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Interest rate, Investment and Unemployment: State-dependent Analysis

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Yves Togba Boboy

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To our LORD, and all that is within me bless his highest name.

ABSTRACT

INTEREST RATE, INVESTMENT AND UNEMPLOYMENT: STATE-DEPENDENT ANALYSIS

by

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We reassess a mechanism of a seminal question that seeks to explain the cyclical variations in unemployment and vacancies. To do so, we discuss conditions for why most search and matching models might not account for such cyclical variations. We then argue that the dynamics of the labor market are state-dependent, split under what we define as a low interest rates state (regime) or a high interest rates state (regime). This suggests an important role for the adjustment costs, investment, cost of capital, and productivity.

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Chapter 1

Introduction

1.1 Introduction

There is a significant interest in understanding the volatility of unemployment and vacancies (Diamond, 1982)[1]. Most matching models rely on number of assumptions that make unemployment to be more responsive to productivity. Ljungqvist and Sargent (2017) summarize these assumptions into fundamental surplus, $y - x$ with y as productivity and x includes sticky wages, unemployment benefits, fixed matching cost, costly acquisition credit and the like. In this research, we propose another interpretation of y and x, split under two regimes (states).

For instance, in the same vein with Shimer (2005), Eckstein, Setty and Weiss (2018) explore another channel of the determination of the equilibrium of unemployment and vacancies, and find that firms profit is influenced by capital costs (through interest rate shock) and thus incentivizes hires and therefore the equilib-

[1]See for further discussion, Diamond (1982), Mortensen and Pissarides, (1994); Pissarides, (2000), Shimer (2005), Hall (2005), Nakamura and Steinsson (2018).

	u	v	f	x	I	Baa	Productivity
Standard Deviation	0.28	0.30	0.24	0.14	0.13	0.16	0.02
Correlation Contemporaneous				u	-0.72	0.20	-0.08
				v	0.81	-0.24	0.09
				f	0.73	-0.14	-0.04
				x	-0.65	-0.22	-0.22
				I	-	-0.30	0.37

Table 1.1: Summary Statistics, US Quarterly Data, Full sample, 1953Q1-2026Q4

Notes: The table reports of the standard deviations and cross-correlation. For similarity, all variables have been Log-Hamilton detrended.

rium unemployment and vacancies. The authors use log Hodrick-Prescott filter and document a strong correlation between Baa (corporate bond yield)[2] and spread to treasuries with unemployment. In this research, we ask how capital cost and investment explain the volatility of unemployment and vacancies under periods of high and low capital costs[3].

First, Table 1.1 documents the correlation between cyclical movement of labor market aggregates, investment, corporate interest rate and labor productivity.[4]. Contrary to the productivity which displays a small standard deviation, labor market aggregates (unemployment, vacancies, job finding rate and job separation rate), investment and the corporate interest rate seem to be more volatile. Thus, investment and corporate interest rate tend to be more correlated with unemployment and vacancies than with the productivity. Yet, job separation rate, investment

[2]Authors use Compustat data and show that 75% of US firms representing 50% employment are Baa rated. This supports the use of Baa corporate interest rate as proxy for capital cost.

[3]To account for the stochastic trend in both labor market aggregates and financial variables, we instead use log-Hamilton Filter.

[4]We use Shimer (2012) to compute the job finding rate, job separation rate and their probabilities.

and corporate interest rate are much correlated to productivity, suggesting either an endogenous behavior of the employment exit rate or the relevance of capital cost and investment for explaining the cyclical behaviors of unemployment and vacancies.

To dip into this, the cross-sectional correlations of separated samples into periods of high and low interest rates reveal that the co-movement observed above are close to what we define as high rate state in Table 1.2. In the low rate state (when firms are financially less constrained), unlike less volatile, the cyclical movement in productivity is slightly more correlated to that of the labor market aggregates. But while the magnitude of both investment and corporate interest rate only slightly decrease, the positive correlation between employment exit rate, unemployment and productivity seems to match with the behaviors of exogenous employment exit rate assumed in most matching models than in high rate state where separation rate is mostly endogenous. But the sign of the correlation reflects more the composition bias rather than what observed in most matching models[5]. Overall, this raises question about how investment and capital cost channels matter for the volatility of unemployment and vacancies and under which conditions the explanatory power of the labor market productivity matters.

