

Risky Business Cycles*

Susanto Basu[†]
Boston College
and NBER

Giacomo Candian[‡]
HEC Montréal

Ryan Chahrour[§]
Boston College

Rosen Valchev[¶]
Boston College

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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 permanent positions, towards part-time and flexible contract workers. A flexible-price model with labor market frictions and fluctuations in risk appetite can explain all of these facts, both qualitatively and quantitatively. The size of risk-driven fluctuations depends on the relationship between the riskiness and productivity of different stores of value: if safe savings vehicles have relatively low marginal products, then a flight to safety will drive a larger aggregate contraction.

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[†]Department of Economics, Boston College, Chestnut Hill, MA 02467. Telephone: 617-552-2182. Email: susanto.basu@bc.edu.

[‡]Department of Applied Economics, 3000, Chemin de la Côte-Sainte-Catherine, Montréal QC, H3T 2A7 Canada. Telephone: 514-340-6810. Email: giacomo.candian@hec.ca.

[§]Department of Economics, Boston College, Chestnut Hill, MA 02467. Telephone: 617-552-0902. Email: ryan.chahrour@bc.edu.

[¶]Department of Economics, Boston College, Chestnut Hill, MA 02467. Telephone: 617-552-8704. Email: valchev@bc.edu.

1 Introduction

Predictable time-variation in the excess returns of risky assets is among the most salient facts in financial economics (Cochrane, 2011). An extensive literature maps out the possible channels through which macroeconomic fluctuations might cause this return variation; see, for example, the classic papers by Campbell and Cochrane (1999), Bansal and Yaron (2004), and Barro (2006). This paper proposes a converse to this popular research program by asking instead: Can *ex ante* changes in required excess returns be a major driver of macroeconomic fluctuations?

We find that the answer is “yes”, both in the context of a model-free empirical analysis and in an estimated structural model with frictional labor markets. Our initial, model-free empirical analysis identifies the shock that drives the bulk of variation in expected excess stock returns, and shows that the same shock also accounts for the bulk of variation in macroeconomic quantities. Moreover, it generates the hallmark business-cycle comovements among output, consumption, investment and employment. To rationalize these results, we propose a real model where shocks to risk premia propagate to the broader economy through frictional labor markets. Estimating our model, we find that it closely replicates the patterns we identify in the data.

Generating comovement via risk-premia fluctuations is challenging in standard models because an increase in risk or risk premia leads to precautionary savings, which move consumption and investment in opposite directions.¹ By contrast, our model generates a version of the Paradox of Thrift: an increase in desired saving leads to a decline in actual saving and, therefore, to a fall in investment. The ultimate source of risk-premia fluctuations is not important for our model. Instead, our model demonstrates a feedback channel from asset prices to the real side of the economy, which can serve as a powerful transmission mechanism that generates comovement as *the consequence* of fluctuations in risk premia, regardless of their origins. We thus avoid taking a strong stand on the specific source of time-varying risk premia, which remains an open question in the literature, and focus instead on the aggregate consequences of such fluctuations.

We begin the paper with a model-free empirical exercise that aims to isolate the potential contribution of risk-premia fluctuations to business cycles. Specifically, we use a standard macroeconomic vector autoregression (VAR) and a maximum-share identifica-

¹For additional intuition, we observe that an increase in risk premia affects allocations today in the same way as bad news about future productivity (e.g. Beaudry and Portier, 2006). Thus, the literatures on risk- and news-driven fluctuations face the same Barro and King (1984) challenges to generating macroeconomic comovement.

tion procedure in the tradition of Uhlig (2003) to identify a shock that explains the largest portion of the five-year-ahead expected equity excess return, our benchmark measure of the equity risk-premium. The identified shock explains the vast majority (around 90%) of unconditional equity risk-premium fluctuations and drives persistent changes in expected excess returns with a half-life of roughly four years. Having isolated the major source of risk premium fluctuations in the data, we next examine the effects of this shock on several important macroeconomic quantities and prices.

We find that an increase in the equity premium, driven by our shock, is also associated with substantial falls in output, consumption, investment, employment, and stock returns, and only a small change in real interest rates.² Thus, our shock generates the type of comovement across macro quantities (and a “smooth” risk-free rate) that is consistent with the main stylized facts about business cycles. The identified shock also explains a substantial proportion of the overall fluctuations in macro aggregates – including over half of the unconditional fluctuations in output, consumption, investment, employment, and stock returns. Furthermore, the shock we identify explains an even greater portion of the *covariance* in the key variables of interest. For example, we find that the covariance of output and stock returns driven by our shock is even larger than the unconditional covariance between these two variables, implying that all other shocks in the data jointly drive these variables in *opposite* directions.

In addition to the main business cycle variables described above, we explore the effects of our shock on a set of additional variables that are not commonly included in business-cycle studies. In particular, we show that the identified shock, while causing a fall in aggregate hours and in total employment, leads *part-time* employment to *rise* significantly, both in absolute terms and as a share of total employment. This fact poses a particular challenge for many standard macroeconomic models which, whether driven by aggregate demand or aggregate supply shocks, generally imply that different types of labor should move in the same direction.

While our approach to identification does not impose an *ex ante* structural interpretation of the shock, the patterns we identify suggest that changes in risk premia and macroeconomic fluctuations largely share a common origin. Indeed, even though it is identified off of the variation in the equity risk-premium, our shock explains as much or more of unconditional macroeconomic fluctuations as the shock of Angeletos et al. (2020), which is also estimated with a maximum-share approach, but instead targets macro quan-

²In robustness checks, we have found aggregate hours to behave similarly to employment.

tities directly.³ Moreover, the tight connection between macroeconomic fluctuations and the measure of *expected* excess stock returns embedded in our VAR suggests that our forward-looking indicator is a useful alternative to more traditional stock market predictors that instead lack predictive power for real activity, as documented by [López-Salido et al. \(2017\)](#). However, the link between the equity risk-premium and business cycles that our shock uncovers poses a fundamental modeling challenge, as increases in risk or risk-premia push against comovement in a standard real model, because the associated increase in precautionary saving depresses consumption, but boosts investment.

To match the empirical patterns we estimate, we build a real business-cycle model with competitive output markets, frictional labor markets, capital adjustment costs, and variable capacity utilization. In our model, changes in risk premia are primarily driven by exogenous variations in risk appetite, modeled as shocks to risk aversion in the utility function. This modeling choice is motivated by the recent empirical work by [Bekaert et al. \(2019\)](#), who find that over 90% of the equity risk-premium is attributable to “risk-aversion” shocks, which are orthogonal to shocks to macroeconomic fundamentals and their volatility. Nevertheless, our theory offers a general propagation mechanism that would transmit fluctuations in risk premia to the macroeconomy regardless of their source.

A key feature of our framework is that we allow for two types of search markets for labor contracts: the first, which we call “full-time”, involves longer-term relationships and sticky real wages, while the second, which we call “part-time”, involves shorter employment spells and flexible wages.

Frictions in forming or severing labor relationships mean that labor, like capital, is a long-lived investment good (as in [Hall, 2017](#)). Thus, in addition to an overall rise in desired savings, a risk-premium shock in our model also leads to portfolio *re-allocation* as agents weigh the risk profiles of the different real savings vehicles that are available. In particular, thanks to wage rigidities in the full-time sector, which amplify the volatility of the resulting surplus accruing to the firm, the estimated model implies that full-time labor is the riskiest asset, and hence an increase in risk aversion leads firms to re-allocate investment away from vacancy postings in the full-time sector, and towards investment in part-time vacancies and physical capital.⁴ Investment in the full-time sector, however, has a relatively high instantaneous marginal product (by contrast, investment in capital goods has zero marginal product today, since capital only becomes productive tomorrow)

³Another 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.

⁴Recent empirical work by [Faia and Pezzone \(2018\)](#) confirms that wage rigidity is indeed an important source of priced risk in the cross-section of firm valuations, consistent with our model.

and the shift away from full-time vacancies ends up lowering aggregate output today. This fall in output, by changing the resource constraint, can cause investment to also fall, driving the economy into a typical business cycle where all four aggregates move together.

We quantify this savings reallocation channel by matching the consequences of a rise in risk aversion in our model to the VAR impulse responses generated by our identified risk-premium shock. We find that the model does an excellent job of matching the data, generating quantitatively realistic business cycle fluctuations in response to such shocks. In particular, the model implies that output, employment, consumption, investment, and real stock prices all fall during a risk-appetite recession. Moreover, the model matches these salient facts without implying a strong cyclical of measured final goods markups, avoiding a contentious debate (e.g. [Rotemberg and Woodford, 1999](#) vs [Nekarda and Ramey, 2013](#)).

The introduction of two types of labor improves the empirical realism of the model in several respects. First, the addition of the part-time workers with flexible wages allows the model to match recent evidence that aggregate wages are cyclical, despite the fact that wages in our full-time sector are relatively rigid. Second, the short duration of part-time jobs ensures that the model does not feature counter-factually long average job duration, thus helping it avoid [Borovicka and Borovicková \(2018\)](#)'s critique of [Hall \(2017\)](#).

Third, the part-time labor sector also helps the model deliver the deep recessions needed to reproduce the comovement of investment and consumption we find in the data. The mechanism works as follows. The increase in risk aversion encourages firms to decrease their investment in the most risky asset, long-term labor relationships. In a model with only long-term labor, this means that firms either should increase their investment or increase the dividends they pay to households, thereby pushing up consumption: depending on parameters, typically either consumption or investment should rise. The addition of the relatively-safe part-time sector provides an additional attractive outlet for this savings, but one with a relatively low marginal product nevertheless. This encourages the firm to increase investment in less-productive part-time jobs, which lowers output and increases the downward pressures on consumption and investment. Importantly, this re-allocation of employment from full-time to part-time labor conditional on a risk-premium shock is indeed a pronounced feature of the data, as we show in our empirical analysis.^{5,6}

Lastly, we observe that the role of wage rigidities in our model is distinct from the

⁵Furthermore, [Mukoyama et al. \(2018\)](#) emphasize that such re-allocation from full-time to part-time labor is crucial for understanding the over-all counter-cyclical of part-time labor in the data.

⁶While we abstract from it, re-allocation from new to old capital could provide a similar amplification mechanism. [Eisfeldt and Rampini \(2006\)](#) indeed document that such re-allocation is also counter-cyclical.

one at play in [Hall \(2005\)](#). There, conditional on TFP shocks, sticky wages amplify the volatility of the cash flows firms expect to receive from new labor relationships. In contrast to the TFP shocks, the risk-premium shocks we estimate in our model have a muted impact on future labor productivity (only indirectly, through the equilibrium fall in the other inputs to production), and thus do not lead to meaningful variations in the cash flows of labor matches. Instead, our shocks primarily affect the economy through their substantial impact on the risk-premium associated with these cash flows. We make this point clear in a counterfactual exercise which shows that, if we shut down the risk-premium fluctuations on the full-time labor sector and keep everything else the same, the model fails to produce significant real fluctuations.

We thus uncover a new way in which wage stickiness can help deliver large changes in the value of workers and resolve the [Shimer \(2005\)](#) puzzle: by driving fluctuations in the risk premia associated with labor input. Remarkably, this amplification channel does not lead to counterfactual properties in the aggregate wage. Indeed, while wage stickiness in the full-time sector is important to deliver large risk-premium fluctuation in that sector, aggregate wages in our model are significantly less rigid than in [Hall \(2005\)](#) thanks to the wage flexibility in the part-time sector.

Related Literature

Time variation in risk premia is well-documented in the finance literature (e.g. [Fama and French, 1989](#)) and our paper stresses the connection between fluctuations in risk, risk premia or risk appetite, and the business cycle in much the way that [Cochrane \(2017\)](#) proposes in general terms. Recent evidence suggests that the equity premium may even be more volatile than previously acknowledged ([Martin, 2017](#)).

Recent macroeconomic research has rekindled interest in the idea of uncertainty- or risk-driven macroeconomic fluctuations ([Gilchrist et al., 2014](#)), but many models of the phenomenon have difficulty generating full macroeconomic comovement for the reasons discussed by [Barro and King \(1984\)](#). For example, [Bloom \(2009\)](#) proposes a model of the firm where non-convex adjustment costs in investment and labor generate real-option-value effects so that an increase in aggregate risk triggers a wait-and-see reaction. The scaling back of production plans thus generates a drop in investment, employment, and output, but not consumption. Authors, such as [Gourio \(2012\)](#) and [Bloom et al. \(2018\)](#), have therefore complemented risk mechanisms with first-moment shocks to generate a drop in consumption along with these other variables. In related work, [Arellano et al. \(2019\)](#) exploit financial frictions to obtain concurrent drops in output and labor as a result

of a shock to idiosyncratic risk, but abstract from investment in physical capital.

One solution to comovement challenges 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. Moreover, New-Keynesian frictions also help deliver large movements in unemployment following uncertainty shocks in models with labor search frictions ([Leduc and Liu, 2016](#); [Challe et al., 2017](#)).⁷ 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 or suboptimal monetary policy to generate business cycle comovements. In this sense, our model provides a propagation mechanism that is consistent with the “anatomy” of business cycles that [Angeletos et al. \(2020\)](#) infer from the data — a propagation mechanism that allows for demand-driven cycles without strict reliance on nominal rigidities.

