\gamma \sigma_z^2) \right) < \frac{1-\alpha}{\alpha} x \quad (\text{B.17})$$

Furthermore, solving for  $\varphi N^{\frac{1-\varepsilon}{\varepsilon}}$  from the Labor Euler equation gives us

$$\varphi N^{\frac{1-\varepsilon}{\varepsilon}} = \frac{1-\alpha}{\alpha}x - W(1 + (\frac{x^{1-\alpha}}{\alpha} - 1)\exp(\gamma\sigma_z^2)) \quad (\text{B.18})$$

Using (B.17) it follows that  $N > 0$  and  $x > 0$ . Consider consumption  $C_0$ : given that  $N > 0$ , we can say that  $C_0 > 0 \iff \frac{C_0}{N} > 0$ . Expanding  $\frac{C_0}{N}$

$$\begin{aligned} \frac{C_0}{N} &= x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}} \\ &= x^\alpha - x - \left( \frac{1-\alpha}{\alpha}x - W(1 + (\frac{x^{1-\alpha}}{\alpha} - 1)\exp(\gamma\sigma_z^2)) \right) \\ &= \frac{x}{\alpha}(\alpha x^{\alpha-1} - 1) + W(1 + (\frac{x^{1-\alpha}}{\alpha} - 1)\exp(\gamma\sigma_z^2)) \\ &= \frac{x}{\alpha\beta}(1 - \alpha x^{\alpha-1}) \end{aligned}$$

where in the last equality we used equation (B.19). The last line is positive if and only if  $1 - \alpha x^{\alpha-1} > 0$ , which we will show is true below.

Plugging (B.18) back into the capital Euler equation and simplifying we have

$$\begin{aligned} 1 &= \alpha x^{\alpha-1} \left( 1 + \beta \frac{x^\alpha - x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}}}{x^\alpha} \right) \\ &= \alpha \left( x^{\alpha-1}(1 + \beta) - \beta - \frac{\beta}{x} \left( \frac{1-\alpha}{\alpha}x - W(1 + (\frac{x^{1-\alpha}}{\alpha} - 1)\exp(\gamma\sigma_z^2)) \right) \right) \\ &= \alpha x^{\alpha-1}(1 + \beta) - \beta + \frac{\alpha\beta W}{x} (1 + (\frac{x^{1-\alpha}}{\alpha} - 1)\exp(\gamma\sigma_z^2)) \end{aligned} \quad (\text{B.19})$$

Rearranging this expression gives us

$$\frac{\alpha\beta W}{x} (1 + (\frac{x^{1-\alpha}}{\alpha} - 1)\exp(\gamma\sigma_z^2)) = (1 + \beta)(1 - \alpha x^{\alpha-1}) \quad (\text{B.20})$$

From (B.17) it follows that  $1 - \alpha x^{\alpha-1} > 0$ . Furthermore, using relationship the bargaining set condition (B.17) can be expressed as

$$0 < \frac{1+\beta}{\beta}(1 - \alpha x^{\alpha-1}) < (1 - \alpha) \quad (\text{B.21})$$

We can now show that wages are inside the bargaining set if and only if  $W \in (0, \bar{W})$ . To do so, first use equation (B.19) to define the following implicit function of  $x$

$$F = (1 + \beta)(\alpha x^{\alpha-1} - 1) + \frac{\alpha\beta W}{x} (1 + (\frac{x^{1-\alpha}}{\alpha} - 1)\exp(\gamma\sigma_z^2)) \quad (\text{B.22})$$



and consider its derivatives in respect to  $x$ ,  $W$  and  $\gamma$ .

$$\begin{aligned}\frac{\partial F}{\partial x} &= (1 + \beta)\alpha(\alpha - 1)x^{\alpha-2} + \alpha\beta W\left(-\frac{1}{x^2} + \left(-\frac{1}{x^{\alpha+1}} + \frac{1}{x^2}\right)\exp(\gamma\sigma_z^2)\right) \\ &= (1 + \beta)\alpha(\alpha - 1)x^{\alpha-2} - \frac{\alpha\beta W}{x^2}(1 + (x^{1-\alpha} - 1)\exp(\gamma\sigma_z^2)) \\ &= \frac{\alpha\beta W}{x^2}\left(\frac{(1 + \beta)}{\beta W}(\alpha - 1)x^\alpha - (1 + (x^{1-\alpha} - 1)\exp(\gamma\sigma_z^2))\right)\end{aligned}$$

$$\begin{aligned}\frac{\partial F}{\partial \gamma} &= \frac{\alpha\beta W}{x}\left(\left(\frac{x^{1-\alpha}}{\alpha} - 1\right)\exp(\gamma\sigma_z^2)\right)\sigma_z^2 \\ \frac{\partial F}{\partial W} &= \frac{\alpha\beta W}{x}\left(1 + \left(\frac{x^{1-\alpha}}{\alpha} - 1\right)\exp(\gamma\sigma_z^2)\right)\end{aligned}$$

Form here it follows that  $\frac{\partial F}{\partial W} > 0$ . Meanwhile, rearranging (B.19) gives us

$$\alpha = (1 - \alpha x^{\alpha-1})x \left[ \frac{1 + \beta}{\beta W} - \frac{\exp(\gamma\sigma_z^2)}{x^\alpha} \right]$$

and hence since  $1 - \alpha x^{\alpha-1} > 0$ , it follows that  $\frac{\exp(\gamma\sigma_z^2)}{x^\alpha} < \frac{1+\beta}{\beta W}$ . Using this in the expression for  $\frac{\partial F}{\partial x}$  above, it follows that

$$\frac{\partial F}{\partial x} < -\frac{\alpha\beta W}{x^2} \left( 1 + \frac{1 + \beta}{\beta W} x(1 - \alpha x^{\alpha-1}) \right) < 0$$

Thus, by the implicit function theorem

$$\frac{\partial x}{\partial W} = -\frac{\frac{\partial F}{\partial W}}{\frac{\partial F}{\partial x}} > 0 \quad (\text{B.23})$$

With this in hand, let us go back to the bargaining set condition (B.21). By (B.19) this condition holds when  $W = 0$ . Further more, since  $\frac{\partial x}{\partial W}$  and  $\frac{\partial(1-\alpha x^{\alpha-1})}{\partial x} > 0$ , then there exists a threshold  $\bar{W}$  (potentially infinite) where for all  $W \in [0, \bar{W})$  condition (B.21) is satisfied. This set is non-empty, hence the assumption that we can pick a  $W$  is inside the bargaining set for any set of structural parameters is innocuous.