We investigate these questions within a matching model with capital and the implied investment and its adjustment costs. In the model setup, workers (employed

[5]The increase in productivity may imply for firms to separate themselves with low productive workers, suggesting a positive relationship between an exogenous employment exit rate and unemployment. Shimer (2005) speculates about this assumption. The structural change in unemployment analysis is beyond the scope of this note. We argue that structural change in unemployment is endogenously shaped as in low rate state, productivity become more correlated to cyclical movement in labor market aggregates. This gives support to the factors that favor labor market reallocation.

	u	v	f	x	I	Baa	Productivity
Standard Deviation	0.26	0.29	0.23	0.14	0.14	0.17	0.02
Correlation Contemporaneous				u	-0.79	0.22	-0.08
				v	0.85	-0.25	0.18
				f	0.78	-0.14	0.02
				x	-0.70	0.42	-0.35
				I	-	-0.30	0.38

Table 1.2: Summary Statistics, US Quarterly Data (High rate state)

Notes: The table reports of the standard deviations and cross-correlation. For similarity, all variables have been Log-Hamilton detrended.

and unemployed) maximize the expected utility of the sum of the labor income and leisure given their holding assets. At a given cost, banks intermediate capital between workers, and firms. Firms then support a vacancy cost and employ workers for given wages negotiating under Nash bargaining setting. Further, in order to invest and buffer against adjustment costs, firms pay a cost for the underlying holding assets (capital and the like).

First, using a smooth transition structural auto-regression model (STVAR), we investigate a proposal explanation of how the cyclical movement in unemployment and vacancies are associated with that of the cost of capital, and investment in order to allow for responses differentiated across high and low interest rates phases. First our results show that the responses of the labor market aggregates (cyclical movement in investment, vacancies, job separation, job finding rates and their probabilities) to corporate interest rate (Baa corporate bond yields) vary across regime such as in the high or low interest rate phases. The estimates imply that an interest rate shock (baa) in bad time (high rate regime or state) leads to much larger responses of unemployment, vacancies, job finding rate and separation rate,

	u	v	f	x	I	Baa	Productivity
Standard Deviation	0.32	0.34	0.32	0.14	0.21	0.12	0.02
Correlation Contemporaneous				u	-0.24	0.22	0.27
				v	0.69	-0.30	-0.18
				f	0.52	-0.28	-0.27
				x	-0.55	0.18	0.12
				I	-	-0.55	0.29

Table 1.3: Summary Statistics, US Quarterly Data (Low rate state)

Notes: The table reports of the standard deviations and cross-correlation. For similarity, all variables have been Log-Hamilton detrended.

investment and the probabilities of job finding and separation rate, while the estimates are less precise for the responses of those variables to interest rate shocks in good time than bad times, suggesting that the impact of an interest rate shocks to labor market aggregates and investments are not different from zero in good time. For instance, the estimates implies that after an interest rate shock during the bad time, unemployment rate and separation rate increase significantly (higher unemployment rate explained by the level of corporate interest rate), vacancies, and job finding rate decrease.

Furthermore, we estimate the news shock, namely the investment specific technology (IST) news shock as a means to capture the investment shock. Our estimates imply that unemployment and separation rates (and their probabilities) decrease while both vacancies and job finding rate (their probabilities) increase following the IST news shock. Our results give support to the underlying proposal under which the cyclical movement in the investment and costs channels explain the equilibrium unemployment and vacancies; that is the cyclical movement in labor aggregates and investment are state-dependent and the behavior under the high interest rate regime (god time) is associated with that of the normal behavior in the labor market.

Having recognized these empirical motivation and evidence, the sensitivity analysis of our model lead to three straightforward results. First, our results point out that the cyclical movement in unemployment and its sensitivity with respect to labor productivity are state-dependent. This suggests an interpretation of the reasons behind Shimer (2005)'s critique under which most matching models cannot account for all cyclical variations in the ratio v-u. Notably, our results implicates a novel interpretation of the sensitivity of the labor market tightness under which the low rate state (regime) coincides with the classical explanations that originate from most search and matching models rather than under the high state rate (e.g. they fail to explain the transition from E to U or U to E during the recession and the paths that favor of the recovery). Thus, our sensitivity analysis also prove that the underlying low rate state is therefore the state under which fundamental surplus coincide with firms profit or match surplus.