Recent work by [Di Tella and Hall \(2020\)](#) is also motivated by the objective of delivering business-cycle comovements via a risk channel, without nominal rigidities. Those authors solve the comovement problem by introducing uninsurable idiosyncratic risk, which creates uncertainty in the marginal product of labor and capital. In this environment, a rise in *idiosyncratic* uncertainty can generate a drop in investment, employment, output and consumption. Obtaining a drop in investment relies on a delicate balance of general equilibrium effects, so that the risk-driven fall in firms’ investment demand is strong enough to offset the precautionary saving motive of the household that stimulates savings.

We differ from this work along two dimensions. First, the above results rely on market incompleteness and idiosyncratic risk, while we work in a setting of complete markets and aggregate risk. Second, by modeling search frictions and long-lived labor relationships, our model treats labor as a form of investment. In turn, our real effects are driven by an empirically relevant reallocation of savings across different types of investment vehicles, which differs from the propagation mechanism of their model where labor is not long-lived.

[Hall \(2017\)](#) argues that the time variation in discount rates or risk premia that are needed to explain the swings of the stock market can also rationalize the fluctuations in unemployment. Recent papers have built on this idea to provide a risk-driven explanation of several patterns in labor markets. [Kilic and Wachter \(2018\)](#) build a model with disaster

⁷Occasionally binding downward wage rigidity also amplifies the impact of uncertainty shocks on labor market variables, with or without nominal rigidities ([Cacciatore and Ravenna, 2020](#)).

risk and real wage stickiness to help resolve the employment volatility puzzle of [Shimer \(2005\)](#). [Kehoe et al. \(2019\)](#) provide another resolution to the Shimer puzzle in a model with time-varying risk that relies on human capital accumulation instead of exploiting inefficiencies in wage contracting. [Mitra and Xu \(2019\)](#) exploit time-varying risk premia in a setting with unobserved heterogeneity in workers productivity to explain the large differences in cyclical unemployment risk across age groups. [Freund and Rendahl \(2020\)](#) show that with risk-averse households heightened uncertainty lowers employment and economic activity via a risk-premium channel that arises because of the positive comovement between consumption and firm value (i.e., equity prices).

These and other models that focus on risk-driven unemployment and asset price fluctuations, largely abstract from capital accumulation or, when capital is considered, do not focus on the comovement properties of the components of aggregate output. This limitation is important because a higher risk premium, by reducing also the demand for investment, may well drive consumption and investment in opposite directions.

2 Risk Premium Shocks

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

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

In the above, Y_t is a vector of observed variables, $B(L)$ contains the weights on past realizations of Y_t , ϵ_t is a vector of structural economic shocks, and A is the structural matrix that our procedure seeks to identify from the reduced-form residuals, $\mu_t \equiv A\epsilon_t$.

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, real per-capita consumption, real per-capita investment, per-capita employment, real ex-post stock returns (inclusive of dividends), real ex-post three-month treasury bill returns, and the level of the dividend-price ratio. Our data range from 1985Q1 through 2018Q4, starting in the mid-1980s to avoid the structural break of the start of the “Great Moderation”.⁸ The VAR is estimated in levels using ordinary least squares, including three lags in the polynomial $B(L)$.

⁸The Appendix contains more details on data definitions.

We augment our baseline VAR with a set of auxiliary variables, S_t , that includes additional labor market and business cycle indicators. These auxiliary variables are related to current and past observations of Y_t according to

$$S_t = \Gamma(L)Y_t + v_t, \quad (3)$$

and 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 (1). Among the variables in S_t , we include total employment, part-time employment, the ex-post return on five-year US bonds, and two measures of market risk perceptions that have appeared recently in the literature.

2.1 Identification Approach

Our goal is to identify a “rotation” matrix A such that the first shock explains the largest portion of the *expected* excess return on equity. Excess returns are not explicitly included in our data, but they can be computed using the variables in Y_t . Specifically, the *realized* j -period cumulative excess return is defined as

$$rp_{t,t+j} \equiv [r_{t+1}^s + r_{t+2}^s + \dots + r_{t+j}^s] - [r_{t+1}^b + r_{t+2}^b + \dots + r_{t+j}^b]. \quad (4)$$

Assuming the variables in Y_t span the information set of investors, we can use the expectations implied by the VAR to derive an expression for the expectation of the excess return:

$$\mathbb{E}_t[rp_{t,t+j}] = (e_5 - e_6) \left[(I - B(L))^{-1} \sum_{i=1}^j L^{-i} \right]_+ A \epsilon_t \quad (5)$$

where $[\cdot]_+$ denotes the annihilator operator that eliminates terms with negative powers in L .⁹

Let $\phi(z) \equiv (e_5 - e_6) \left[(I - B(z))^{-1} \sum_{i=1}^j z^{-i} \right]_+ A$ be the z transfer-function associated with the MA(∞) representation in (5). The variance of $E_t[rp_{t,t+j}]$ associated with spectra

⁹For example, in the case of a VAR(1) so that $Y_t = BY_{t-1} + A\epsilon_t$, the expression in (5) reduces to

$$E_t[RP_{t+j}] = (e_5 - e_6)(B + B^2 + \dots + B^j)(I - BL)^{-1}A\epsilon_t.$$

of periodicity $p \equiv [p_1, p_2]$ is given by

$$\sigma_p^{rp} = \frac{1}{2\pi} \int_{2\pi/p_2}^{2\pi/p_1} \phi(e^{-i\lambda}) \phi(e^{-i\lambda})' d\lambda. \quad (6)$$

Conversely, the contribution of each to the variance in the same range is given by

$$\Omega_p^{rp} = \frac{1}{2\pi} \int_{2\pi/p_2}^{2\pi/p_1} \phi(e^{-i\lambda})' \phi(e^{-i\lambda}) d\lambda. \quad (7)$$

Following Uhlig (2004), we find the shock that explains the most of σ_p^{rp} by computing q_1 , the eigenvector associated with the largest eigenvalue of Ω_p^{rp} , and setting

$$A = \hat{A}q_1, \quad (8)$$

where \hat{A} is the Cholesky decomposition of the matrix $\Sigma_\mu \equiv \text{cov}(\mu_t)$.

To implement the procedure, we need to specify the horizon at which excess returns are computed and the frequency band we want our procedure to target. As a baseline case we choose $j = 20$, consistent with common practice in the finance literature of considering variation in the five-year excess equity return. Second we choose $p = [2, 500]$, corresponding to fluctuations of periodicity anywhere between 2 and 500 quarters. Practically, this corresponds to targeting unconditional variances, 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. In robustness checks, we find our main qualitative and quantitative findings are robust to our choice of lag-length in the VAR as well as to estimating the VAR in VECM form so long as we allow for more than two independent trends in the data.

Before turning to the key empirical results, in Figure 1 we plot the expected excess stock return as estimated by our VAR, $E_t(rp_{t,t+20})$ against the realized excess return over that same forecasting horizon, $rp_{t,t+20}$. The Figure shows that both series exhibit substantial variation, though the ex-post series is not surprisingly somewhat more volatile. Moreover, the figure shows that VAR-implied excess return is, indeed, a remarkably good predictor of excess stock returns: it explains about 53% of the unconditional variation in actual realized returns. Overall, the figure emphasizes that there is a substantial predictable component in excess stock returns and that our VAR captures that predictability very well.

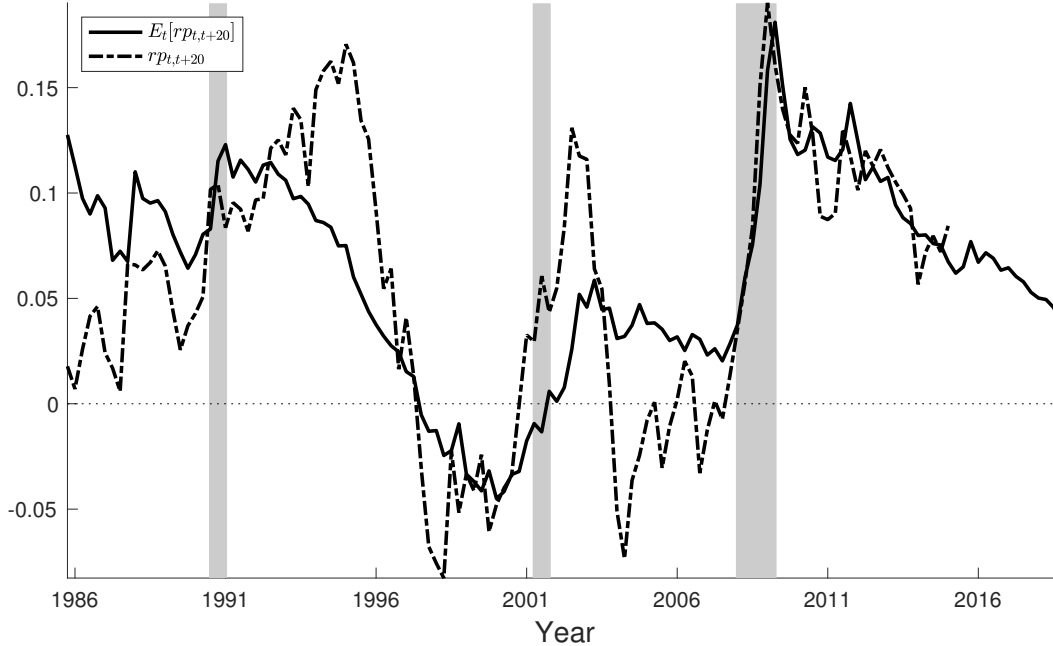


Figure 1: Ex-ante and ex-post excess stock returns.

2.2 Empirical Results

Our identification procedure based on [Uhlig \(2003\)](#) extracts the structural shock (or combination of shocks) that accounts for the bulk of the fluctuations in the VAR-implied expected excess returns. Our identification procedure cannot label the deep origins of this shock uniquely. More generally, a seminal finding of the asset pricing literature is that risk-premia are excessively volatile and not clearly attributable to any one fundamental. For example, recent work by [Bekaert et al. \(2019\)](#) finds that equity risk-premia are in fact almost entirely driven by exogenous shocks to “risk-aversion” or “risk-appetite”, emphasizing that this is a shock to the pricing of assets rather than a shock to the fundamental volatility of cash flows. Given these results, it is likely that we are recovering the same shock, hence, we will simply label the result of our identification procedure as a “risk-premium” or “risk-aversion” shock, and study how the broader set of macro variables react to such shocks. Our results can then serve as a well-defined empirical target for *any* model in which risk premia vary over time, either exogenously or endogenously as a result of some other shocks.

Figure 2 plots the impulse responses of the major business cycle variables in response to the shock identified by our VAR procedure. The first panel plots the response of the equity risk premium itself, which rises significantly on impact and stays elevated for at least four years. The numbers in the panel titles represent the percent of variance of the

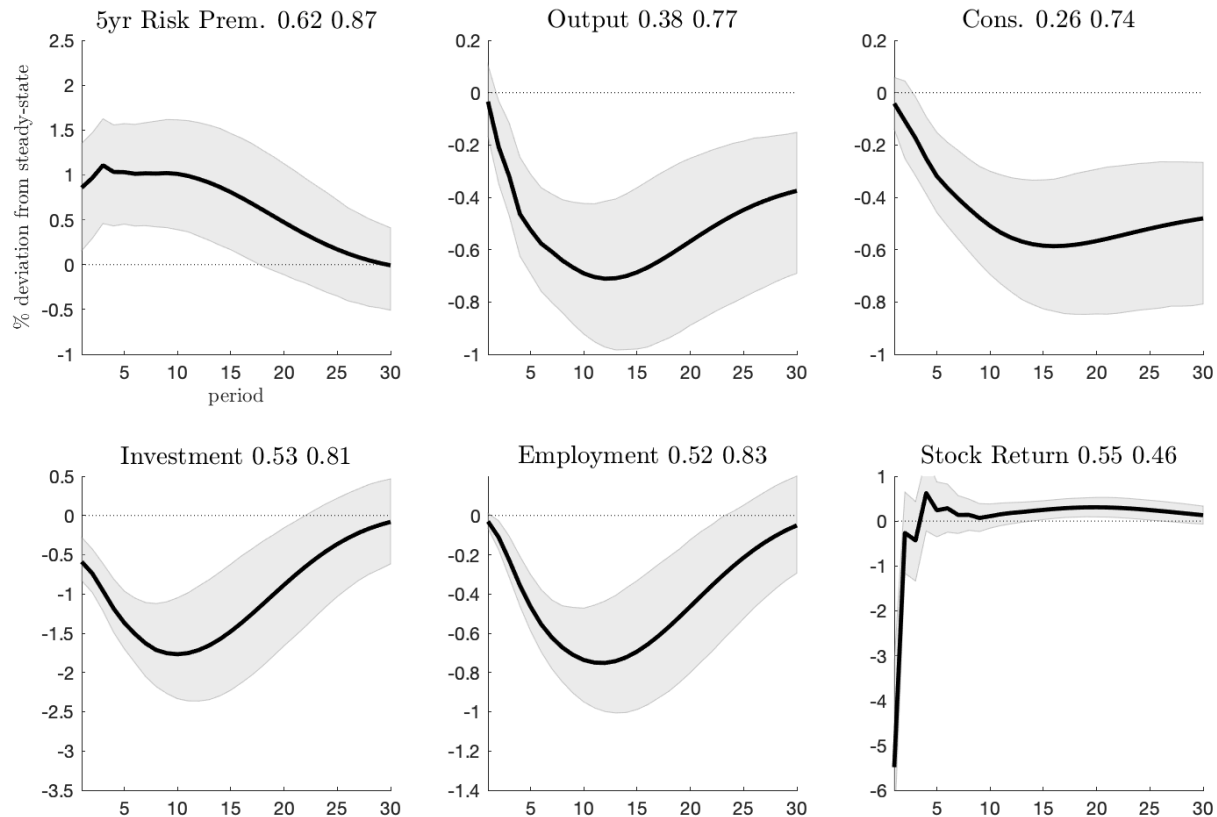


Figure 2: Impulse responses to VAR-identified risk premium shock. Numbers in subplot titles correspond to the percent of variance explained at the business cycle and unconditional frequencies, respectively.

risk premium explained by our shock at the business cycle and unconditional frequencies, respectively. Not surprisingly, since this is what our procedure targets, these numbers are high: the shock explains nearly 90% of the unconditional variation in the predictable five-year excess return of equity.