Furthermore, since similarly  $\frac{\partial F}{\partial \gamma} > 0$ , by the implicit function theorem it also follows that

$$\frac{\partial x}{\partial \gamma} > 0 \quad (\text{B.24})$$

We can now show that  $N$  and  $K$  both fall with  $\gamma$ , but  $N$  falls by more. Substitute (B.19) into the labor Euler equation and simplify to get

$$\varphi N^{\frac{1-\varepsilon}{\varepsilon}} = \frac{1+\beta}{\beta} x^\alpha - \frac{1+\alpha\beta}{\alpha\beta} x \quad (\text{B.25})$$

Define

$$F_N \equiv \frac{1+\beta}{\beta} x^\alpha - \frac{1+\alpha\beta}{\alpha\beta} x - \varphi N^{\frac{1-\varepsilon}{\varepsilon}} \quad (\text{B.26})$$

Taking derivatives

$$\frac{\partial F_N}{\partial N} = -\frac{1-\varepsilon}{\varepsilon} \varphi N^{\frac{1-\varepsilon}{\varepsilon}-1} < 0 \quad (\text{B.27})$$

$$\frac{\partial F_N}{\partial x} = \alpha \frac{1+\beta}{\beta} x^{\alpha-1} - \frac{1+\alpha\beta}{\alpha\beta} = \frac{1+\beta}{\beta} \left( \alpha x^{\alpha-1} - \frac{1+\alpha\beta}{\alpha(1+\beta)} \right) < \frac{1+\beta}{\beta} (\alpha x^{\alpha-1} - 1) < 0 \quad (\text{B.28})$$

Thus,

$$\frac{\partial N}{\partial \gamma} < 0 \quad (\text{B.29})$$

So far we know that the capital-labor ratio ( $x$ ) rises and  $N$  falls, but it remains to be shown that  $K$  itself falls as well. To show this, differentiate equation (B.26) with respect to  $\gamma$ , but with a small twist:

$$\begin{aligned} \frac{\partial F_N}{\partial \gamma} &= \frac{\partial F_N}{\partial \ln(x)} \frac{\partial \ln(x)}{\partial \gamma} + \frac{\partial F_N}{\partial \ln(N)} \frac{\partial \ln(N)}{\partial \gamma} \\ &= \frac{\partial F_N}{\partial \ln(x)} \left( \frac{\partial \ln(K)}{\partial \gamma} - \frac{\partial \ln(N)}{\partial \gamma} \right) + \frac{\partial F_N}{\partial \ln(N)} \frac{\partial \ln(N)}{\partial \gamma} \end{aligned}$$

Rearrange to isolate  $\frac{\partial \ln(K)}{\partial \gamma}$  on the left hand side

$$\begin{aligned} \frac{\partial \ln(K)}{\partial \gamma} &= \frac{\partial \ln(N)}{\partial \gamma} \frac{\frac{\partial F_N}{\partial \ln(x)} - \frac{\partial F_N}{\partial \ln(N)}}{\frac{\partial F_N}{\partial \ln(x)}} \\ &= \frac{\partial \ln(N)}{\partial \gamma} \frac{(1+\alpha) \frac{1+\beta}{\beta} x^\alpha - 2 \frac{1+\alpha\beta}{\alpha\beta} x}{\alpha \frac{1+\beta}{\beta} x^\alpha - \frac{1+\alpha\beta}{\alpha\beta} x} \end{aligned}$$

Focus on the term multiplying  $\frac{\partial \ln(N)}{\partial \gamma}$  on the right. By equation (B.28) the denominator is negative. Turning to the numerator

$$(1 + \alpha) \frac{1 + \beta}{\beta} x^\alpha - 2 \frac{1 + \alpha \beta}{\alpha \beta} x = \frac{1 + \alpha}{\alpha} \frac{1 + \beta}{\beta} x (\alpha x^{\alpha-1} - \frac{2(1 + \alpha \beta)}{(1 + \alpha)(1 + \beta)}) < 0 \quad (\text{B.30})$$

Since  $\frac{2(1 + \alpha \beta)}{(1 + \alpha)(1 + \beta)} > 1$ . Thus,  $N$  and  $K$  move together and hence, together with the observation that  $\frac{\partial x}{\partial \gamma} > 0$  we have that  $K$  falls but by less than  $N$ :

$$\frac{\partial \ln(N)}{\partial \gamma} < \frac{\partial \ln(K)}{\partial \gamma} < 0 \quad (\text{B.31})$$

**Part 3: fall in  $C_0$ :**

$$\begin{aligned} \frac{\partial C_0}{\partial \gamma} &= N \left( (\alpha x^\alpha - x) \frac{\partial \ln(K)}{\partial \gamma} + ((1 - \alpha)x^\alpha - \frac{\varphi}{\varepsilon} N^{\frac{1-\varepsilon}{\varepsilon}}) \frac{\partial \ln(N)}{\partial \gamma} \right) \\ &= N \left( (\alpha x^\alpha - x) \frac{\partial \ln(K)}{\partial \gamma} + ((1 - \alpha)x^\alpha - \frac{1}{\varepsilon} (\frac{1 - \alpha}{\alpha} x - W(1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2))) \frac{\partial \ln(N)}{\partial \gamma} \right) \\ &= N \left( (\alpha x^\alpha - x) \frac{\partial \ln(K)}{\partial \gamma} + (\frac{1 - \alpha}{\alpha} (\alpha x^\alpha - \frac{x}{\varepsilon}) + \frac{W}{\varepsilon} (1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2))) \frac{\partial \ln(N)}{\partial \gamma} \right) \\ &= N \left( (\alpha x^\alpha - x) + \frac{1 - \alpha}{\alpha} (\alpha x^\alpha - \frac{x}{\varepsilon}) + \frac{W}{\varepsilon} [1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] \left( \frac{\alpha^{\frac{1+\beta}{\beta}} x^\alpha - \frac{1+\alpha\beta}{\alpha\beta} x}{(1 + \alpha) \frac{1+\beta}{\beta} x^\alpha - 2 \frac{1+\alpha\beta}{\alpha\beta} x} \right) \right) \frac{\partial \ln(K)}{\partial \gamma} \end{aligned}$$

Since we know that  $\frac{\partial \ln(K)}{\partial \gamma} < 0$ , we just need to show that the term multiplying it in the last line above is positive. We can simplify things a little bit by noticing that  $|\frac{\partial \ln(N)}{\partial \gamma}| > |\frac{\partial \ln(K)}{\partial \gamma}|$  (that is  $\frac{\alpha^{\frac{1+\beta}{\beta}} x^\alpha - \frac{1+\alpha\beta}{\alpha\beta} x}{(1 + \alpha) \frac{1+\beta}{\beta} x^\alpha - 2 \frac{1+\alpha\beta}{\alpha\beta} x} > 1$ ), hence

$$\begin{aligned} (\alpha x^\alpha - x) + \frac{1 - \alpha}{\alpha} (\alpha x^\alpha - \frac{x}{\varepsilon}) + \frac{W}{\varepsilon} [1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] \left( \frac{\alpha^{\frac{1+\beta}{\beta}} x^\alpha - \frac{1+\alpha\beta}{\alpha\beta} x}{(1 + \alpha) \frac{1+\beta}{\beta} x^\alpha - 2 \frac{1+\alpha\beta}{\alpha\beta} x} \right) > \\ (\alpha x^\alpha - x) + \frac{1 - \alpha}{\alpha} (\alpha x^\alpha - \frac{x}{\varepsilon}) + \frac{W}{\varepsilon} [1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] \end{aligned}$$