Finally, in order to have a high volatility of unemployment with respect to productivity, most models rely on different calibrated values; that is Ljungqvist and Sargent (2017)'s critique. Having recognized that, our results indicate that while the behavior of the inflows into and outflows from unemployment that results from the change in productivity is subjected to the state-dependence, the cyclical variations in investment, its adjustment costs and capital cost better capture that behavior. Third, our results point out that while the elasticity of the matching tightness with respect to productivity matters, the elasticity of the matching tightness with respect to capital cost, investment and, its adjustment costs also have straightforward implications for explaining the volatility of unemployment and vacancies. Thus, having recognized that the traditional matching models fail to explain the volatility of unemployment under what we consider as high rate state. The account of these new features help better explain the volatility of unemployment under both states and therefore strongly explain the inflows into and outflows from unemployment. These channels are important to understand the transmission mechanism of policies in the bond and money markets and in the labor market.

1.2 Literature Review

The literature on research on capital-embodied productivity growth in the context of frictional labour was pioneered by Aghion and Howitt (1994) and Mortensen and Pissarides (1998). Hornstein, Krusell, and Violante (2007) in a DMP framework, demonstrate that depending on the level of the presence of labour-market regulations (unemployment benefits, payroll taxes, and firing costs), capital-embodied technological change may reduce labor demand and raises equilibrium unemployment and unemployment durations. Ljungqvist and Sargent (2017) shows that Hornstein et al. (2007) put a matching function into a model with vintage capital and use it to argue a substantial increase in Europe unemployment to an acceleration in the rate of capital-embodied technological change. Ljungqvist and Sargent (2017) shows that Hornstein et al. (2007)'s results depends on the assumption of the equilibrium lifespan of machines which they relate to the annuity value of the layoff tax and what matters in Hornstein et al's framework, is the size of the fundamental surplus fraction.

In this research, we include investment and capital costs to study how they matter for the elasticity of market tightness. This paper is also close to Michaillat (2012) who argue that the search and matching model of unemployment converge asymptotically to full employment when matching frictions disappear, which makes these models inadequate to study recessionary unemployment or unemployment in bad time. Michaillat (2012) introduces job rationing in the traditional search and matching model but our sensitivity of the model show that the equilibrium of vacancies and unemployment is state dependent, split under period of high and low cost of capital.

Recently there are several papers studying financial conditions in DMP model (Hall 2016; Petrosky-Nadeau 2014; Wasmer and Weil 2004; Petrosky-Nadeau and Wasmer 2013; Schoefer, 2015; Hall, 2016). Closest to our paper is Eckstein, Setty, Weiss (2018), modeling how corporate interest rate affects equilibrium of unemployment and vacancies, in a Diamond, Mortesen and Pissarides model. In our paper, we conduct a sensitive analyses to demonstrate how the underlying equilibrium vary under period of higher and low interest rate.

There is also a literature that deviates from using productivity shocks as the underlying force for unemployment volatility, as we do here, thus breaking the strong correlation between unemployment and labor productivity (Shimer, 2005). In a similar vein, Michaillat (2012) find that the search and matching model coincide with the behavior of labor market in normal time but in recessions, job rationing is acute, driving the rise in unemployment, whereas matching frictions contribute little to unemployment. Intuitively in recessions, jobs are lacking, the labor market is slack, and recruiting is easy and inexpensive, so matching frictions do not matter much. In our paper, we make a claim that the traditional search and matching model matches with the period where interest rate is low.

This paper is also related to the rare literature of the implications of investment specific technological shock in explaining the cyclical variation of labor market outcome. For instance, Faccini and Ortigueira find that investment specific technology explain 40 percent of the ob served volatility in the US labor market. Faccini and Ortigueira endogenize labor productivity to firms investment and hiring policy which align with Ljungqvist and Sargent's critique. The authors assume that a positive shock to investment-specific technology increases investment by making capital relatively cheap, but impose a strong assumption, assuming that a convex adjustment costs create a tension between investment and hiring, leading to an initial contraction in hiring. We differ with this work in sense that without imposing strong assumption, our paper analyzes the implications of investment to explain the elasticity of the labor market tightening under periods of higher and lower interest rate, claiming that the search and matching model explain the market tightness only under period featured by low interest rate.