The next four panels in the figure show the responses of the main macro aggregates. The figures shows that all of these variables are substantially affected by our shock, with output, consumption, investment and employment all falling substantially on impact, and remaining depressed for an extended period. The last panel shows that the shock is also associated with a sharp drop in stock prices on impact (fall in ex-post return), followed, after more than a year, by a persistent period of higher than average returns. These eventual higher than average returns underlie the elevated risk-premium.

The titles of these five panels similarly report the percent of variance explained by the shock, and these values are also quite large: at business cycle frequencies the shock

Table 1: Unconditional Covariance Explained - Baseline Procedure

	Output	Cons.	Investment	Employment	Stock Return
Output	0.77				
Cons.	0.77	0.74			
Investment	0.85	0.93	0.81		
Employment	0.88	0.88	0.88	0.83	
Stock Return	1.29	1.00	1.41	0.99	0.46

explains more than half of variables except consumption and output and the explains substantially more than half of unconditional variations. In short, this “risk-premium” shock causes large fluctuations that follow all of the standard patterns associated with the typical business cycle, exemplified with strong comovement across Y, C, I and N .

Table 1 presents an alternative perspective on how important the identified shock is for generating comovement in the data. Each entry in the table reports the unconditional covariance 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 reported in the panel titles of Figure 2. By contrast, the off-diagonal elements are not bounded between zero and one: They will take negative values if the covariance implied by 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 covariance.

The Table shows that, as important as our shock is for the variances of each variable, it is an even more important driver of comovement among the variables. For example, the “share” of 1.29 for the covariance between output and stock returns implies that the unconditional output-stock return covariance is *smaller* than the covariance implied by our identified shock alone. Thus, all other shocks that affect output and stock prices must move them in *opposite* directions. More generally, all of the off-diagonal entries in the table are above 0.75, indicating that our identified shock explains the large majority of the unconditional comovement we find in the data.

Since our identification procedure is closely related to the “main business cycle shock” identification of Angeletos et al. (2020), it is natural to compare our findings here with theirs.¹⁰ In particular, those authors identify the shock that explains the largest portion

¹⁰Kurmann and Otrok (2013) have also followed a similar strategy, identifying the shock which best explains changes in the slope of yield curve. Interestingly, however, the shock they recover *does not*

Table 2: Unconditional Covariance Explained - Angeletos et al. (2020) procedure

	Output	Cons.	Investment	Employment	Stock Return
Output	0.62				
Cons.	0.62	0.59			
Investment	0.67	0.74	0.59		
Employment	0.72	0.74	0.67	0.66	
Stock Return	0.59	0.67	-0.20	0.64	0.51

of the (business cycle) variance of a single quantity variable, such as a measure of employment, output or investment. To compare our results, we perform their procedure on our estimated VAR by targeting just employment over business cycle frequencies.

Table 2 reports the same covariance shares as we report for our identified shock. The table shows that the shock identified using their procedure captures a somewhat smaller share of unconditional output fluctuations, as well as a smaller portion of the comovement across the variables, especially with regard to stock returns. Backing out the point estimates of identified shocks, however, the two series are strongly correlated at 89.7%. Meanwhile, though we do not report them, the corresponding impulse responses are qualitatively similar to what we find. Hence we conclude that, though we target very different portions in the data (excess returns vs employment, unconditional vs business cycles) the shock we identify is closely related to this “main business cycle” shock. From this perspective, the central contribution of our empirical exercise is to show that the “main business cycle shock” is also very strongly related to financial market outcomes and, in particular, is responsible for the strong counter-cyclicity of equity risk-premia.

Figure 3 reports impulse responses to our identified shock for some additional variables of interest, including those included in our vector of auxiliary vector S_t . The first panel in the top row shows a somewhat surprising result – the employment of part-time workers actually *increases* in response to our shock. This response is significant after the impact period, and the fluctuations induced by our shock explain a very large portion of the fluctuations in this series as well – 74% of the unconditional variance. The second panel plots the share of part-time employment in total employment; since total employment is falling this share rises even more in percentage terms than the part-time employment itself. Finally, last panel of the first row shows that aggregate hours-per-worker fall substantially after the shock, which is another manifestation of the shift towards part-time employees.

generate the full comovement pattern, as on impact of their “yield-curve” shock investment falls. Thus, we are recovering a different kind of shock.

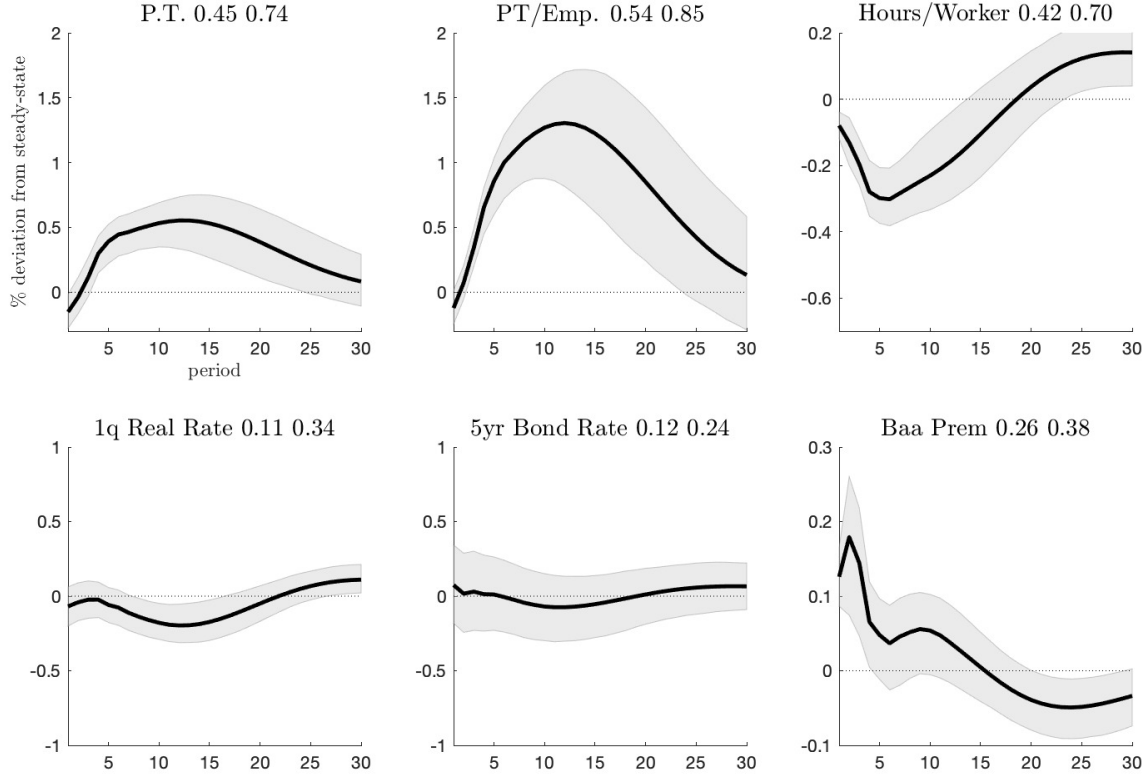


Figure 3: Impulse responses to VAR-identified risk premium shock for additional variables. Numbers in subplot titles correspond to the percent of variance explained at the business cycle and unconditional frequencies, respectively.

The final row of the figure shows that real interest rates, both short and longer term, are hardly affected by our shock at all. The fluctuations are small for both variables, never significant for the 5-year bond rate, and capture only relative small portions of the variance of either.

While safe rates are relatively unaffected by the shock, the final panel of figure show that excess bond returns — measured by the spread between Baa-rated corporate debt and the 10-year treasury yield — do rise strongly in the period after the shock, though the effect is significantly less persistent than for the equity risk-premium. While we do not report it, the perceived-risk measure of [Pflueger et al. \(2020\)](#) also increases strongly in response to our shock. Overall, the risk premia of a variety of asset classes rise, in the periods after our shock hits the economy.

3 Model

Here, we propose a theory that can explain the empirical patterns we have isolated above. Our model is a standard real economy, with frictional labor markets, capital adjustment costs, and variable capacity utilization. The model consists of a representative household and a representative firm. The household consumes, supplies labor inelastically, and invests in firm shares along with firm and government debt instruments. The firm produces final goods and accumulates labor and capital in order to maximize shareholder value. We present the key elements of the model below and relegate full derivations to the Appendix.

The central challenge a model faces in matching our empirical results, is that generating comovement via risk fluctuations is challenging, because an increase in risk leads to precautionary savings, which move consumption and investment in opposite directions. Frictions in forming or severing labor relationships effectively turn labor into another investment good and thus a real savings technology. As a result, in addition to an overall increase in desired savings the agents are also facing a portfolio choice problem.

The key to our mechanism is that labor relationships are in fact *riskier* than capital, hence the increase in risk leads to a re-allocation of savings from vacancies (i.e. investment in labor relationships) to capital. This has a negative impact on current output, not only because resources invested in vacancies tend to have an immediate effect on output while capital only becomes operational with a lag, but also because the marginal product of labor is higher at our benchmark estimation. Thus, reallocation of savings towards capital, and away from labor, has a negative impact on output, and through the general equilibrium effect of market clearing, ends up lowering both consumption and investment.

To sum up, upon an increase in risk, our economy experiences a shifting allocation of savings towards an effectively safer, but less productive asset, which depresses output, and causes all four main macro aggregates to fall together with it.

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

$$V_t = \max \left[(1 - \beta)C_t^{1-1/\psi} + \beta(\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1-1/\psi}{1-\gamma_t}} \right]^{\frac{1}{1-1/\psi}}, \quad (9)$$

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

$$C_t + P_t^e X_{t+1} + Q_t^c (B_{t+1}^c - dB_t^c) + \frac{1}{R_t^r} B_{t+1} \leq (D_t^e + P_t^e) X_t + B_t^c + B_t + E_t^l. \quad (10)$$

In the above, Q_t^c is price of a multi-period corporate bond where a fraction $(1 - d)$ of the principal is repaid each period, 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 γ_t and can vary over-time, while ψ is the intertemporal elasticity of substitution.

The Epstein-Zin preferences in equation (9) imply the following stochastic discount factor between t and $t + 1$:

$$M_{t,t+1} \equiv \left(\frac{\partial V_t / \partial C_{t+1}}{\partial V_t / \partial C_t} \right) = \beta \left(\frac{C_{t+1}}{C_t} \right)^{1-1/\psi} \left(\frac{C_t}{C_{t+1}} \right) \left(\frac{V_{t+1}}{(\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1}{1-\gamma_t}}} \right)^{1/\psi-\gamma_t}. \quad (11)$$

Households supply labor inelastically, but labor markets are subject to search and matching frictions in the spirit of [Mortensen and Pissarides \(1994\)](#). There are two types of labor contracts: the first, which we call “full-time”, involves longer-term relationships and sticky wages, labeled $W_{1,t}$, while the second, which we call “part-time”, involves shorter employment spells and flexible wages, $W_{2,t}$. We denote with $N_{1,t}$ and $N_{2,t}$ the masses of labor currently working under the full-time and part-time contracts, respectively. While employment status may vary across workers, their consumption is the same because the household provides perfect consumption insurance for its members.