We will show that there is a threshold  $\bar{\gamma}$ , such that when  $\gamma > \bar{\gamma}$  this expression is indeed positive and thus  $C_0$  falls with  $\gamma$ .

$$\begin{aligned} &(\alpha x^\alpha - x) + \frac{1 - \alpha}{\alpha} (\alpha x^\alpha - \frac{x}{\varepsilon}) + \frac{W}{\varepsilon} [1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] \\ &= x(\alpha x^{\alpha-1} - 1) + \frac{1 - \alpha}{\alpha} x(\alpha x^{\alpha-1} - 1 + 1 - \frac{1}{\varepsilon}) + \frac{W}{\varepsilon} [1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] \\ &= \frac{1 - \alpha}{\alpha} \frac{\varepsilon - 1}{\varepsilon} x + \frac{x}{\alpha} (\alpha x^{\alpha-1} - 1) + \frac{W}{\varepsilon} [1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] \end{aligned}$$

$$= \frac{1 - \alpha \varepsilon - 1}{\alpha} \frac{1}{\varepsilon} x + W[1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] (\frac{1}{\varepsilon} - \frac{\beta}{1 + \beta}) > 0$$

where in the last equality we use equation (B.20) to substitute  $\frac{x}{\alpha}(1 - \alpha x^{\alpha-1}) = \frac{\beta}{1+\beta} W[1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)]$ . Lastly, we observe that the last line is positive if and only if the following holds:

$$\begin{aligned} & \frac{1 - \alpha \varepsilon - 1}{\alpha} \frac{1}{\varepsilon} x + W[1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] (\frac{1}{\varepsilon} - \frac{\beta}{1 + \beta}) > 0 \\ \iff & (1 - \alpha) \frac{(1 - \varepsilon)(1 + \beta)}{1 + \beta(1 - \varepsilon)} < \frac{\alpha W}{x} [1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] = \frac{1 + \beta}{\beta} (1 - \alpha x^{\alpha-1}) \end{aligned}$$

For a given  $W$ ,  $\frac{1+\beta}{\beta}(1 - \alpha x^{\alpha-1})$  is increasing in  $\gamma$ , and keeping  $W$  fixed wages remain in the bargaining set up to the point at which  $\frac{1+\beta}{\beta}(1 - \alpha x^{\alpha-1}) = (1 - \alpha)$ . But since  $\frac{(1-\varepsilon)(1+\beta)}{1+\beta(1-\varepsilon)} < 1$ , the left hand side of the inequality is less than  $(1 - \alpha)$ . Thus, for any  $W$  we can always find a range of  $\gamma$  above a threshold  $\bar{\gamma}$  such that

$$((1 - \alpha) \frac{(1 - \varepsilon)(1 + \beta)}{1 + \beta(1 - \varepsilon)}) < \frac{\alpha W}{x} [1 + (\frac{x^{1-\alpha}}{\alpha} - 1) \exp(\gamma \sigma_z^2)] < (1 - \alpha) \quad (\text{B.32})$$

□

## C Model

This section contains a detailed derivation of the real business cycle model that we use in our main analysis.

### C.1 Households

The economy is populated by a representative household with a continuum of members of unit measure. In period  $t$ , the household chooses aggregate consumption ( $C_t$ ), government bond holdings ( $B_{t+1}$ ), corporate bond holdings ( $B_{t+1}^c$ ), and firm share holdings ( $X_{t+1}$ ), to maximize lifetime utility

$$V_t = \max \left[ (1 - \beta) C_t^{1-1/\psi} + \beta (\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1-1/\psi}{1-\gamma_t}} \right]^{\frac{1}{1-1/\psi}} \quad (\text{C.1})$$

subject to the period budget constraint, denoted in terms of the consumption numeraire,

$$C_t + P_t^e X_{t+1} + Q_t^c (B_{t+1}^c - dB_t^c) + \frac{1}{R_t^r} B_{t+1} \leq (D_t^e + P_t^e) X_t + B_t^c + B_t + E_t^l. \quad (\text{C.2})$$

In the above,  $Q_t^c$  is price of a multi-period corporate bond with average duration  $(1-d)^{-1}$ ,  $R_t^r$  is the one-period safe real interest rate,  $P_t^e$  is the price of a share of the representative firms that pays a real dividend  $D_t^e$ , and  $E_t^l$  is the household's total labor earnings (detailed below). Risk aversion is denoted by  $\gamma_t$ , while  $\psi$  is the intertemporal elasticity of substitution.

Epstein-Zin preferences imply the following stochastic discount factor:

$$M_{t,t+1} = \left( \frac{\partial V_t / \partial C_{t+1}}{\partial V_t / \partial C_t} \right) = \beta \left( \frac{C_{t+1}}{C_t} \right)^{1-1/\psi} \left( \frac{C_t}{C_{t+1}} \right) \left( \frac{V_{t+1}}{(\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1}{1-\gamma_t}}} \right)^{1/\psi-\gamma_t}. \quad (\text{C.3})$$

The first order conditions for the households yield

$$\begin{aligned} 1 &= R_t^r \mathbb{E}_t M_{t,t+1}, \\ P_t^E &= \mathbb{E}_t [M_{t,t+1} (D_{t+1}^E + P_{t+1}^E)], \\ Q_t^c &= \mathbb{E}_t [M_{t,t+1} (dQ_{t+1}^c + 1)]. \end{aligned}$$

## C.2 Firms

The representative firm chooses  $N_{1,t}$ ,  $N_{2,t}$ ,  $v_{1,t}$ ,  $v_{2,t}$ ,  $K_{t+1}$ , and  $I_t$  to maximize its discounted cash flow:

$$\max \mathbb{E}_t \sum_{s=0}^{\infty} \left( \frac{\partial V_t / \partial C_{t+s}}{\partial V_t / \partial C_t} \right) D_{t+s}, \quad (\text{C.4})$$

subject to the production function:

$$Y_t \leq (K_t)^\alpha (Z_t N_t)^{1-\alpha}, \quad (\text{C.5})$$

and the labor aggregator:

$$N_t = \left( (1-\Omega) N_{1,t}^{\frac{\theta-1}{\theta}} + \Omega N_{2,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad (\text{C.6})$$