Chapter 2

Empirical and Theoretical Analsys

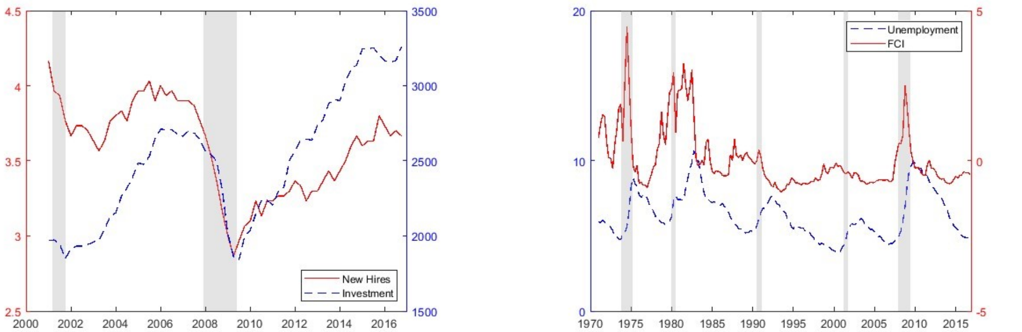
This chapter presents the empirical and theoretical analysis of our research questions that seeks to motivate the relevance of the investment and capital costs channels as a proposal explanation for the cyclical movement in labor market aggregates[1].

2.1 Empirical motivtion and analysis

In this section, we discuss about the relevance of the investment and capital costs channels as a proposal explanation for the cyclical movement in labor market aggregates. We collect data from different sources presented in the Appendix A.

First, Figure 2.1(a) displays the time series of the variables job creation and investment. It is shown that period of recessions featured by the decline in job creation coincide with that of the decrease in investment. As one can observe, during the early stage of the recession the inflows into unemployment is more

[1]Details about the data and model are provided in the Appendix A.



(a) Job creation and Investment (b) Unemployment and Financial Condition

Figure 2.1: Simple facts

Notes: Times series of job creation and investment and Chicago Financial Condition Index and unemployment rate. The shaded regions are NBER recessions. Appendix A provides details about the data.

important than that of the outflows and thus investment also declines.

At the same time, the rise in adjustment costs and also the opportunity cost of capital during the recession may decrease the firms match surplus, lowering the overall expected values and thus increases the volatility of unemployment. In Figure 2.1(b), we document the dynamics of the variables financial conditions and unemployment rate [2]. It is shown that recessions are associated with weak corporate financial conditions and spike in the unemployment rate. These evidences seem to suggest that the duration of unemployment spells is associated with the corporate cost and investment channels.

To shed light on the channels, we use both a SVAR model (linear) and a smooth transition structural autoregression model (STVAR), namely the regime switching

[2]Note that we use the variable FCI to draw some conclusions about its interaction with unemployment rate as the factor index includes many corporate related variables.

vector autoregression model where the transitions across states are smooth in order to allow for responses differentiated across high and low rates (captured by the state of the Baa–Aaa credit spread,). First, we study how the cyclical movement in the cost of capital, proxy by the corporate interest rate (Baa), is associated with the equilibrium unemployment and vacancies. Further, incorporating investment into these SVAR model helps draw some conclusions about its relevance. Broadly, we consider unemployment u, vacancies v, hours, job finding rate f, job separation rate s and their probabilities (F and S) as labor market aggregates [3].

2.1.1 Methodology

We consider the following linear SVAR model with p lags:

$$y_t = c + \sum_{y=1}^{p} \beta_j y_{t-1} + \epsilon_t \tag{2.1}$$

where y_t contains our observed variables and β_j are coefficients matrix. We choose the lag length $p = 4$. We use a sample periods from 1953Q1 to 2016Q4. In our model setups (estimated separately), we use recursive identification scheme to identify capital cost and investment shocks. First, for the cost channel model, we order corporate interest rate (Baa) first, following by employment exit rate, vacancies, investment, job finding rate, unemployment. We make simple identification assumptions about the speed of the cyclical movement in endogenous variables after an unexpected change in corporate interest rate, as we prove this reasoning within the extended DMP (Diamond Mortensen and Pissarides) framework.