Workers search sequentially. Specifically, all unemployed workers at the beginning of period t first try to find a full-time job. If the search is unsuccessful, a given worker searches for a part-time job.¹¹ Accordingly, the mass of searchers for the two types of contracts are:

$$S_{1,t} = 1 - (1 - \rho_1)N_{1,t-1} - (1 - \rho_2)N_{2,t-1}, \quad (12)$$

$$S_{2,t} = 1 - N_{1,t} - (1 - \rho_2)N_{2,t-1}. \quad (13)$$

Equation (12) reflects the following timing assumptions. At the beginning of period t , a fraction ρ_1 and ρ_2 of employment relationships that were active in the full-time and part-time sector at time $t - 1$ experience exogenous separation and the corresponding

¹¹This 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 that this is the case in all our simulations. See the Appendix for the formal details.

workers enter the pool of unemployed. All of these workers, $\rho_1 N_{1,t-1} + \rho_2 N_{2,t-1}$, and those who were unemployed in the previous period, $U_{t-1} \equiv 1 - N_{1,t-1} - N_{2,t-1}$, look for a full-time job at time t . Equation (13) then states that all agents who were unemployed at the beginning of the period and did not find a full-time job, then search in the part-time sector.

The introduction of distinct full-time and part-time sectors creates some subtle issues regarding how workers are compensated in case they are unemployed or “under-employed”. We assume that a worker who finds no employment in either sector in period t is unemployed in that period. Such a worker receives 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 κ_t that corresponds to the benefits (e.g., of home production) from the additional time made available by part-time work.

Because the representative household self-insures, aggregate household earnings each period are thus:

$$E_t^l = W_{1,t}N_{1,t} + (W_{2,t} + \kappa_t)N_{2,t} + b_{2,t}(1 - N_{1,t} - N_{2,t}). \quad (14)$$

The implicit ranking of labor-market outcomes implied by the sequence of search imposes restrictions on κ_t and $b_{2,t}$. To ensure that full-time work is preferred to part-time, κ_t cannot be too large. Meanwhile, to ensure that part-time work is preferable to unemployment, $b_{2,t}$ must also not be too large; we verify both conditions in all of our simulations.

Firms

The representative firm seeks to maximize the present discounted value of its cash flows,

$$D_t = Y_t - W_{1,t}N_{1,t} - W_{2,t}N_{2,t} - I_t - \gamma_{1,t}^l v_{1,t} - \gamma_{2,t}^l v_{2,t}, \quad (15)$$

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 $\gamma_{i,t}^l$ 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 consistent with the

household problem above. Its objective is to maximize

$$\mathbb{E}_t \sum_{s=0}^{\infty} \left(\frac{\partial V_t / \partial C_{t+s}}{\partial V_t / \partial C_t} \right) D_{t+s}, \quad (16)$$

subject to the production function,

$$Y_t \leq (K_t u_t)^\alpha (Z_t N_t)^{1-\alpha}, \quad (17)$$

the labor aggregator,

$$N_t = \left((1 - \Omega) N_{1,t}^{\frac{\theta-1}{\theta}} + \Omega N_{2,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad (18)$$

the capital accumulation equation,

$$K_{t+1} = \left(1 - \delta(u_t) - \frac{\phi_K}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 \right) K_t + I_t, \quad (19)$$

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

$$N_{1,t} = (1 - \rho_1) N_{1,t-1} + \Theta_{1,t} v_{1,t}, \quad (20)$$

$$N_{2,t} = (1 - \rho_2) N_{2,t-1} + \Theta_{2,t} v_{2,t}. \quad (21)$$

Depreciation depends on utilization via the following functional form:

$$\delta(u_t) = \delta + \delta_1(u_t(i) - u) + \frac{\delta_2}{2}(u_t(i) - u)^2. \quad (22)$$

In the above constraints, Z_t is an exogenous labor-augmenting technology, and $\Theta_{i,t}$ is the probability of filling a type- i vacancy.

We follow [Jermann \(1998\)](#) by assuming the representative firm finances a percentage of its capital stock each period through debt. Like in [Gourio \(2012\)](#), this financing occurs with multi-period riskless bonds. Firm debt evolves according to

$$B_{t+1}^c = dB_t^c + L_t, \quad (23)$$

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 $\frac{1}{1-d}$. 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 $B^c/K \equiv \nu = \xi/(1-d)$. The price of the multi-period bond (Q_t^c) is determined by the pricing equation

$$Q_t^c = \mathbb{E}_t [M_{t,t+1}(dQ_{t+1}^c + 1)] . \quad (24)$$

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

$$D_t^E = D_t - B_t^c + \xi K_{t+1}. \quad (25)$$

Since the [Modigliani and Miller \(1958\)](#) theorem holds in our model, leverage does not affect firm value or optimal firm decisions. Leverage makes the price of equity more volatile, however, and allows us to map the model concept of equity returns to the data.

The value of a type- i labor match for a firm, $J_{i,t}$, in equilibrium is given by:

$$J_{i,t} = MPL_{i,t} - W_{i,t} + (1 - \rho_i)\mathbb{E}_t \{M_{t,t+1}J_{i,t+1}\} . \quad (26)$$

Equation (26) states that the value a of match is equal to the current surplus the firm extracts from it, 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 condition forward, we can rewrite the value of a match as:

$$J_{i,t} = \underbrace{\sum_{j=0}^{\infty} \frac{(1 - \rho_i)^j \mathbb{E}_t (MPL_{i,t+j} - W_{i,t+j})}{R_{t,t+j}^R}}_{\text{cash flow}} + \underbrace{\sum_{j=1}^{\infty} (1 - \rho_i)^j \text{Cov}_t (M_{t,t+j}, MPL_{i,t+j} - W_{i,t+j})}_{\text{risk premium}}, \quad (27)$$

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

The asset-pricing equation (27) expresses the value of a match as the sum of two terms. The first term is the present value of cash-flows, in this case surplus from the match from the view point of the firm, discounted with the relevant risk-free rate $R_{t,t+j}^R = \mathbb{E}_t [M_{t,t+j}]^{-1}$. The second term is a risk adjustment. Assets whose dividend streams covary negatively with the stochastic discount factor, and positively with consumption, have lower prices or higher risk premia, since holding those assets gives the investor a more volatile consumption stream. In this particular context, labor relationships whose future firm's surplus covary more negatively with the stochastic discount factor will carry a higher risk premium.

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 (to be described momentarily). The initial value of the wage is the Nash bargained wage that would emerge in a non-stochastic steady-state with $Z = 1$:

$$W_1 = \eta_1 \left[(1 - \Omega)(1 - \alpha) \left(\frac{uK}{N} \right)^\alpha \left(\frac{N}{N_1} \right)^{\frac{1}{\theta}} + \gamma_1^l \theta_1 \right] + (1 - \eta_1)b_1, \quad (28)$$

where $\eta_1 \in [0, 1]$ and $\theta_1 = \frac{v_1}{S_1}$ denote the workers' bargaining power and the steady-state labor market tightness in the full-time sector, while b_1 represents 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 outside option for the full-time sector is

$$b_1 \equiv P_2^m(W_2 + \kappa) + (1 - P_2^m)b_2, \quad (29)$$

In case the worker declines a full-time job, they find a part-time job with probability P_2^m , earning a wage W_2 plus κ units of additional home production made possible by part-time work. With probability $(1 - P_2^m)$, the worker becomes fully unemployed, earning formal unemployment benefits plus home production valued of b_2 .¹²

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

$$W_{2,t} = \eta_2 \left[\Omega(1 - \alpha)Z_t \left(\frac{u_t K_t}{Z_t N_t} \right)^\alpha \left(\frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} + \gamma_{2,t}^l \theta_{2,t} \right] + (1 - \eta_2)b_{2,t}. \quad (30)$$

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. As can be seen explicitly in equation (27), the differences in duration of employment spells ($\rho_2 > \rho_1$) and in the wage flexibility result in different risk profiles of the two labor contracts and can therefore give rise to asymmetric responses to changes in risk appetite.

¹²Because of sticky wages in sector 1, time variation in b_1 would have no effect on equilibrium.

Government

The government finances a stream of expenditures, which are exogenous but only gradually catch-up with the trend in the economy. The initial value of the government expenditure in a non-stochastic steady-state with $Z = 1$ is

$$G = \bar{g}Y. \quad (31)$$

Government expenditures and the pecuniary component of unemployment benefits are financed using a purely lump-sum tax instrument. As a result, government bonds remain 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:

$$N_{1,t} = (1 - \rho_1)N_{1,t-1} + M_{1,t}, \quad (32)$$

$$N_{2,t} = (1 - \rho_2)N_{2,t-1} + M_{2,t}, \quad (33)$$

where $M_{1,t}$ and $M_{2,t}$ represent the matches from the CES matching functions of the full-time and part-time sectors, respectively. These matching functions take the form:

$$M_{i,t} = \chi_i v_i^{\epsilon_i} S_i^{1-\epsilon_i}, \quad (34)$$

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

$$Y_t = C_t + I_t + \gamma_{1,t}^l v_{1,t} + \gamma_{2,t}^l v_{2,t} + G_t. \quad (35)$$

In order to ensure our model satisfies the usual accounting identity, we follow [den Haan and Kaltenbrunner \(2009\)](#) by including job posting costs in defining our model analogue to measured investment, i.e., $\tilde{I}_t \equiv I_t + \gamma_{1,t}^l v_{1,t} + \gamma_{2,t}^l v_{2,t}$.

Exogenous Processes

The economy is perturbed by two exogenous disturbances. The first is technology, Z_t , which we assume is integrated of order one and follows an AR(1) in log-growth rates:

$$\log(\Delta Z_t) = \rho_z \log(\Delta Z_{t-1}) + \sigma_z \epsilon_t^z, \quad (36)$$

The second is risk aversion, γ_t , with dynamics governed by an AR(2) processes in logs:

$$\log(\gamma_t/\gamma_{ss}) = \rho_{1,\gamma} \log(\gamma_{t-1}/\gamma_{ss}) + \rho_{2,\gamma} \log(\gamma_{t-2}/\gamma_{ss}) + \sigma_\gamma \epsilon_t^\gamma. \quad (37)$$

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 outside options, the sticky full-time wage, and government expenditure are all cointegrated with technology, with a common error-correction rate of ω . Specifically, for each variable $X \in \{\gamma_{1,t}, \gamma_{2,t}, b_{1,t}, b_{2,t}, W_{1,t}, G_t\}$, we assume that $X_t = \Gamma_t \bar{X}$ where \bar{X} is the deterministic steady-state value, and

$$\Gamma_{t+1} = \Gamma_t^\omega Z_t^{1-\omega}. \quad (38)$$

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

$$W_{1,t} = \left(\frac{Z_{t-1}}{\Gamma_{t-1}}\right)^{1-\omega} W_{1,t-1}. \quad (39)$$

Thus, the 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 fully with changes in productivity.

4 Quantifying the Mechanism

We quantify the potential of our model to match our empirical evidence via an impulse-response matching exercise, where we match the model-implied IRF to a risk-aversion shock, γ_t , to the empirical impulse responses to the “risk-premium” shock we identified in Section 2. In addition, we also further discipline the model by matching several uncon-

Table 3: Calibrated Parameters

Name	Description	Value
β	Discount rate	0.994
ψ	Intertemporal elasticity of substitution	2.500
α	Capital share	0.300
δ	Capital depreciation rate	0.025
δ_2	Cap. util. cost $\times 100$	0.030
\bar{g}	Steady-state G/Y	0.200
d	Corporate bond duration	0.975
Labor Markets		
ρ_1	Separation Rate - FT	0.044
ρ_2	Separation Rate - PT	0.354
η_1	HH's bargaining power - FT	0.500
η_2	HH's bargaining power - PT	0.200
Exogenous Processes		
σ_z	Std. dev. of tech shock	0.006

ditional moments in the data. Thus, the estimation exercise is restricted with numerous and different kinds of data moments, leading to a highly over-identified system and tight parameter estimates as we report below.

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 counter-factual path in which a single one-standard deviation shock to γ_t is realized.

4.1 Calibrated Parameters and Steady-State Targets

To begin, we calibrate a set of standard parameters *ex ante* to values that are consistent with the literature, as summarized in Table 3. Namely, we set $\beta = 0.994$ to be consistent with a non-stochastic steady-state annual real interest rate around 2.4%. The capital share is set to a standard value of 0.3 in the production function. Because the estimated model includes risk, this will imply an unconditional capital income share that is slightly less than 0.3. We use a standard long-run depreciation rate of $\delta = 0.025$. The relatively low curvature parameter of the capital depreciation function, $\delta_2 = 0.0003$, implies that adjustments in utilization are relatively inexpensive, consistent with the values used by [Christiano, Eichenbaum, and Evans \(2005\)](#). Finally, we assume that on average government expenditures are 20% of GDP and fix the bond duration parameter $d = 0.975$, so

as to imply corporate debt has a 10-year maturity, as in [Gourio \(2012\)](#).

The elasticity of intertemporal substitution plays an important role in models that target asset pricing facts, and we set this parameter to $\psi = 2.5$. This value is relatively high compared to the standard macro literature that focuses on quantities only, but is in-line with values used by macro-finance papers that target asset pricing moments ([Schorfheide et al., 2018](#)). Nevertheless, the overall qualitative patterns we estimate do not rely on any restriction on ψ and can still emerge, for example, even when $\psi < 1$. Our primary motivation for choosing a high elasticity is that this choice allows our model to match fairly large responses of consumption to our shock without generating counterfactually-large changes in safe interest rates (which is also the same basic tension that has led the previous asset-pricing literature to use $\psi > 1$).