The capital accumulation equation is

$$K_{t+1} = \left(1 - \delta - \frac{\phi_K}{2} \left(\frac{I_t}{K_t} - \delta\right)^2\right) K_t + I_t, \quad (\text{C.7})$$

and the laws of motion for employment in the full-time and part-time sectors are given by

$$N_{1,t} = (1 - \rho_1)N_{1,t-1} + \Theta_{1,t}v_{1,t}, \quad (\text{C.8})$$

$$N_{2,t} = (1 - \rho_2)N_{2,t-1} + \Theta_{2,t}v_{2,t}. \quad (\text{C.9})$$

where  $\rho_1$  and  $\rho_2$  are exogenous separation rates. The cash flows of the firm are given by

$$D_t = Y_t - W_{1,t}N_{1,t} - W_{2,t}N_{2,t} - I_t - \varphi_{1,t}v_{1,t} - \varphi_{2,t}v_{2,t}. \quad (\text{C.10})$$

The problem of the firms yields the following equilibrium conditions:

$$q_t = \mathbb{E}_t \left[ M_{t+1} \left( R_{t+1}^K + q_{t+1} \left( 1 - \delta - \frac{\phi_K}{2} \left( \frac{I_{t+1}}{K_{t+1}} - \delta \right)^2 + \phi_K \left( \frac{I_{t+1}}{K_{t+1}} - \delta \right) \frac{I_{t+1}}{K_{t+1}} \right) \right) \right] \quad (\text{C.11})$$

$$\frac{1}{q_t} = 1 - \phi_K \left( \frac{I_t}{K_t} - \delta \right), \quad (\text{C.12})$$

$$R_t^K K_t = \alpha (K_t)^\alpha (Z_t N_t)^{1-\alpha}, \quad (\text{C.13})$$

$$(\text{C.14})$$

and finally

$$\frac{\varphi_{1,t}}{\Theta_{1,t}} = (1 - \Omega)(1 - \alpha)Z_t \left( \frac{K_t}{Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{1,t}} \right)^{\frac{1}{\theta}} - W_{1,t} + \mathbb{E}_t \left\{ M_{t,t+1} \frac{(1 - \rho_1)\varphi_{1,t+1}}{Q_{1,t+1}^m} \right\}, \quad (\text{C.15})$$

$$\frac{\varphi_{2,t}}{\Theta_{2,t}} = \Omega(1 - \alpha)Z_t \left( \frac{K_t}{Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} - W_{2,t} + \mathbb{E}_t \left\{ M_{t,t+1} \frac{(1 - \rho_2)\varphi_{2,t+1}}{Q_{2,t+1}^m} \right\}. \quad (\text{C.16})$$

In equilibrium  $\Theta_{i,t} = \frac{m_i(S_{i,t}, v_{i,t})}{v_{i,t}}$  where  $m_i$  is the Cobb-Douglas matching function for sector  $i$ . The equilibrium wages in each sector are given by:

$$W_{1,t} = \Gamma_t \eta_1 \left[ (1 - \Omega)(1 - \alpha) \left( \frac{K}{N} \right)^\alpha \left( \frac{N}{N_1} \right)^{\frac{1}{\theta}} + \varphi_1 v_1 / S_1 \right] + (1 - \eta_1) \Gamma_t b_1, \quad (\text{C.17})$$

$$W_{2,t} = \eta_2 \left[ \Omega(1 - \alpha) Z_t \left( \frac{K_t}{Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} + \varphi_{2,t} v_{2,t} / S_{2,t} \right] + (1 - \eta_2) b_{2,t}. \quad (\text{C.18})$$

Workers search sequentially in the two sectors. All unemployed workers at the beginning of period  $t$  first try to find a job in sector one. If the search is unsuccessful, a given worker searches in the second sector. Accordingly, the mass of searchers in the two sectors is given by

$$S_{1,t} = 1 - (1 - \rho_1) N_{1,t-1} - (1 - \rho_2) N_{2,t-1}, \quad (\text{C.19})$$

$$S_{2,t} = 1 - N_{1,t} - (1 - \rho_2) N_{2,t-1}, \quad (\text{C.20})$$

where the total labor force has been normalized to unity.

### C.3 Equilibrium

An equilibrium of the economy is a sequence for  $\{Y_t, C_t, I_t, G_t, K_t, v_{1,t}, v_{2,t}, N_t, N_{1,t}, N_{2,t}, S_{1,t}, S_{2,t}, R_t^K, q_t, R_t^r, M_t, V_t, W_{1,t}, W_{2,t}, P_t^E, D_t^E, B_t^c, Q_t^c, \Gamma_t\}$  that satisfies the following conditions:

$$Y_t = (K_t)^\alpha (Z_t N_t)^{1-\alpha}, \quad (\text{C.21})$$

$$N_t = \left( (1 - \Omega) N_{1,t}^{\frac{\theta-1}{\theta}} + \Omega N_{2,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad (\text{C.22})$$

$$N_{2,t} = (1 - \rho_1) N_{2,t-1} + m_2(S_{2,t}, v_{2,t}), \quad (\text{C.23})$$

$$N_{1,t} = (1 - \rho_2) N_{2,t-1} + m_1(S_{1,t}, v_{1,t}), \quad (\text{C.24})$$

$$S_{1,t} = 1 - (1 - \rho_1) N_{1,t-1} - (1 - \rho_2) N_{2,t-1}, \quad (\text{C.25})$$

$$S_{2,t} = 1 - N_{1,t} - (1 - \rho_2) N_{2,t-1}, \quad (\text{C.26})$$

$$\begin{aligned} \frac{\varphi_{1,t} v_{1,t}}{m_1(S_{1,t}, v_{1,t})} &= (1 - \Omega)(1 - \alpha) Z_t \left( \frac{K_t}{Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{1,t}} \right)^{\frac{1}{\theta}} - W_{1,t} + \\ &+ \mathbb{E}_t \left\{ M_{t,t+1} \frac{(1 - \rho_1) \varphi_{1,t+1} v_{1,t+1}}{m_1(S_{1,t+1}, v_{1,t+1})} \right\}, \end{aligned} \quad (\text{C.27})$$

$$\frac{\varphi_{2,t}v_{2,t}}{m_2(S_{2,t}, v_{2,t})} = \Omega(1 - \alpha)Z_t \left( \frac{K_t}{Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} - W_{2,t} + \quad (\text{C.28})$$

$$+ \mathbb{E}_t \left\{ M_{t,t+1} \frac{(1 - \rho_2)\varphi_{2,t+1}v_{2,t+1}}{m_2(S_{2,t+1}, v_{2,t+1})} \right\},$$

$$W_{1,t} = \Gamma_t \eta \left[ (1 - \Omega)(1 - \alpha) \left( \frac{K}{N} \right)^\alpha \left( \frac{N}{N_1} \right)^{\frac{1}{\theta}} + \varphi_1 \frac{v_1}{S_1} \right] + (1 - \eta)\Gamma_t b_1, \quad (\text{C.29})$$