[3] We compute the variables job finding rate f, job separation rate s and their probabilities (F and S) following Shimer (2012)

Furthermore, we estimate the news shock, namely the investment specific technology-IST news shock as a means to capture the investment shock. We use the IST's measure built on Ben Zeev and Khan (2015) which identifies IST news shocks, and extend Barsky and Sims (2011) medium-horizon restriction method for identifying news and employ Fisher's (2006) assumptions linking IST and the relative price of investment goods. Our goal is to estimate the extent to which the ins and outs of the labor market is explained by the investment.

To dip into this, we use a smooth transition structural autoregression model (STVAR), namely the regime switching vector autoregression model where the transitions across states are smooth in order to allow for responses differentiated across high and low rates (captured by the state of the Baa–Aaa credit spread), following Auerbach and Gorodnichenko (2012) and Bachmann and Sims (2012) which is close to smooth transition autoregressive (STAR) models developed in Granger and Teravistra (1993). We consider the following STVAR model :

$$\mathbf{Y}_t = (1 - F(z_t))\Phi_H(L)\mathbf{Y}_{t-1} + F(z_t)\Phi_L(L)\mathbf{Y}_{t-1} + \epsilon_t \quad \epsilon_t \sim N(0, \Omega) \tag{2.2}$$

with $\Omega = \Omega_H(1 - F(z_t)) + \Omega_L F(z_t)$, $F(z_t) = \frac{\mathbf{exp}(-\gamma z_t)}{1+\mathbf{exp}(-\gamma z_t)}$ with $\gamma > 0$ and $\mathbf{exp}(z_t) = 1$ and $E(z_t) = 0$; where the set $\mathbf{Y} = [Baa \quad f \quad x \quad i \quad v \quad u]$ is the detrended vector of endogenous variables such as Baa is Baa corporate bond yield, f job finding rate, x separation rate, i investment, v vavancies and u unemployment [4]. The underlying ordering of variables in $\mathbf{Y}$, means that shocks in others variables

[4]We also estimate the model using investment-specific technology news shock with the following

have no contemporaneous effect on Baa; $\Phi_H(L)$ and $\Phi_L(L)$ are the coefficient matrices captured the dynamics of the high and low rates phases; Ω is the variance-covariance matrix of reduced-form residuals, which varies with the state of the interest rate (high or low) given by Ω_H and Ω_L, which are the state-contingent covariance matrices in high and low state rates phases.

$F(z_t)$ is the probability of being in the low state bounded between 0 and 1 with the smoothness parameter γ; z is an index (normalized to have unit variance so that γ is scale invariant) of the cost of capital (spread), with positive z indicating high rate state. We calibrate γ so that we can have over 30% of the observed frequencies of period of low rate. The state of low interest rate is defined as a pariod in which $F(z_t) > 0.8$. The model is estimated using maximum likelihood methods. Furthermore, given the non linearity of the problem, it may be difficult to construct confidence intervals for parameter estimates as well as impulse responses. To address these issues, we use a Markov Chain Monte Carlo (MCMC) method developed in Chernozhukov and Hong (2003). We set the lag length to 4 (linear model) and 3 (non-linear model) driving by AIC and BIC criterions.

To check whether our results are robusts, we apply this time the local projection technique (LP) by Jorda (2005) and specify the quantile regression to capture the state of the economy (state depenent) of each period in good and bad times. We consider the following LP model with p lags :

$$y_{t+h} = c_h + \lambda_h x_t + \sum_{j=1}^{p} \delta_{h,j} x_{t-j} + \epsilon_t \tag{2.3}$$

ordering $\mathbf{Y}_t = [Baa \quad p \quad f \quad x \quad v \quad u]$ with p as productivity.

where y_{t+h} is our variables of interest such as the cyclical movement in unemployment, vacancies, job finding rate (and its probabilities), separation rate (and their probabilities). $\delta_{h,j}$ is a vector of coefficients associated with the lags of x_{t-j}. The IRFs are sequences of Λ_h estimated with a set of regressions for each horizon h using the model (2.2). One should note that we use more lags (selected using specific criterion) and control specifications to check the robustness of the model while we estimate at the first place a Bayesian LP with some control variables as a mean to leave the data drive the results.