In terms of labor market parameters, the key calibrated parameters are the separation rates, ρ_1 and ρ_2 . We pick these values to satisfy two features of the data. First, separation rates for employees in the part-time and other temporary positions are much higher than those with full-time permanent positions. Second, the average separation rate in the US economy is around 10% ([Yashiv, 2008](#)). To capture the first requirement, we fix $\rho_2/\rho_1 = 8$, in line with recent estimates of the relative separation rates of part-timers to full-timers from the longitudinal dimension of the U.S. Current Population Survey ([Lariau, 2017](#)). We then fix the level of separations in the full-time sector so that the aggregate quarterly separation rate is 10%. We also choose standard values for the Nash bargaining parameters (and generally find that alternative choices for these parameters play a small role in our results).

Finally, we use the [Basu et al. \(2006\)](#); [Fernald \(2014\)](#) data on utilization-adjusted U.S. TFP to calibrate the process for productivity. Over our sample period, we find that productivity is an almost perfect random walk and it has standard deviation in growth rates of 0.6%, implying $\rho_z = 0$ and $\sigma_z = 0.006$.

The remaining parameters are estimated by matching the impulse-responses to a risk-aversion shock, and also eight additional unconditional moments, which we report in [Table 4](#). Our approach is to place extremely high weight on the unconditional moment targets in the estimation procedure (described below), with the idea being to get as good of a match as possible in terms of unconditional moments, and then see how the model does in terms of conditional dynamics. As we can see from the third column in [Table 4](#), the model can indeed match the unconditional targets perfectly.

The first three entries, the average equity premium, the share of part-time workers, and the average unemployment rate are easily observed and we match their average values

Table 4: Unconditional Target Moments

Description	Data	Model
Equity risk premium	0.064	0.063
Share of part-time	0.180	0.182
LR unemployment	0.060	0.061
Vancancy Rate	0.035	0.035
Hiring cost/GDP	0.010	0.010
PT earn./FT earn.	0.500	0.497
Std. Dev. HP log(Emp/Pop)	0.011	0.011
Std. Dev. HP log(vacan.)	0.117	0.117

over our sample period. The vacancy rate of 3.5% is fixed to be consistent with the full-sample average of the JOLTS dataset, which starts in 2000. In turn, we assume that the ratio of hiring costs to GDP is 1%, in-line with [Blanchard and Galí \(2010\)](#).

Next, we target a ratio of full-time to part-time earnings of 0.5. This ratio should account not just for any hourly wage differential, but should also include the lower number of hours worked by people in part-time positions. The wage and hourly data is not sufficiently disaggregated to directly speak to this moment, but we have found that our results change very little if we make a different choice here.

Finally, 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 reasonable Beveridge curve. We also note that since the model is indeed successful at matching both of these moments, this implies it also does not suffer from the Shimer puzzle.

4.2 Estimation Procedure

Aside from the additional long-run target moments in Table 4, 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. We denote the set of parameters we estimate with Π , and those includes the steady-state risk aversion parameter γ , the capital adjustment cost parameter, ϕ_K , the aggregate leverage ratio ν , the vacancy posting costs, γ_1^l and γ_2^l , the value of outside options b_1 and b_2 , the production share of part-time labor Ω , the four parameters governing the aggregate matching technologies, the cointegration parameter ω , and the

Table 5: Estimated Parameters

Name	Description	Point Est.	Std Err.
γ_{ss}	Steady-state risk aversion	79.123	11.508
ϕ_k	Capital Adj. Cost	12.478	2.210
ν	Leverage Ratio	0.822	0.024
Labor Markets			
γ_1^l	Vacancy posting cost - FT	4.092	0.442
γ_2^l	Vacancy posting cost - PT	0.144	0.020
b_1	Value if no perm posit.	1.108	0.045
b_2	Value if unemployed	0.645	0.006
Ω	Labor contrib. of PT	0.172	0.008
θ	Elas. between FT & PT	1.715	0.108
ϵ_1	Matching elasticity - FT	0.329	0.023
ϵ_2	Matching elasticity - PT	0.514	0.016
χ_1	Matching technology - FT	0.794	0.051
χ_2	Matching technology - PT	0.959	0.020
ω	Cointegration parameter (i.e. wage adj.)	0.968	0.009
Risk Aversion Process			
$\rho_{1,\gamma}$	AR(1) risk av. shock	1.960	0.026
$\rho_{2,\gamma}$	AR(2) risk av. shock	-0.966	0.025
σ_γ	Std. dev. of risk av. shock	0.025	0.010

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

parameters of the risk aversion shock, $\rho_{1,\gamma}$, $\rho_{2,\gamma}$ and σ_γ .

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. The objective function of our estimation is then given by

$$\mathcal{L}(\Pi) \equiv (\hat{\psi} - \psi(\Pi))'W(\hat{\psi} - \psi(\Pi)). \quad (40)$$

In the above, 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 eight unconditional targets, we are essentially targeting $7 \times 30 = 210$ impulse response moments with just nine degrees of freedom.

4.3 Estimation Results

Table 5 reports the estimated values $\hat{\Pi}$ along with standard errors for the estimates. The estimation procedure finds a global interior optimum, and the corresponding parameters value are quite plausible. For example, the estimated value for the average level of risk aversion, $\gamma = 79.9$, is high but remains similar to or lower than the values found/used by several 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).

Figure 4 shows that the impulse responses implied by the estimated model (blue-dot lines) do an excellent job of matching the data, and in particular generate the familiar aggregate comovement pattern that traditionally defines the standard business cycle. On the macroeconomic side, the changes in output, consumption and employment track the data quite closely. The change in investment on impact exactly matches the sharp fall we observe in the data, and although the model then undershoots modestly for several subsequent periods it remains within the standard error bands of the data.

In addition to the macro variables, the model does an excellent job capturing two central features of asset prices. First, the model closely captures the persistent increase in the 5-year equity risk premium, which was central to our identification of the empirical shock and is similarly central for disciplining the risk-aversion shock in the model. Second, the model also matches the pattern of realized equity returns very well, with a steep fall in stock returns on impact, followed by a long period of above-average returns (which generate the expected excess return underlying the elevated risk-premium). Thus, the model is successful at capturing both the business cycle comovements and the counter-cyclical risk-premium that we found in the data.

Perhaps the key and most surprising result is that our model predicts a substantial and long-lived decline in investment, despite the increase in desired saving implied by the risk aversion shock.¹³ How can this happen? Barro and King (1984) show that generating the typical comovement of macroeconomic variables in response to non-technology shocks is quite difficult. Indeed, a rise in risk aversion leads to a precautionary behavior that reduces consumption and increases desired savings, which typically leads to an increase in investment in equilibrium. Put differently, absent aggregate supply shifters, output normally does not fall enough to drive a joint decline in consumption and investment.

¹³Recall from eq. (35) that investment in our model includes both investment in capital and in vacancy posting. Each contributes roughly half of the fall in measured investment, with the fall in vacancies contributing more early on and the fall in capital investment contributing more after the first year.

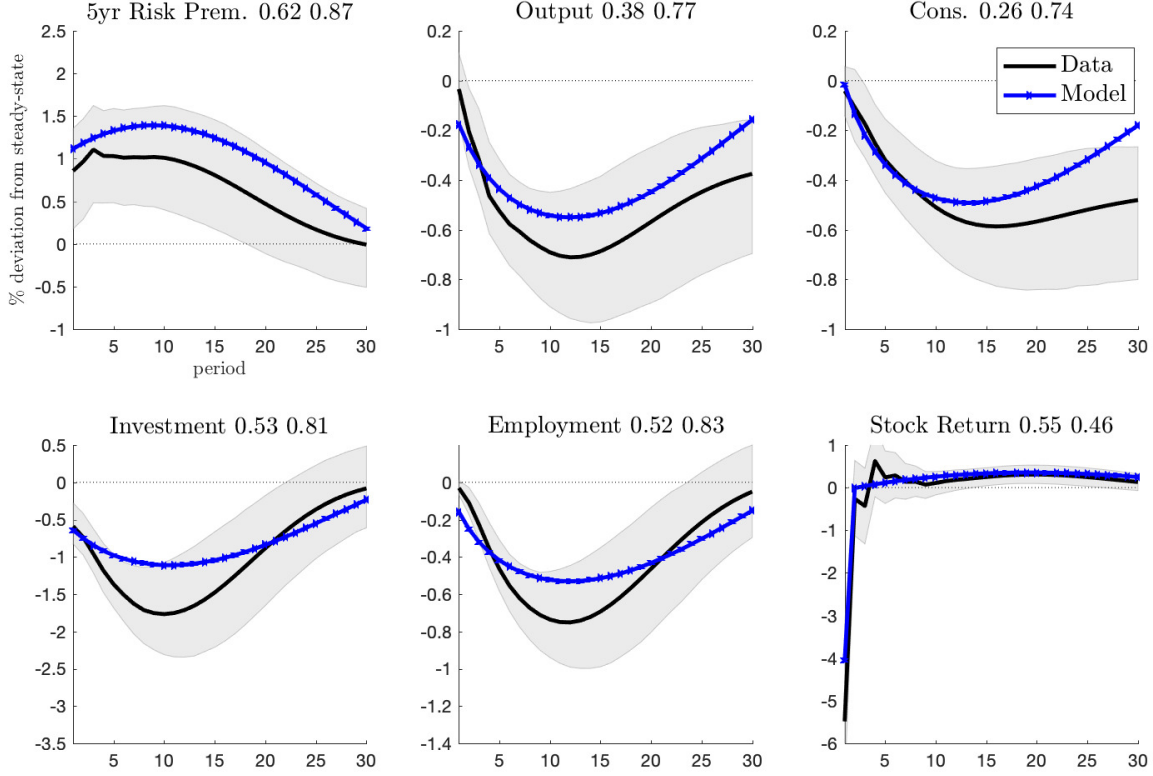


Figure 4: Impulse responses to VAR-identified risk premium shock along with model-implied responses.

In our model, the above intuition is more subtle because firms have several ways to invest: either in physical capital or in one of two-types of long-lived labor relationships. As it would in standard real business cycle model, the increase in risk aversion gives rise to precautionary motives that reduce consumption and increases overall savings. However, because agents in our economy have many savings technologies, precautionary motives also induce a reallocation of savings towards *safer assets*.

Focusing first on the choice between labor and capital: If labor is sufficiently risky, the firms' investment composition shifts away from labor relationships (i.e. vacancies) and towards physical capital. This reallocation of investment induces a fall in new vacancies, which can be strong enough so that employment itself falls sharply. This has two effects, first it lowers the marginal product of capital and second also lowers equilibrium output, and if strong enough, these two effects can combine to drive equilibrium investment down with the other macroeconomic variables. In Section 4.5 we discuss in detail what makes labor sufficiently risky in our estimation.

Since the bulk of labor is in long-term relationships, reallocation between long-term

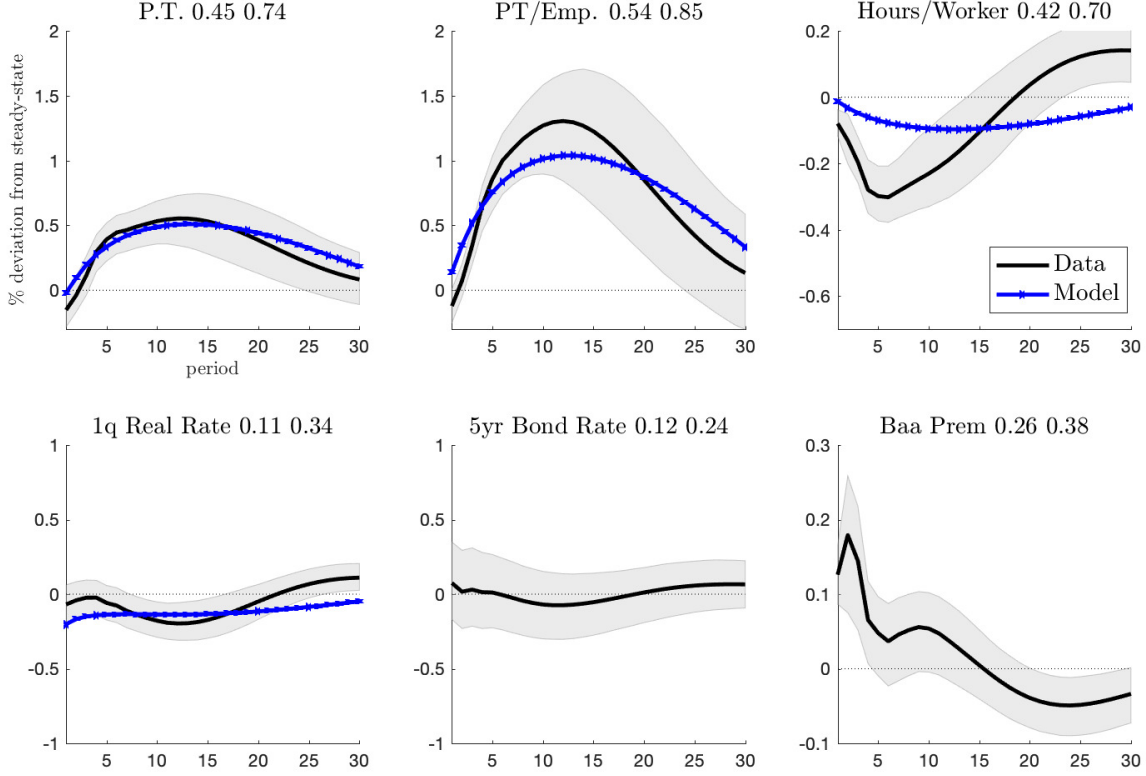


Figure 5: Impulse responses to VAR-identified risk premium shock along with model-implied responses.

labor and capital is the crucial channel determining the qualitative effects of the change in risk aversion. Nevertheless, the quantitative effects of the shock also depend importantly on the re-allocation between the two types of labor. In particular, firm willingness to substitute the shorter-term, part-time hires for longer-term, full-time hires depends on the relative riskiness of the two types of relationships. Since our calibration choices imply, intuitively, that short-term labor relationships are relatively less risky, due to both a flexible wage and shorter duration, an increase in risk aversion induces firms to shift their vacancy postings towards the safer, part-time sector. This amplifies the effects of the re-allocation from capital to labor, because it turns out that at our estimation the part-time labor has a lower marginal product than full-time labor, and hence re-allocation within labor leads to a further drop in output.