$$W_{2,t} = \eta \left[ \Omega(1 - \alpha)Z_t \left( \frac{K_t}{Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} + \varphi_{2,t} \frac{v_{2,t}}{S_{2,t}} \right] + (1 - \eta)b_{2,t}, \quad (\text{C.30})$$

$$M_{t,t+1} = \beta \left( \frac{C_{t+1}}{C_t} \right)^{1-1/\psi} \left( \frac{C_t}{C_{t+1}} \right) \left( \frac{V_{t+1}}{(\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1}{1-\gamma_t}}} \right)^{1/\psi-\gamma_t}, \quad (\text{C.31})$$

$$P_t^E = \mathbb{E}_t [M_{t,t+1} (D_{t+1}^E + P_{t+1}^E)], \quad (\text{C.32})$$

$$Q_t^c = \mathbb{E}_t [M_{t,t+1} (dQ_{t+1}^c + 1)], \quad (\text{C.33})$$

$$1 = R_t^r \mathbb{E}_t M_{t,t+1}, \quad (\text{C.34})$$

$$R_t^K = \alpha \left( \frac{K_t}{Z_t N_t} \right)^{\alpha-1}, \quad (\text{C.35})$$

$$q_t = \mathbb{E}_t [M_{t+1} (R_{t+1}^K + \quad (\text{C.36})$$

$$+ q_{t+1} \left( 1 - \delta - \frac{\phi_K}{2} \left( \frac{I_{t+1}}{K_{t+1}} - \delta \right)^2 + \phi_K \left( \frac{I_{t+1}}{K_{t+1}} - \delta \right) \frac{I_{t+1}}{K_{t+1}} \right)],$$

$$K_{t+1} = \left( 1 - \delta \frac{\phi_K}{2} \left( \frac{I_t}{K_t} - \delta \right)^2 \right) K_t + I_t, \quad (\text{C.37})$$

$$\frac{1}{q_t} = 1 - \phi_K \left( \frac{I_t}{K_t} - \delta \right), \quad (\text{C.38})$$

$$Y_t = C_t + I_t + \gamma_1 v_{1,t} + \gamma_2 v_{2,t} + G_t, \quad (\text{C.39})$$

$$G_t = \bar{g} Y_t, \quad (\text{C.40})$$

$$D_t^E = Y_t - W_{1,t} N_{1,t} - W_{2,t} N_{2,t} - I_t - \varphi_{1,t} v_{1,t} - \varphi_{2,t} v_{2,t} - B_t^c + \xi K_{t+1}, \quad (\text{C.41})$$

$$B_{t+1}^c = dB_t^c + \xi K_{t+1} / Q_t^c, \quad (\text{C.42})$$

$$V_t = \max \left[ (1 - \beta)(C_t)^{1-1/\psi} + \beta(\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1-1/\psi}{1-\gamma_t}} \right]^{\frac{1}{1-1/\psi}}, \quad (\text{C.43})$$

$$\Gamma_{t+1} = \Gamma_t^\omega Z_t^{1-\omega}. \quad (\text{C.44})$$



## C.4 Stationary Equilibrium

The model economy follows a balanced-growth path driven by the technology process,  $Z_t$ , which we assume is integrated of order one and follows an AR(1) in log-growth rates:

$$\log(Z_t) = \log(Z_{t-1}) + \sigma_z \epsilon_t^z, \quad (\text{C.45})$$

To describe the dynamics of the model in terms of stationary variables, we stationarize any of the trending variables,  $X_t$ , by defining their stationary counterpart,  $\hat{X}_t \equiv \frac{X_t}{Z_{t-1}}$ . The equilibrium of the economy in terms of these stationary variables is a sequence for  $\{\hat{Y}_t, \hat{C}_t, \hat{I}_t, \hat{G}_t, \hat{K}_t, \hat{v}_{1,t}, v_{2,t}, N_t, N_{1,t}, N_{2,t}, S_{1,t}, S_{2,t}, R_t^K, q_t, R_t^r, M_t, \hat{V}_t, \hat{W}_{1,t}, \hat{W}_{2,t}, \hat{P}_t^E, \hat{D}_t^E, \hat{B}_t^c, Q_t^c, \hat{\Gamma}_t\}$  that satisfies the following conditions:

$$\hat{Y}_t = (\hat{K}_t)^\alpha (\Delta Z_t N_t)^{1-\alpha}, \quad (\text{C.46})$$

$$N_t = \left( (1 - \Omega) N_{1,t}^{\frac{\theta-1}{\theta}} + \Omega N_{2,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad (\text{C.47})$$

$$N_{2,t} = (1 - \rho_1) N_{2,t-1} + m_2(S_{2,t}, v_{2,t}), \quad (\text{C.48})$$

$$N_{1,t} = (1 - \rho_2) N_{2,t-1} + m_1(S_{1,t}, v_{1,t}), \quad (\text{C.49})$$

$$S_{1,t} = 1 - (1 - \rho_1) N_{1,t-1} - (1 - \rho_2) N_{2,t-1}, \quad (\text{C.50})$$

$$S_{2,t} = 1 - N_{1,t} - (1 - \rho_2) N_{2,t-1}, \quad (\text{C.51})$$

$$\frac{\hat{\Gamma}_t \varphi_1 v_{1,t}}{m_1(S_{1,t}, v_{1,t})} = (1 - \Omega)(1 - \alpha) \Delta Z_t \left( \frac{\hat{K}_t}{\Delta Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{1,t}} \right)^{\frac{1}{\theta}} - \hat{W}_{1,t} +$$

$$+ \mathbb{E}_t \left\{ M_{t,t+1} \Delta Z_t \frac{(1 - \rho_1) \hat{\Gamma}_{t+1} \varphi_1 v_{1,t+1}}{m_1(S_{1,t+1}, v_{1,t+1})} \right\},$$

$$\frac{\hat{\Gamma}_t \varphi_2 v_{2,t}}{m_2(S_{2,t}, v_{2,t})} = \Omega(1 - \alpha) \Delta Z_t \left( \frac{\hat{K}_t}{\Delta Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} - \hat{W}_{2,t} +$$

$$+ \mathbb{E}_t \left\{ M_{t,t+1} \Delta Z_t \frac{(1 - \rho_2) \hat{\Gamma}_{t+1} \varphi_2 v_{2,t+1}}{m_2(S_{2,t+1}, v_{2,t+1})} \right\},$$

$$\hat{W}_{1,t} = \hat{\Gamma}_t \eta \left[ (1 - \Omega)(1 - \alpha) \left( \frac{\hat{K}}{N} \right)^\alpha \left( \frac{N}{N_1} \right)^{\frac{1}{\theta}} + \varphi_1 \frac{v_1}{S_1} \right] + (1 - \eta) \hat{\Gamma}_t b_1, \quad (\text{C.54})$$