The model in (2.3) can be extended to a state-dependent model by allowing the parameters to change according to the state of the economy, which are captured by the quantile regression following Koenker and Bassett (1978). Let consider our variales of interest x_t a sequence of K-vectors of known design matrix, and y_{t+h} is variable in the regression process $u_t = y_t - x_t\Lambda$. The ϕth regression quantile is defined as a solution of the minimization problem :

$$\min_{b\in\mathbb{R}^K}\left[\sum_{t\in\{t:y_t\geqslant x_t\lambda\}}\phi|y_t - x_t\lambda| + \sum_{t\in\{t:y_t\leq x_t\lambda\}}(1-\phi)|y_t - x_t\lambda|\right]$$

The least absolute error estimator is the regression median, e.i., the regression quantile for $\phi = 1/2$. In this research, we consider both values of ϕ for 10th and 90th. We use the the state depenepent LP only for the estimates of the responses of the labor market aggregate to the Baa interest rate shock (for the investment specific technology-IST news shock, we use the full sample).

Furthermore, we take the square of the variable shock (interaction variable) to capture whether the responses depend on the level of interest rate. We make the responses of the aggregates of the labor market to the level of the corporate interest rate to vary whether the economy and the labor market are in good and bad times.

2.1.2 Empirical Results

Figure 2.2 compares the dynamics of the probability of being in the high rate state (regime or phase) $(1 - F(z_t)$ with recessions identified by the NBER. We can note that period of high probabilities of being under periods of high spread coincide with the periods of underperformances of the economy, where unemployment rate is high.

Figures 2.2-2.4 show impulse responses to a 1% increase in corporate interest rate (Baa) for both the linear SVAR and for the STVAR models. Figure 2.2 displays the 90 percent confidence interval for the linear model, while Figure 2.3 and Figure 2.4 plot the confidence bands for the high rate state (regime) and low rate state (regime), respectively. First, our results show that the responses of the labor market aggregates (cyclical movement in investment, vacancies, job separation, job finding rates and their probabilities) to corporate interest rate (Baa corporate bond yields) vary across regime such as in the high or low interest rate phases.

The estimates imply that an interest rate shock (baa) in bad time (high rate

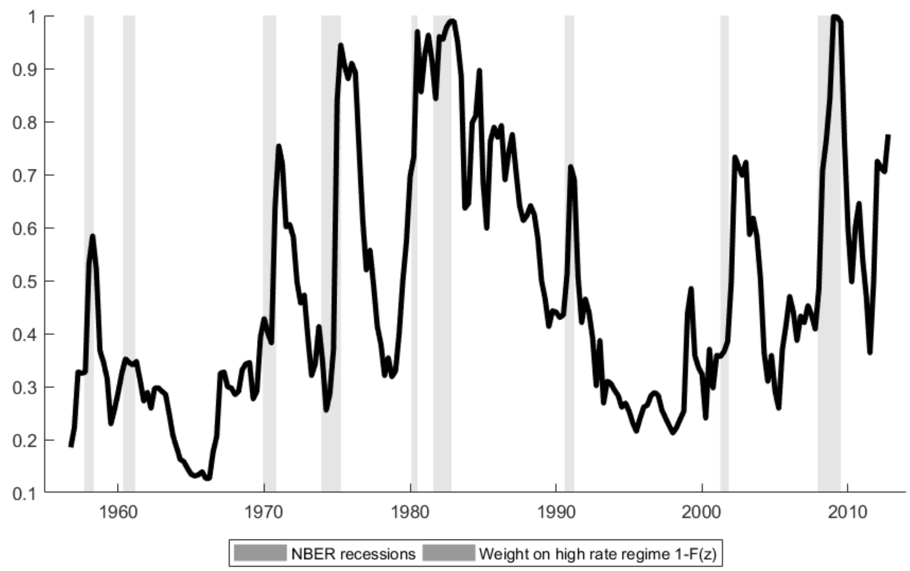


Figure 2.2: NBER Dates and Weight on high rates Regime $1 - F(z)$

Note: The shaded region shows recessions as defined by the NBER. The solid black line shows the weight on high rates regime $1 - F(z)$.