The first row of Figure 5 captures the model's implications for the re-allocation within labor types. In the first panel, we show the model's implications for part-time employment, and the second panel shows the response of the (logged) ratio of part-time to full-time employment. These figures show that the model not only captures the patterns of total

employment, but also captures very well the concurrent reallocation between the full-time and part-time sectors that is also a significant feature of the data. The third panel of the first row plots the impulse response of hours-per-worker in the data and model. Since our model does not include an intensive margin within jobs, we construct this response by assuming that hours of a part-time worker are exactly half the hours of full-time workers. This panel shows that the (extensive margin) reallocation of workers across worker types can account for a portion, but not all, of the fall in hours-per-worker seen in the data.

The bottom left panel of the figure reports the model implied dynamics of the real interest rate. While the model implies a somewhat larger fall in real interest rates in response to the shock, the economic significance of the difference is modest. The limited response of the real interest rate in the model highlights that in our model recessions are driven by varying *risk premia*, and the associated re-allocation of savings towards safer assets rather than by intertemporal substitution of present for future consumption. This business-cycle narrative is consistent with the central lesson of the macro-finance literature summarized in [Cochrane \(2017\)](#). Overall, we conclude, the model does a remarkably good job of matching the quantitative patterns in the data.

4.4 Risk Premia

Above, we discussed the basic intuition that underlies our model’s ability to deliver realistic macroeconomic comovements based on differences in the relative risk profile of capital and labor. Our argument requires labor to be sufficiently risky, and more risky than capital investment, in order for aggregate variables to all decline together. We now verify these patterns hold in our estimation by measuring in the model the risk premia associated with the three types of available investment assets: capital, full-time and part-time vacancies.

We begin by defining the equity premium as the extra return on a share of the representative firm relative to the risk free rate. Specifically, we define the return on equity and the equity risk premium as:

$$R_{t+1}^E = \frac{D_{t+1}^E + P_{t+1}^E}{P_t^E},$$

$$EP_t = \mathbb{E}_t \left[\frac{R_{t+1}^E}{R_t^R} \right].$$

The return reflects the cash flow generated by the stock plus the change in the market price of equity.

Analogous measures of returns can be derived for the other assets in this economy. For example, we can define the excess return on physical capital as

$$KP_t = \mathbb{E}_t \left[\frac{\tilde{R}_{t+1}^K}{R_t^R} \right],$$

where

$$\tilde{R}_{t+1}^K \equiv \frac{\alpha u_{t+1} \left(\frac{u_{t+1} K_{t+1}}{Z_{t+1} N_{t+1}} \right)^{\alpha-1} + q_{t+1} (1 - \delta(u_{t+1}) - \text{adj.costs})}{q_t}, \quad (41)$$

can be derived by rearranging the capital Euler equation. In (41) the return on capital reflects the net cash flow of a unit of capital, equal to its marginal product plus the change in the market price net of depreciation and adjustment costs.

Similarly, the vacancy posting condition of a firm can be re-cast in terms of a return on a dollar invested in vacancies:

$$R_{i,t+1}^L = \frac{(MPL_{i,t} - W_{i,t})R_t^R + (1 - \rho_i) \frac{\gamma_{i,t+1}^l}{\Theta_{i,t+1}}}{\frac{\gamma_{i,t}^l}{\Theta_{i,t}}},$$

which then allows us to define the risk-premium of this type of investment too:

$$LP_{i,t} = \mathbb{E}_t \left[\frac{R_{i,t+1}^L}{R_t^R} \right] = 1 - (1 - \rho_i) \Theta_{i,t} \text{Cov}_t \left(M_{t,t+1}, \frac{1}{\Theta_{i,t+1}} \right),$$

where $MPL_{i,t}$ denotes the marginal product of labor in sector i . The definition of the return reflects the net cash flow from a filled vacancy, equal to the marginal product of labor minus the wage plus the change in the value of a job. The latter equals the vacancy cost, γ_i^l , times the duration of the typical vacancy, $\frac{1}{Q_{i,t}^m}$. In contrast to capital, which becomes productive with a one-period delay, the labor generates the cash flow immediately, so the first term in the numerator of the return is multiplied by R_t^R .

The labor market premium is higher when the covariance between tightness and the stochastic discount factor is more negative. Intuitively, a tighter labor market indicates that the vacancy filling probability is low or that the marginal value of the workers to the firm is high. Thus, if tightness increases when the stochastic discount factor is high (i.e., in a recession), it means that workers of this type are a good hedge: they are most valuable when marginal utility is high. Conversely, if in a recession the tightness of a particular labor market is low, it means that the job filling probability is high or that

Table 6: Steady-state Annualized Risk Premia

Description	Value (%)
Capital premium	0.5
Full-time labor premium	18.7
Part-time labor premium	4.1

the marginal value of these workers is low. These workers are poor hedges and, therefore, command a risk premium.

Table 6 reports the (annualized) steady state premia implied by our model. Our estimated baseline model implies an average capital premium of 0.5% over the safe interest rate, and an average full-time labor premium of 18.7%, several times larger than our target equity premium and much larger than the capital premium. Finally, the part-time labor premium of 4.1% captures the crucial features of the part-time sector as having (i) flexible wages and (ii) a shorter duration – this makes the part-time labor less risky than full-time labor, and thus makes it an attractive alternative to full-time positions during periods of heightened risk aversion.

Assessing the quantitative realism of the labor and capital premia is a daunting task, as empirical counterparts of these objects are not readily available.¹⁴ Nevertheless, we can try to map them into a measurable object by recognizing that the overall value of firm equity in the model reflect the market value of installed capital plus the value of the established relationships with workers. In this way, our use of the targeted equity premium, which is much less difficult to measure in the data, provides the most direct empirical discipline on the values reported here.

In addition to the unconditional levels of risk-premia, it is also interesting to ask whether the model implies realistic variability of excess returns. To answer this question, we compute the famous Sharpe (1994) ratio using quaterly returns:

$$SR = \frac{E[\log(R_{t+1}^E/R_t^b)]}{std[\log(R_{t+1}^E/R_t^b)]}. \quad (42)$$

The annualized Sharpe ration implied by our model is 0.45, which is quite close to the empirical value of 0.41 in our sample. Similarly, the model-implied standard-deviation of

¹⁴A first attempt of decomposing firm value in the contribution of the inputs of production using firm-level data on U.S. publicly traded firms is Belo et al. (2019), who indeed find a significant contribution of “installed” labor to firm value, in-line with our theory.

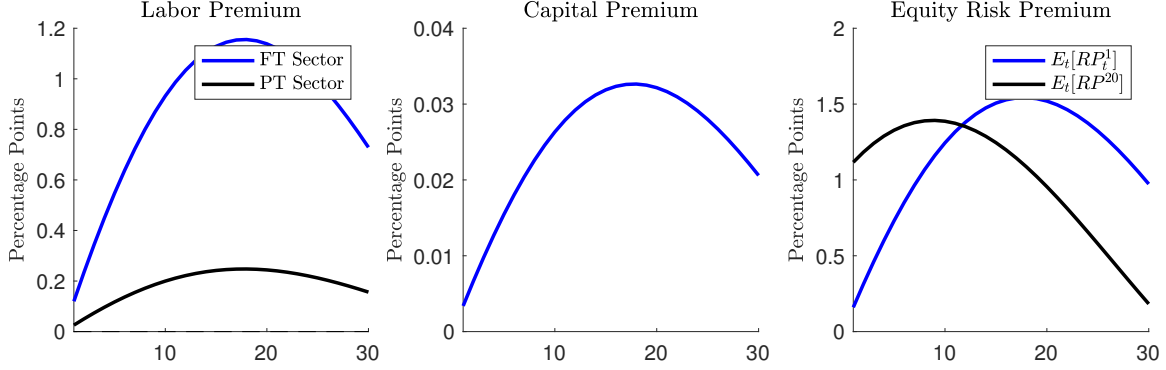


Figure 6: Impulse responses of risk premia in the model following a risk appetite shock.

the (annualized) 5-year risk premium is $100 \times \text{std}(rp_{t,t+20}) = 6.68\%$, which is very similar to the corresponding realized standard-deviation in our data sample of 6.41%. These results provide additional confirmation that our model provides a quantitatively realistic match to the data, including a variety of important moments related to risk premia.

Figure 6 reports the responses of the risk premia to the risk aversion shock in our estimated model. The figure shows that, as suggested by our discussion above, the risk premia for the full-time sector rises substantially more than that of the part-time sector and capital, conditional on an aggregate increase in risk-aversion. The last panel of the figure shows the patterns of the one-quarter and the five-year expected equity risk premia. The figure emphasizes that the bulk of the increase in the longer-term risk premia occurs because of expected excess returns that occur a year or more after the arrival of the shock. This feature is also consistent with our reduced-form evidence that shows statistically significant excess stock returns beginning a year after the identified shock.

4.5 Inspecting the Mechanism

To examine what features of the model are crucial for our results, and why, we perform a set of counter-factual experiments changing one parameter or one feature at a time, otherwise using the estimated values for the other parameters of the model.

Figure 7 plots the resulting impulse responses when we counter-factually fix capacity utilization (circle lines), against the IRFs implied by the baseline estimation (blue lines). The key observation is that capital utilization plays an important amplification role, where without it the model does not generate a sufficient fall in output and employment on impact. Specifically, without the drop of capital utilization in our benchmark model, the MPL of labor remains relatively high, which mutes the fall in employment. In turn,

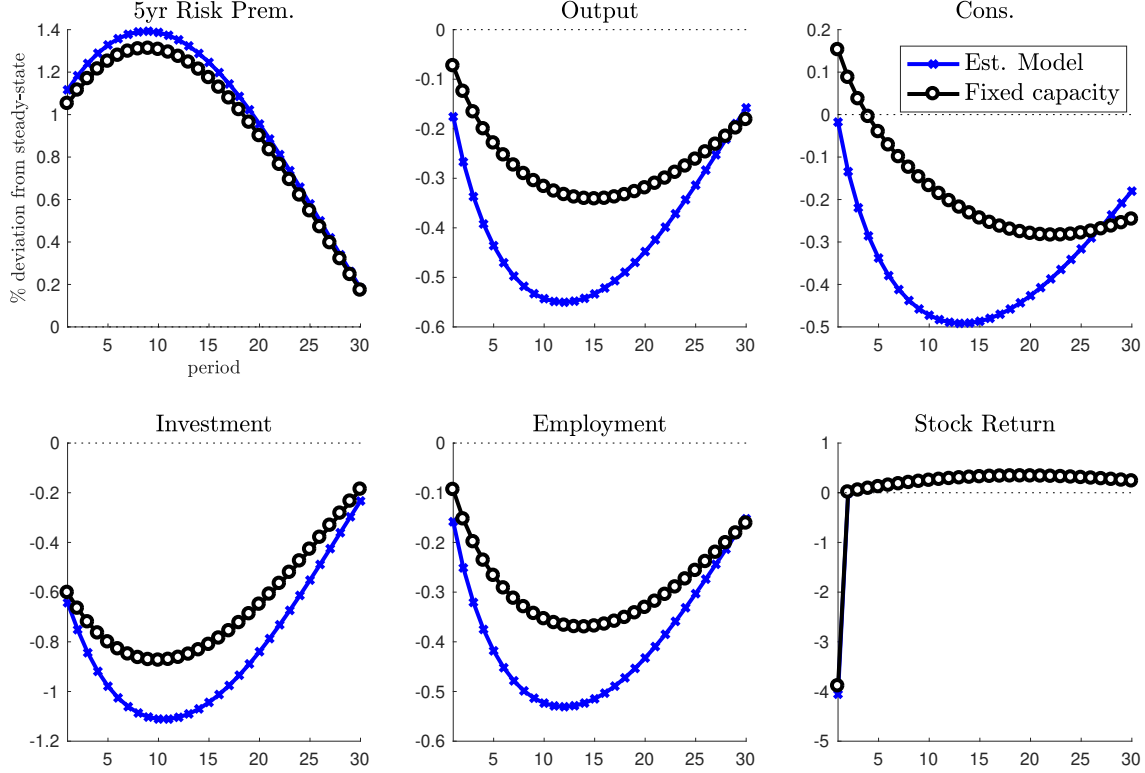


Figure 7: Model responses with fixed capacity utilization.

output falls by less as well, and hence either consumption or investment must fall by less than under our baseline calibration. In this case, it turns out that consumption actually rises on impact and only falls after subsequent changes in the capital stock and labor push down output to the point where the model once-again achieves the usual business-cycle comovement patterns.