$$\hat{W}_{2,t} = \eta \left[ \Omega(1 - \alpha) \Delta Z_t \left( \frac{\hat{K}_t}{\Delta Z_t N_t} \right)^\alpha \left( \frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} + \hat{\Gamma}_t \varphi_2 \frac{v_{2,t}}{S_{2,t}} \right] + (1 - \eta) \hat{\Gamma}_t b_2, \quad (\text{C.55})$$

$$M_{t,t+1} = \beta \left( \frac{\hat{C}_{t+1} \Delta Z_t}{\hat{C}_t} \right)^{1-1/\psi} \left( \frac{\hat{C}_t}{\hat{C}_{t+1} \Delta Z_t} \right) \left( \frac{\hat{V}_{t+1}}{(\mathbb{E}_t \hat{V}_{t+1}^{1-\gamma_t})^{\frac{1}{1-\gamma_t}}} \right)^{1/\psi - \gamma_t}, \quad (\text{C.56})$$

$$\hat{P}_t^E = \mathbb{E}_t \left[ M_{t,t+1} \Delta Z_t \left( \hat{D}_{t+1}^E + \hat{P}_{t+1}^E \right) \right], \quad (\text{C.57})$$

$$Q_t^c = \mathbb{E}_t \left[ M_{t,t+1} (dQ_{t+1}^c + 1) \right], \quad (\text{C.58})$$

$$1 = R_t^r \mathbb{E}_t M_{t,t+1}, \quad (\text{C.59})$$

$$R_t^K = \alpha \left( \frac{\hat{K}_t}{\Delta Z_t N_t} \right)^{\alpha-1}, \quad (\text{C.60})$$

$$q_t = \mathbb{E}_t \left[ M_{t,t+1} \left( R_{t+1}^K + \right. \right. \quad (\text{C.61})$$

$$\left. + q_{t+1} \left( 1 - \delta - \frac{\phi_K}{2} \left( \frac{\hat{I}_{t+1}}{\hat{K}_{t+1}} - \delta \right)^2 + \phi_K \left( \frac{\hat{I}_{t+1}}{\hat{K}_{t+1}} - \delta \right) \frac{\hat{I}_{t+1}}{\hat{K}_{t+1}} \right) \right],$$

$$\hat{K}_{t+1} = \left( 1 - \delta - \frac{\phi_K}{2} \left( \frac{\hat{I}_t}{\hat{K}_t} - \delta \right)^2 \right) \frac{\hat{K}_t}{\Delta Z_t} + \frac{\hat{I}_t}{\Delta Z_t}, \quad (\text{C.62})$$

$$\frac{1}{q_t} = 1 - \phi_K \left( \frac{\hat{I}_t}{\hat{K}_t} - \delta \right), \quad (\text{C.63})$$

$$\hat{Y}_t = \hat{C}_t + \hat{I}_t + \hat{\Gamma}_t \gamma_1 v_{1,t} + \hat{\Gamma}_t \gamma_2 v_{2,t} + \Delta Z_t \bar{g} Y, \quad (\text{C.64})$$

$$\hat{G}_t = \Delta Z_t \bar{g} Y, \quad (\text{C.65})$$

$$\hat{D}_t^E = \hat{Y}_t - \hat{W}_{1,t} N_{1,t} - \hat{W}_{2,t} N_{2,t} - \hat{I}_t - \Gamma_t (\varphi_1 v_{1,t} + \varphi_2 v_{2,t}) - \hat{B}_t^c + \xi \frac{\hat{K}_{t+1}}{\Delta Z_t}, \quad (\text{C.66})$$

$$\hat{B}_{t+1}^c = d\hat{B}_t^c / \Delta Z_t + \xi \hat{K}_{t+1} / Q_t^c, \quad (\text{C.67})$$

$$\hat{V}_t = \max \left[ (1 - \beta) (\hat{C}_t)^{1-1/\psi} + \Delta Z_t^{1-1/\psi} \beta (\mathbb{E}_t \hat{V}_{t+1}^{1-\gamma_t})^{\frac{1-1/\psi}{1-\gamma_t}} \right]^{\frac{1}{1-1/\psi}}, \quad (\text{C.68})$$

$$\hat{\Gamma}_{t+1} = \hat{\Gamma}_t^\omega (\Delta Z_t)^{-\omega}. \quad (\text{C.69})$$

## C.5 Labor Market Search

We assume that workers in the economy search for a job sequentially, first in the full-time and, if they fail to find a full-time job, then in the part-time sector. In what follows, we derive conditions under which this sequence is optimal. We verify *ex post* that these conditions hold in our estimated model.

Let us define the value of a matched worker in sector 1 and 2 and the value of unem-

ployment as:

$$\mathbb{W}_t^1 = W_{1,t} + \mathbb{E}_t \left\{ M_{t,t+1} \left[ (1 - \rho_1) \mathbb{W}_{t+1}^1 + \rho_1 \max\{\mathbb{S}_{t+1}^1, \mathbb{S}_{t+1}^2, \mathbb{U}_{t+1}\} \right] \right\}, \quad (\text{C.70})$$

$$\mathbb{W}_t^2 = (W_{2,t} + \kappa_t) + \mathbb{E}_t \left\{ M_{t,t+1} \left[ (1 - \rho_2) \mathbb{W}_{t+1}^2 + \rho_2 \max\{\mathbb{S}_{t+1}^1, \mathbb{S}_{t+1}^2, \mathbb{U}_{t+1}\} \right] \right\}, \quad (\text{C.71})$$

$$\mathbb{U}_t = b_2 + \mathbb{E}_t \left\{ M_{t,t+1} \max\{\mathbb{S}_{t+1}^1, \mathbb{S}_{t+1}^2, \mathbb{U}_{t+1}\} \right\}, \quad (\text{C.72})$$

where  $\mathbb{S}_t^1$  and  $\mathbb{S}_t^2$  are, respectively, the expected value of searching in both sectors sequentially or just in the part-time sector:

$$\mathbb{S}_t^1 = P_{1,t}^m \mathbb{W}_t^1 + (1 - P_{1,t}^m) \mathbb{S}_t^2. \quad (\text{C.73})$$

$$\mathbb{S}_t^2 = P_{2,t}^m \mathbb{W}_t^2 + (1 - P_{2,t}^m) \mathbb{U}_t. \quad (\text{C.74})$$