regime or state) leads to much larger responses of unemployment, vacancies, job finding rate and separation rate, investment and the probabilities of job finding and separation rate, while the estimates (Figure 2.4) are less precise for the responses of those variables to interest rate shocks in good time (low rate phase) than bad times (high rate phase), suggesting that the impact of an interest rate shocks to labor market aggregates and investments are not different from zero in good time (low rate regime). For instance, the estimates implies that after an interest rate shock during the bad time, unemployment rate and separation rate increase significantly, while vacancies, investment and job finding rate decrease while in the low rate regime (state), unemployment and separation rate decrease and job finding and vacancies increase. After an interest rate shock during, the the magniture of the peak response of the investment is more important in the high rate regime than in low rate regime.

Figure 2.2-2.4 shows that in the high rate state, the cyclical movement in investment, vacancies, labor productivity and job finding rate significantly decrease and job separation rate and unemployment rise in response to corporate interest rate shock. Formally, this channel matters in explaining the equilibrium unemployment and vacancies. More importantly, these results are consistent with view that firms surplus, which depends on more than wages or vacancy posting cost, is sensitive to the cyclical movement in the broader corporate's capital cost. We finally replace the employment exit and job finding by their probabilities instead of their rates, and find that employment exit probabilities endogenously rises while job finding probabilities significantly decreases following the shock.

Figures 2.5 shows impulse responses to a 1% increase in IST news shock. Our estimates imply that unemployment and separation rates decrease while both vacancies and job finding rate increase following the IST news shock. As shown in the correlation results above, we can show that the responses of unemployment, vacancies, job finding rate and separation vary under good and bad periods in term of their magnitudes. In this research, we present the mean responses as to show the importance of the investment in explaining labor market dynamics.

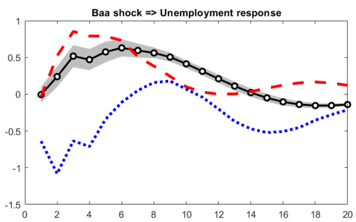
More importantly, the results from both channels give support to investment, and capital costs, say first, as a proposal explanation of the cyclical movement in unemployment and vacancies and thus of that of employment exit and job finding probabilities. Next, we shows how both channels reduce firms expected utility of filling vacancy and thus firms surplus.

To check whether our results are robusts, we apply this time the local projection technique (LP). Figures B.1-B.4 show the responses of the labor market aggregates and investment to interest rate shock under what we define as bad and good time (high rate or low rate regimes or states) using a simple state dependent Local Projection. Similar to the results from the SVAR and STVAR models, the estimates in the Figure B.1-B.3 imply that an interest rate shock (baa) in bad time leads to much larger responses of unemployment (rate and level), vacancies, job finding rate and separation rate, investment and the probabilities of job finding and separation rate, though the estimates are less precise for interest rate shocks in good time than bad times, suggesting that the impact of an interest rate shocks to labor market aggregates and investments are not different from zero in good time.

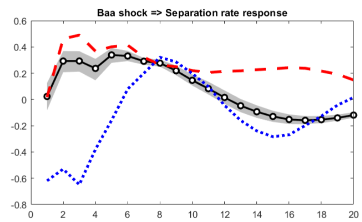
For instance, the estimates implies that after an interest rate shock during the bad time, unemployment rate and separation rate increase significantly (higher unemployment rate explained by the level of corporate interest rate), vacancies, and job finding rate decreases. Furthermore, we find that investment decreases for almost 7 quarter before to increase. To test whether our estimates are riven by the theoretical prediction about the irreversible investment, we estimate the new model, this time, by using investment in level. Our estimates confirm that in bad time, a corporate interest rate shock lead to persistent decline in investment.