By contrast, Figure 8 displays the counterfactual responses when all wages are flexible and set according to Nash bargaining period by period. The figure shows that wage stickiness is crucial for the strength of our mechanism. Without sticky wages, our model faces a classic [Shimer \(2005\)](#) puzzle of negligible changes in employment (although in contrast to [Shimer \(2005\)](#), here we consider a shock to risk aversion, not TFP). The reason is that wage stickiness is crucial for generating a high risk premium on full-time labor relationships. With flexible wages, such labor relationships are much safer, hence the re-allocation of investment conditional on risk-aversion shocks, which drive the fall in labor and output in our benchmark model, is largely absent. As a result, the risk-aversion shocks are no longer able to generate meaningful fluctuations in aggregate quantities, a finding that emphasizes that the Shimer puzzle extends beyond shocks to productivity to other potential sources of aggregate fluctuations, including second-moment shocks.

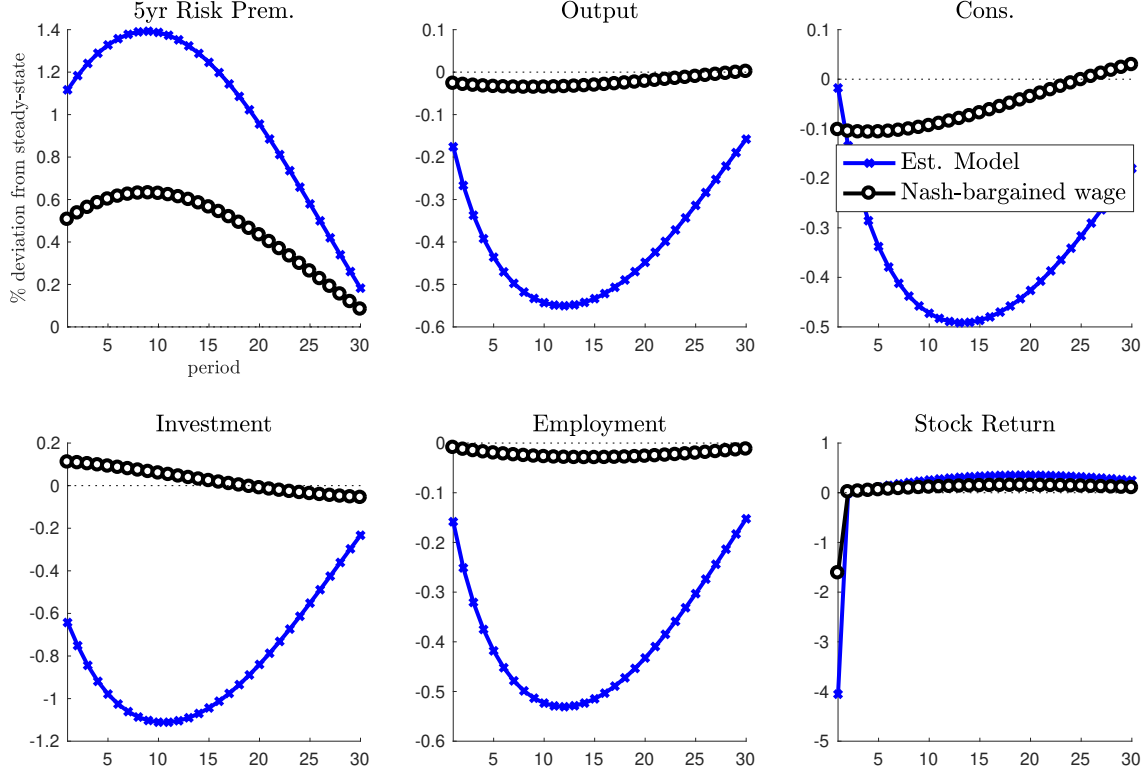


Figure 8: Model responses with Nash-bargained wages.

Our next counterfactual exercise demonstrates, directly, the fundamental role of risk premia in driving business cycle comovements in our estimated model. Equation (27) in Section 3 has shown that the value of a match to a firm is the sum of the discounted cash flows associated with the match plus a risk premium. Figure 9 shows the responses to a risk aversion shock in a counterfactual economy where the risk-premium effect on either full-time or part-time labor is shut down so that firms value this type of workers only according to the cash-flow effect. The picture shows that when we eliminate the risk premium associated with full-time workers, our model fails to reproduce business cycle comovements and delivers only negligible changes in all aggregate variables, including employment. By contrast, shutting down the risk premium on part-time workers leaves the dynamic responses to the risk aversion shock virtually unchanged relative to our baseline.

We thus conclude that it is the high riskiness of the full-time workers that allows the model to match the aggregate responses to changes in risk premia. The reason is two-fold. On the one hand, the part-time sector is relatively small as it accounts for 18% of total employment, and on the other hand, the risk-premium of the part-time sector in the benchmark model is only moderately higher than that of capital. Therefore, if that

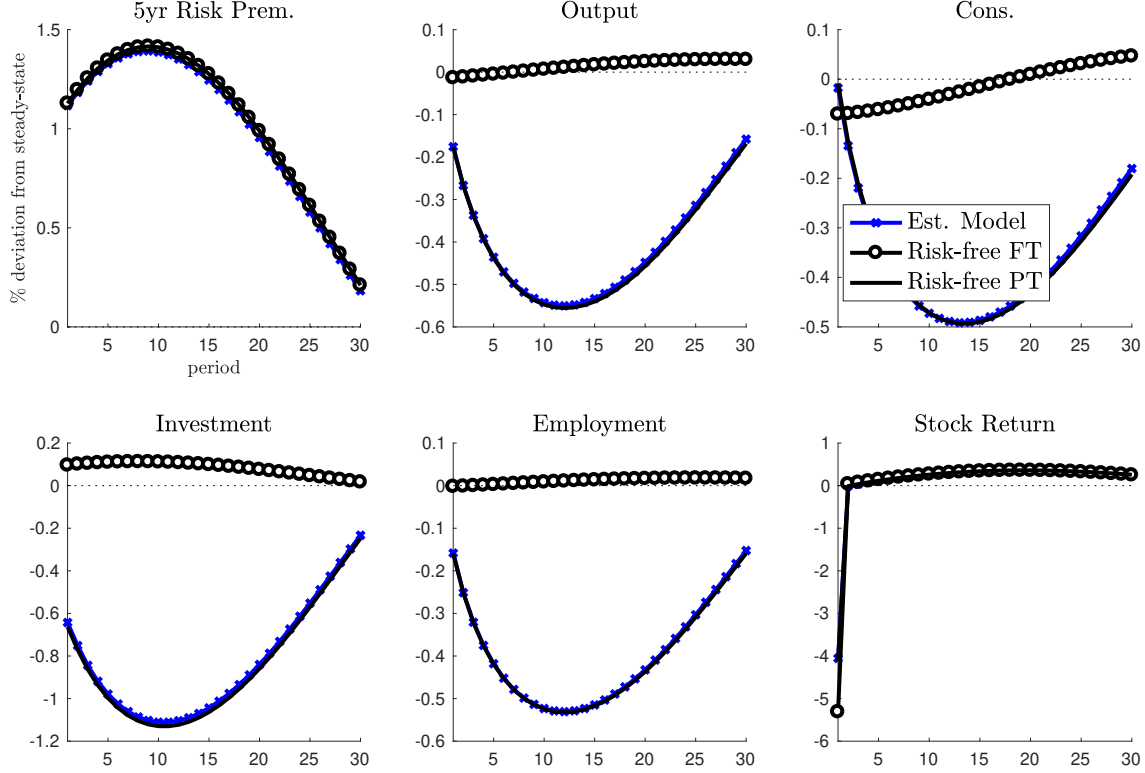


Figure 9: Model responses without risk premia.

was the only risk-premium on labor, there would very little resulting re-allocation from investment in vacancies to investment in physical capital, and hence only a small fall in current output would be due to such rebalancing of savings.

By showing that the effect of the risk-aversion shock dissipates when full-time workers are safe, this exercise not only clarifies the role of wage stickiness in our model but also sets it apart from previous contributions. In [Hall \(2005\)](#), wage stickiness resolves the [Shimer \(2005\)](#) puzzle because it makes the value of matches more volatile. The volatility comes from the large movements in the cash flows associated with these matches following productivity shocks when wages are sticky.

By contrast, our last two counterfactuals demonstrate that in our model sticky wages generate volatility in the value of full-time matches by means of variation in the risk premia associated with these matches, not in the volatility of their cash flows. The key is the different type of shock we consider. Intuitively, a risk-aversion shock has only a muted impact on future labor productivity (only indirectly, through the equilibrium fall in capital and utilization), unlike a direct shock to the level of TFP. Hence, a risk-premium shock, even with sticky wages, does not lead to meaningful variation in the cash flows of any given labor match. It does, however, have a significant impact on the *pricing* of these

cash flows, by making firms much more sensitive to the uncertainty involved with future surpluses from labor matches.

In this sense, we uncover a new way in which wage stickiness can help deliver large changes in the value of workers and thus resolve the [Shimer \(2005\)](#) puzzle: by driving large changes in the risk premia associated with employment.

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 contrasts with many business cycles models that emphasize the effects of intertemporal substitution, and instead 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 \(2017\)](#).

To focus attention on this particular 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](#)), and heterogeneous asset valuations ([Caballero and Simsek, 2020](#)). All of these features likely play a role in generating the data. 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 should apply to other forms of saving available in the economy (risky private investments versus safe government bonds, foreign investment for open economies, etc.) Future research should continue to look for similar patterns of savings reallocation in other markets, and explore the business cycle consequences of that mechanism in those contexts as well.

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Appendix

A Model

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

A.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

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

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

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

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 γ_t , while ψ is the intertemporal elasticity of substitution.

Epstein-Zin preferences imply the following stochastic discount factor:

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

The first order conditions for the households yield

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

A.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:

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

subject to the production function:

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

and the labor aggregator:

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

The capital accumulation equation is

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

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

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

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

where ρ_1 and ρ_2 are exogenous separation rates. The cash flows of the firm are given by

$$D_t = Y_t - W_{1,t} N_{1,t} - W_{2,t} N_{2,t} - I_t - \gamma_{1,t}^l v_{1,t} - \gamma_{2,t}^l v_{2,t}. \quad (\text{A.10})$$

The problem of the firms yields the following equilibrium conditions:

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

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

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

$$q_t \delta'(u_t) = R_t^K, \quad (\text{A.14})$$

and finally

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

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

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:

$$W_{1,t} = \Gamma_t \eta_1 \left[(1 - \Omega)(1 - \alpha) \left(\frac{u_t K_t}{Z_t N_t} \right)^\alpha \left(\frac{N_t}{N_{1,t}} \right)^{\frac{1}{\theta}} + \gamma_{1,t}^l v_{1,t} / S_{1,t} \right] + (1 - \eta_1) \Gamma_t b_1, \quad (\text{A.17})$$

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

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

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

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

where the total labor force has been normalized to unity.