Equations (C.70)-(C.72) reflect the assumption that as soon as workers separate from their employers, they can immediately begin to search. A worker will always prefer to search at least in the part time sector instead of foregoing search if

$$\mathbb{S}_t^2 \geq \mathbb{U}_t. \quad (\text{C.75})$$

Looking the definition of  $\mathbb{U}_t$  makes clear that this condition will be satisfied if  $b_{2,t}$  is not too large. In other words, the monetary compensations from not searching at all cannot be too high. We verify this condition ex post and we assume it for the rest of the argument so that  $\max\{\mathbb{S}_{t+1}^1, \mathbb{S}_{t+1}^2, \mathbb{U}_{t+1}\} = \max\{\mathbb{S}_{t+1}^1, \mathbb{S}_{t+1}^2\}$ . For a worker to weakly strictly prefer to search in both sectors we need:

$$\mathbb{S}_t^1 \geq \mathbb{S}_t^2. \quad (\text{C.76})$$

Inspection of the above equations reveals that a necessary condition for this to hold is that  $\kappa_t$  be not too large. That is, the non-wage compensation from working only part-time should not be too high. If both these conditions are satisfied, we can replace the definitions in (C.70)-(C.72) with

$$\mathbb{W}_t^1 = W_{1,t} + \mathbb{E}_t \left\{ M_{t,t+1} \left[ (1 - \rho_1) \mathbb{W}_{t+1}^1 + \rho_1 \mathbb{S}_{t+1}^1 \right] \right\}, \quad (\text{C.77})$$

$$\mathbb{W}_t^2 = (W_{2,t} + \kappa_t) + \mathbb{E}_t \left\{ M_{t,t+1} \left[ (1 - \rho_2) \mathbb{W}_{t+1}^2 + \rho_2 \mathbb{S}_{t+1}^1 \right] \right\}, \quad (\text{C.78})$$

$$\mathbb{U}_t = b_2 + \mathbb{E}_t \left\{ M_{t,t+1} \mathbb{S}_{t+1}^1 \right\}, \quad (\text{C.79})$$

Equations (C.77)-(C.79) together with (C.73)-(C.74) define the variables  $\{\mathbb{W}_t^1, \mathbb{W}_t^2, \mathbb{S}_t^1, \mathbb{S}_t^2, \mathbb{U}_t\}$  under the assumption that conditions (C.75)-(C.76) hold.

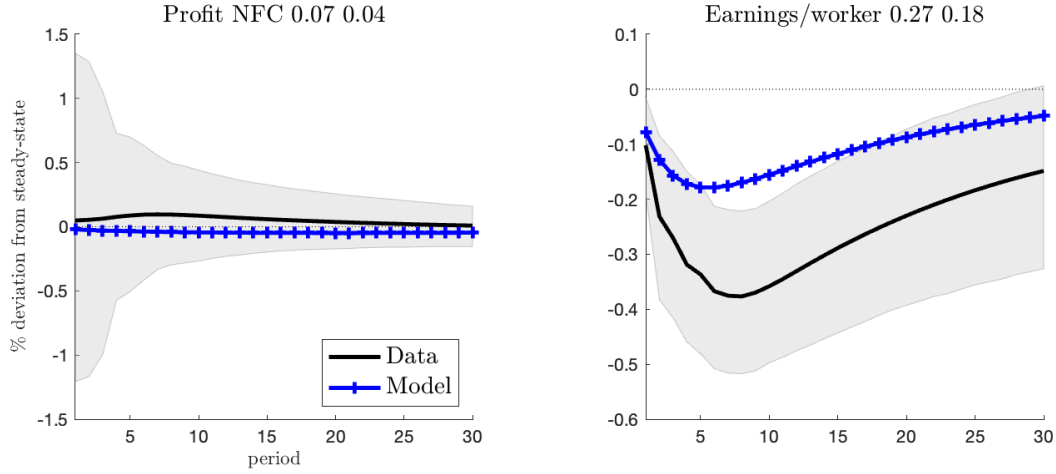


Figure D.1: Response of discounted profits and earnings-per-worker in model and data.

We verify the inequalities above in our estimated model and find that they each hold in the (non-stochastic) steady-state of our economy. Since our model is estimated locally, this is all that is required for our procedure to be coherent. As an additional check, however, we verified the conditions also hold in the stochastic steady-state of the model. Finally, across a long simulation of the economy, we find condition (C.76) holds in over 99% of periods, and C.75 holds in over 85% of periods.

## D Earnings-per-worker

Our assumptions about sticky wages in the full-time sector are stark for simplicity. Of course, the literature has come to contrasting and often opposed conclusions about the cyclicity of wages. One straightforward and common measure of wages is earnings-per-worker. The second panel of Figure D.1 plots the empirical and model implied response of earnings-per-worker, under our baseline empirical and model estimates.

The figure shows that earnings-per-worker fall modestly in response to the shock both in the data and in the model. While the model fall is somewhat less than in the data, it falls in or near the empirical confidence band. In the model, there are two reasons this measure of wages shows non-trivial adjustment in response to risk shocks, even though the wages of full-times workers do not respond. First, the wages of existing part-time workers are flexible and they fall in response to the shock. Second, the share of part time workers grows in the model as a share of total employment: since those workers have lower

earnings, this also reduces earnings-per-worker. We conclude from this figure that, while our assumptions about wages are probably an oversimplification, the overall implications for earnings-per-worker are not strongly counterfactual.

## E Alternative Estimation Procedure

Our baseline estimation procedure compares theoretical impulse responses to those estimated from a particular empirical procedure on real data. In general, however, applying our empirical procedure to data generated by the model only imperfectly identifies the theoretical response to risk aversion disturbances. To alleviate concern that our results could be driven by potential misspecification of the identification procedure, we reestimated the model using an alternative procedure that aligns analogous objects in the model and data. In particular, define  $\hat{\Psi}^m(\Pi)$  to be the vector of impulse responses generated by applying our exact empirical procedure to a sample of 5,000 period of data generated by the model under parameter vector  $\Pi$  (stacked along with the same unconditional moments as  $\Psi(\Pi)$ ). Then, the parameter vector is estimated to minimize the loss function

$$\mathcal{L}^m(\Pi) \equiv (\hat{\Psi} - \hat{\Psi}^m(\Pi))'W(\hat{\Psi} - \hat{\Psi}^m(\Pi)). \quad (\text{E.1})$$

Figure E.1 presents the impulse response for the model when reestimated in this way. The figure shows that the model impulse responses are very similar to our baseline procedure. The second column of Table E.1 shows the parameters of the reestimated model. The estimated risk aversion parameter is modestly higher, as is the elasticity between the two types of labor, but other parameters remain close to our baseline estimated.

## F Low IES results

To emphasize that a high intertemporal elasticity is not essential for our results, Figure E.2 plots the implied impulse response for the model, estimated with  $\psi = 0.5$ . The model match the data nearly as well as in our baseline, but with a somewhat larger miss on the interest rate response. The third column of Table E.1 presents the parameters estimated in this case.