A.3 Equilibrium

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

ditions:

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

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

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

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

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

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

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

$$\begin{aligned} \frac{\gamma_{2,t}^l v_{2,t}}{m_2(S_{2,t}, v_{2,t})} &= \Omega(1 - \alpha) Z_t \left(\frac{u_t K_t}{Z_t N_t} \right)^\alpha \left(\frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} - W_{2,t} + \\ &\quad + \mathbb{E}_t \left\{ M_{t,t+1} \frac{(1 - \rho_2) \gamma_{2,t+1}^l v_{2,t+1}}{m_2(S_{2,t+1}, v_{2,t+1})} \right\}, \end{aligned} \quad (\text{A.28})$$

$$W_{1,t} = \Gamma_t \eta \left[(1 - \Omega)(1 - \alpha) \left(\frac{u_t K_t}{Z_t N_t} \right)^\alpha \left(\frac{N_t}{N_{1,t}} \right)^{\frac{1}{\theta}} + \gamma_{1,t}^l \frac{v_{1,t}}{S_{1,t}} \right] + (1 - \eta) \Gamma_t b_{1,t}, \quad (\text{A.29})$$

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

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

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

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

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

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

$$R_t^K = q_t \delta'(u_t), \quad (\text{A.36})$$

$$\begin{aligned} q_t &= \mathbb{E}_t \left[M_{t+1} \left(u_{t+1} R_{t+1}^K + \right. \right. \\ &\quad \left. \left. + q_{t+1} \left(1 - \delta(u_{t+1}) - \frac{\phi_K}{2} \left(\frac{I_{t+1}}{K_{t+1}} - \delta \right)^2 + \phi_K \left(\frac{I_{t+1}}{K_{t+1}} - \delta \right) \frac{I_{t+1}}{K_{t+1}} \right) \right) \right], \end{aligned} \quad (\text{A.37})$$

$$K_{t+1} = \left(1 - \delta(u_t) - \frac{\phi_K}{2} \left(\frac{I_t}{K_t} - \delta\right)^2\right) K_t + I_t, \quad (\text{A.38})$$

$$\frac{1}{q_t} = 1 - \phi_K \left(\frac{I_t}{K_t} - \delta\right), \quad (\text{A.39})$$

$$Y_t = C_t + I_t + \gamma_1 v_{1,t} + \gamma_2 v_{2,t} + G_t, \quad (\text{A.40})$$

$$G_t = \bar{g} Y_t, \quad (\text{A.41})$$

$$D_t^E = Y_t - W_{1,t} N_{1,t} - W_{2,t} N_{2,t} - I_t - \gamma_{1,t}^l v_{1,t} - \gamma_{2,t}^l v_{2,t} - B_t^c + \xi K_{t+1}, \quad (\text{A.42})$$

$$B_{t+1}^c = dB_t^c + \xi K_{t+1} / Q_t^c, \quad (\text{A.43})$$

$$V_t = \max \left[(1 - \beta)(C_t)^{1-1/\psi} + \beta(\mathbb{E}_t V_{t+1}^{1-\gamma_t})^{\frac{1-1/\psi}{1-\gamma_t}} \right]^{\frac{1}{1-1/\psi}}, \quad (\text{A.44})$$

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

A.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:

$$\log(\Delta Z_t) = \rho_z \log(\Delta Z_{t-1}) + \sigma_z \epsilon_t^z, \quad (\text{A.46})$$

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 $\{\hat{Y}_t, \hat{C}_t, \hat{I}_t, \hat{G}_t, \hat{K}_t, \hat{u}_t, \hat{v}_{1,t}, \hat{v}_{2,t}, N_t, N_{1,t}, N_{2,t}, S_{1,t}, S_{2,t}, R_t^K, q_t, R_t^r, M_t, \hat{V}_t, \hat{W}_{1,t}, \hat{W}_{2,t}, \hat{P}_t^E, \hat{D}_t^E, \hat{B}_t^c, Q_t^c, \hat{\Gamma}_t\}$ that satisfies the following conditions:

$$\hat{Y}_t = (u_t \hat{K}_t)^\alpha (\Delta Z_t N_t)^{1-\alpha}, \quad (\text{A.47})$$

$$N_t = \left((1 - \Omega) N_{1,t}^{\frac{\theta-1}{\theta}} + \Omega N_{2,t}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad (\text{A.48})$$

$$N_{2,t} = (1 - \rho_1) N_{2,t-1} + m_2(S_{2,t}, v_{2,t}), \quad (\text{A.49})$$

$$N_{1,t} = (1 - \rho_2) N_{2,t-1} + m_1(S_{1,t}, v_{1,t}), \quad (\text{A.50})$$

$$S_{1,t} = 1 - (1 - \rho_1) N_{1,t-1} - (1 - \rho_2) N_{2,t-1}, \quad (\text{A.51})$$

$$S_{2,t} = 1 - N_{1,t} - (1 - \rho_2) N_{2,t-1}, \quad (\text{A.52})$$

$$\frac{\hat{\Gamma}_t \gamma_1^l v_{1,t}}{m_1(S_{1,t}, v_{1,t})} = (1 - \Omega)(1 - \alpha) \Delta Z_t \left(\frac{u_t \hat{K}_t}{\Delta Z_t N_t} \right)^\alpha \left(\frac{N_t}{N_{1,t}} \right)^{\frac{1}{\theta}} - \hat{W}_{1,t} + \quad (\text{A.53})$$

$$\begin{aligned}
& + \mathbb{E}_t \left\{ M_{t,t+1} \Delta Z_t \frac{(1-\rho_1) \hat{\Gamma}_{t+1} \gamma_1^l v_{1,t+1}}{m_1(S_{1,t+1}, v_{1,t+1})} \right\}, \\
\frac{\hat{\Gamma}_t \gamma_2^l v_{2,t}}{m_2(S_{2,t}, v_{2,t})} &= \Omega(1-\alpha) \Delta Z_t \left(\frac{u_t \hat{K}_t}{\Delta Z_t N_t} \right)^\alpha \left(\frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} - \hat{W}_{2,t} + \\
& + \mathbb{E}_t \left\{ M_{t,t+1} \Delta Z_t \frac{(1-\rho_2) \hat{\Gamma}_{t+1} \gamma_2^l v_{2,t+1}}{m_2(S_{2,t+1}, v_{2,t+1})} \right\},
\end{aligned} \tag{A.54}$$

$$\hat{W}_{1,t} = \hat{\Gamma}_t \eta \left[(1-\Omega)(1-\alpha) \left(\frac{u \hat{K}}{N} \right)^\alpha \left(\frac{N}{N_1} \right)^{\frac{1}{\theta}} + \gamma_1^l \frac{v_1}{S_1} \right] + (1-\eta) \hat{\Gamma}_t b_1, \tag{A.55}$$

$$\hat{W}_{2,t} = \eta \left[\Omega(1-\alpha) \Delta Z_t \left(\frac{u_t \hat{K}_t}{\Delta Z_t N_t} \right)^\alpha \left(\frac{N_t}{N_{2,t}} \right)^{\frac{1}{\theta}} + \hat{\Gamma}_t \gamma_2^l \frac{v_{2,t}}{S_{2,t}} \right] + (1-\eta) \hat{\Gamma}_t b_2, \tag{A.56}$$

$$M_{t,t+1} = \beta \left(\frac{\hat{C}_{t+1} \Delta Z_t}{\hat{C}_t} \right)^{1-1/\psi} \left(\frac{\hat{C}_t}{\hat{C}_{t+1} \Delta Z_t} \right) \left(\frac{\hat{V}_{t+1}}{(\mathbb{E}_t \hat{V}_{t+1}^{1-\gamma_t})^{\frac{1}{1-\gamma_t}}} \right)^{1/\psi-\gamma_t}, \tag{A.57}$$

$$\hat{P}_t^E = \mathbb{E}_t \left[M_{t,t+1} \Delta Z_t \left(\hat{D}_{t+1}^E + \hat{P}_{t+1}^E \right) \right], \tag{A.58}$$

$$Q_t^c = \mathbb{E}_t \left[M_{t,t+1} (dQ_{t+1}^c + 1) \right], \tag{A.59}$$

$$1 = R_t^r \mathbb{E}_t M_{t,t+1}, \tag{A.60}$$

$$R_t^K = \alpha \left(\frac{u_t \hat{K}_t}{\Delta Z_t N_t} \right)^{\alpha-1}, \tag{A.61}$$

$$R_t^K = q_t \delta'(u_t), \tag{A.62}$$

$$\begin{aligned}
q_t &= \mathbb{E}_t \left[M_{t,t+1} \left(u_{t+1} R_{t+1}^K + \right. \right. \\
& \left. \left. + q_{t+1} \left(1 - \delta(u_{t+1}) - \frac{\phi_K}{2} \left(\frac{\hat{I}_{t+1}}{\hat{K}_{t+1}} - \delta \right)^2 + \phi_K \left(\frac{\hat{I}_{t+1}}{\hat{K}_{t+1}} - \delta \right) \frac{\hat{I}_{t+1}}{\hat{K}_{t+1}} \right) \right) \right],
\end{aligned} \tag{A.63}$$

$$\hat{K}_{t+1} = \left(1 - \delta(u_t) - \frac{\phi_K}{2} \left(\frac{\hat{I}_t}{\hat{K}_t} - \delta \right)^2 \right) \frac{\hat{K}_t}{\Delta Z_t} + \frac{\hat{I}_t}{\Delta Z_t}, \tag{A.64}$$

$$\frac{1}{q_t} = 1 - \phi_K \left(\frac{\hat{I}_t}{\hat{K}_t} - \delta \right), \tag{A.65}$$

$$\hat{Y}_t = \hat{C}_t + \hat{I}_t + \hat{\Gamma}_t \gamma_1 v_{1,t} + \hat{\Gamma}_t \gamma_2 v_{2,t} + \Delta Z_t \bar{g} Y, \tag{A.66}$$

$$\hat{G}_t = \Delta Z_t \bar{g} Y, \tag{A.67}$$

$$\hat{D}_t^E = \hat{Y}_t - \hat{W}_{1,t} N_{1,t} - \hat{W}_{2,t} N_{2,t} - \hat{I}_t - \Gamma_t (\gamma_1^l v_{1,t} + \gamma_2^l v_{2,t}) - \hat{B}_t^c + \xi \frac{\hat{K}_{t+1}}{\Delta Z_t}, \tag{A.68}$$

$$\hat{B}_{t+1}^c = d\hat{B}_t^c / \Delta Z_t + \xi \hat{K}_{t+1} / Q_t^c, \tag{A.69}$$

$$\hat{V}_t = \max \left[(1 - \beta)(\hat{C}_t)^{1-1/\psi} + \Delta Z_t^{1-1/\psi} \beta (\mathbb{E}_t \hat{V}_{t+1}^{1-\gamma_t})^{\frac{1-1/\psi}{1-\gamma_t}} \right]^{\frac{1}{1-1/\psi}}, \quad (\text{A.70})$$

$$\hat{\Gamma}_{t+1} = \hat{\Gamma}_t^\omega (\Delta Z_t)^{-\omega}. \quad (\text{A.71})$$

A.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 unemployment as:

$$\mathbb{W}_t^1 = W_{1,t} + \mathbb{E}_t \left\{ M_{t,t+1} \left[(1 - \rho_1) \mathbb{W}_{t+1}^1 + \rho_1 \max\{\mathbb{S}_{t+1}^1, \mathbb{S}_{t+1}^2, \mathbb{U}_{t+1}\} \right] \right\}, \quad (\text{A.72})$$

$$\mathbb{W}_t^2 = (W_{2,t} + \kappa_t) + \mathbb{E}_t \left\{ M_{t,t+1} \left[(1 - \rho_2) \mathbb{W}_{t+1}^2 + \rho_2 \max\{\mathbb{S}_{t+1}^1, \mathbb{S}_{t+1}^2, \mathbb{U}_{t+1}\} \right] \right\}, \quad (\text{A.73})$$

$$\mathbb{U}_t = b_2 + \mathbb{E}_t \left\{ M_{t,t+1} \max\{\mathbb{S}_{t+1}^1, \mathbb{S}_{t+1}^2, \mathbb{U}_{t+1}\} \right\}, \quad (\text{A.74})$$

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:

$$\mathbb{S}_t^1 = P_{1,t}^m \mathbb{W}_t^1 + (1 - P_{1,t}^m) \mathbb{S}_t^2. \quad (\text{A.75})$$

$$\mathbb{S}_t^2 = P_{2,t}^m \mathbb{W}_t^2 + (1 - P_{2,t}^m) \mathbb{U}_t. \quad (\text{A.76})$$

Equations (A.72)-(A.74) 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

$$\mathbb{S}_t^2 \geq \mathbb{U}_t. \quad (\text{A.77})$$

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:

$$\mathbb{S}_t^1 \geq \mathbb{S}_t^2. \quad (\text{A.78})$$

Inspection of the above equations reveals that a necessary condition for this to hold is

that κ_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 (A.72)-(A.74) with

$$\mathbb{W}_t^1 = W_{1,t} + \mathbb{E}_t \left\{ M_{t,t+1} \left[(1 - \rho_1) \mathbb{W}_{t+1}^1 + \rho_1 \mathbb{S}_{t+1}^1 \right] \right\}, \quad (\text{A.79})$$

$$\mathbb{W}_t^2 = (W_{2,t} + \kappa_t) + \mathbb{E}_t \left\{ M_{t,t+1} \left[(1 - \rho_2) \mathbb{W}_{t+1}^2 + \rho_2 \mathbb{S}_{t+1}^1 \right] \right\}, \quad (\text{A.80})$$

$$\mathbb{U}_t = b_2 + \mathbb{E}_t \left\{ M_{t,t+1} \mathbb{S}_{t+1}^1 \right\}, \quad (\text{A.81})$$

Equations (A.79)-(A.81) together with (A.75)-(A.76) 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 (A.77)-(A.78) hold.

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 each conditions holds in at least 95% of realizations.

B 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).

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).