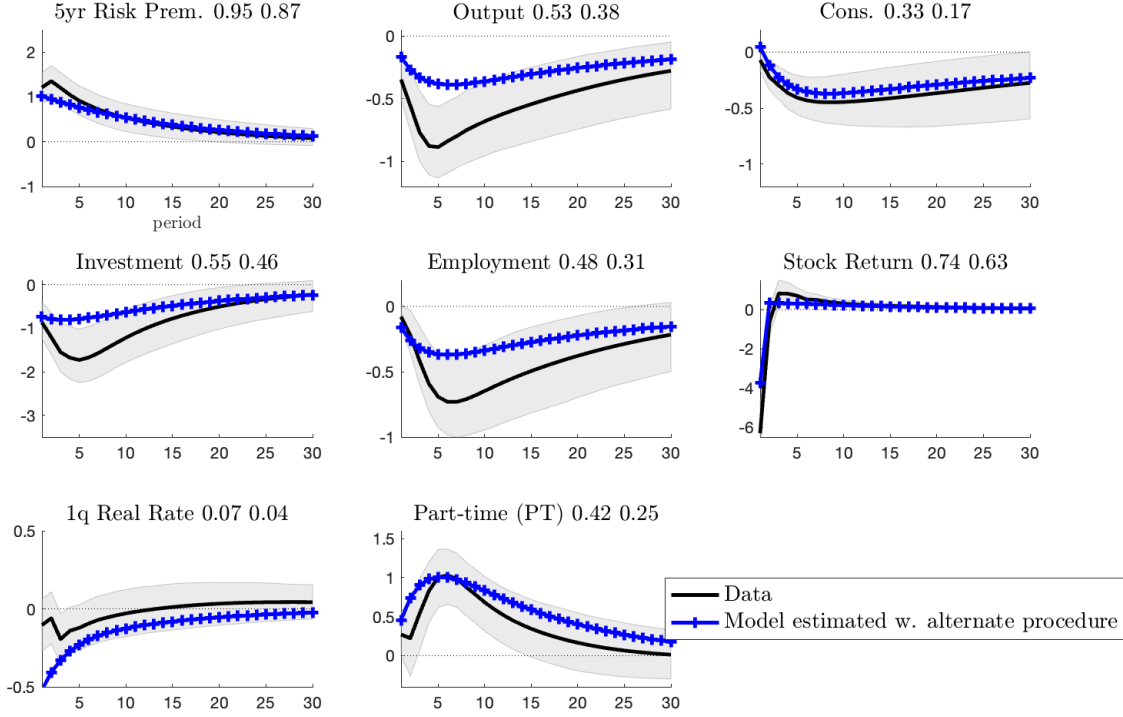


Figure E.1: Model responses when estimated using alternative procedure.

Table E.1: Estimated Parameters

Name	Description	Base Est.	Alt. Procedure	Low IES
$\gamma_{ss}$	Steady-state risk aversion	42.263	67.860	91.270
$\nu$	Leverage Ratio	0.792	0.763	0.541
<b>Labor Markets</b>				
$\varphi_1$	Vacancy posting cost - FT	1.087	0.933	2.323
$\varphi_2$	Vacancy posting cost - PT	0.058	0.051	0.078
$b_1$	Value if no perm posit.	1.088	1.049	1.132
$b_2$	Value if unemployed	0.497	0.498	0.484
$\Omega$	Labor contrib. of PT	0.199	0.217	0.175
$\theta$	Elas. between FT & PT	3.547	5.000	2.693
$\epsilon_1$	Matching elasticity - FT	0.492	0.547	0.214
$\epsilon_2$	Matching elasticity - PT	0.975	0.975	0.891
$\chi_1$	Matching technology - FT	0.646	0.669	0.405
$\chi_2$	Matching technology - PT	2.661	2.936	1.770
$\omega$	Gradual wage adj.	0.966	0.943	0.990
<b>Risk Aversion Process</b>				
$\rho_\gamma$	AR(1) risk av. shock	0.935	0.931	0.948
$\sigma_\gamma$	Std. dev. of risk av. shock	0.465	0.338	0.322

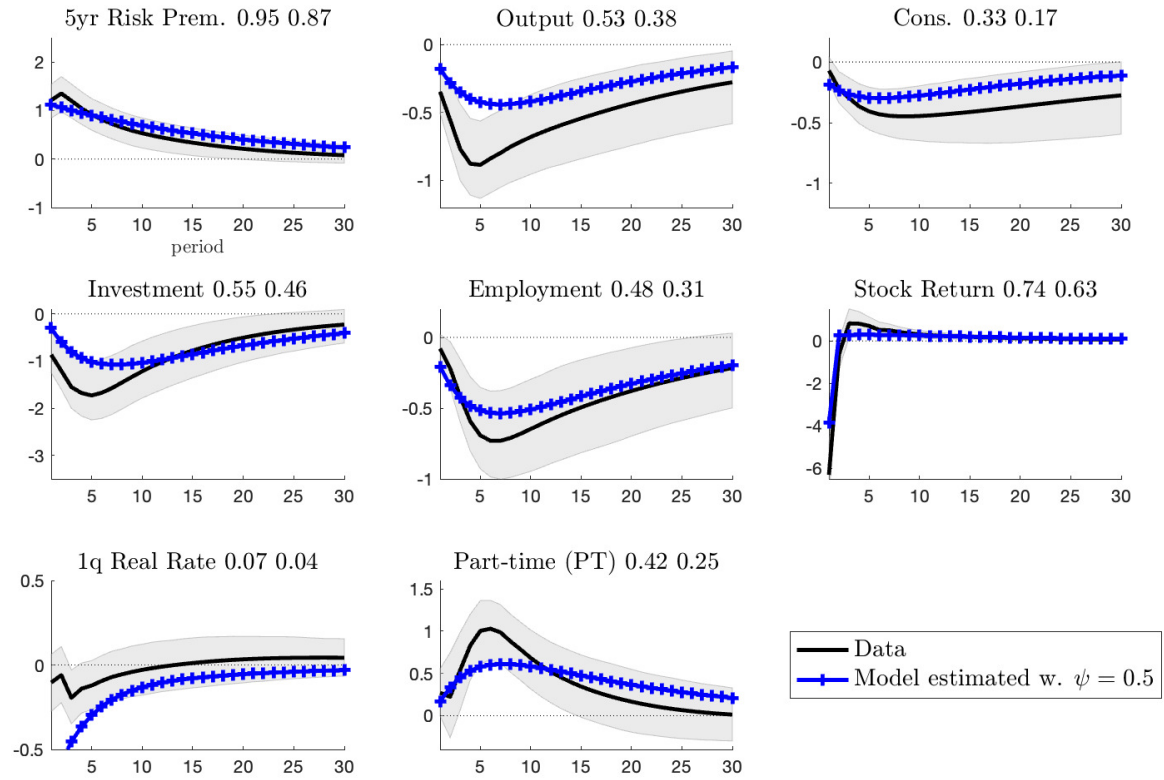


Figure E.2: Model responses with low intertemporal elasticity of substitution.