In Figure B.4, our estimates imply that unemployment and separation rates (and their probabilities) decrease while both vacancies and job finding rate (their probabilities) increase following the IST news shock. As shown in the correlation results above, we can show that the responses of unemployment, vacancies, job finding rate and separation vary under good and bad periods in term of their magnitudes. In this research, we present the mean responses as to show the importance of the investment in explaining labor market dynamics.

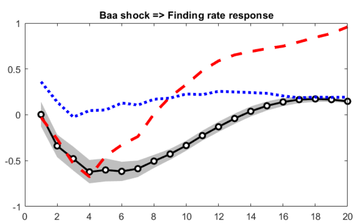
We first note that empirically one can estimate a structural model and conduct a counterfactual analysis as to draw conclusion about the relevance of the factors that drive ups and downs the magnitude of these parameters. In this section, we assumed the model to be real so we can similarly draw implications for the relevance and magnitude of each of its parameters and variables. Broadly, our estimates show that the responses of labor market aggregates and investment to Baa interest rate shock and to an investment shock are significant and state-dependent (regime or phase), suggesting that both investment and the cost of capital play an important role in explaining the equilibrium of unemployment and vacancies.



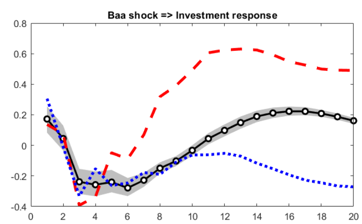
(a)



(b)



(c)



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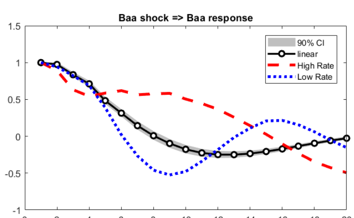

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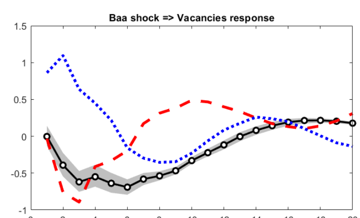
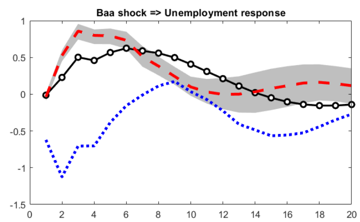


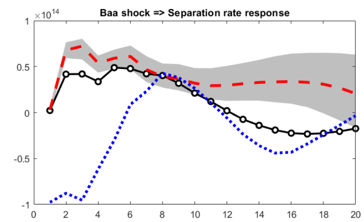
(f)

Figure 2.3: IRFs (Interest rate shock using STVAR)

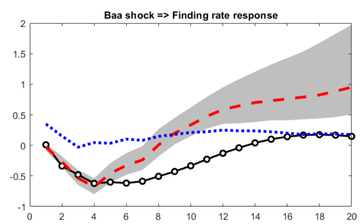
Notes: The figures show impulse responses to a 1% increase in corporate interest rate (Baa). Shaded region is the 90 percent confidence interval for the high rate phase. Dashed red lines show the responses in high rate phase (long dash) and Dashed bleu lines show the responses in low rate phase (short dash) regimes. The solid line with circles shows the response in the linear model.



(a)



(b)



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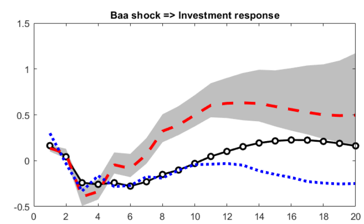

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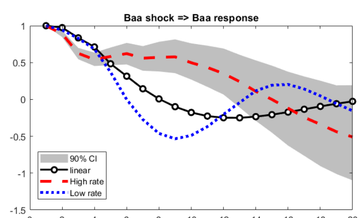

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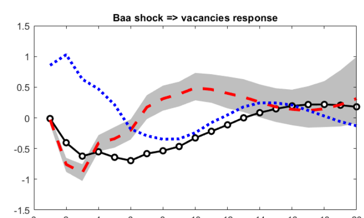
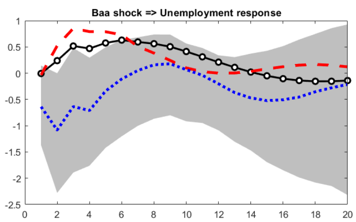


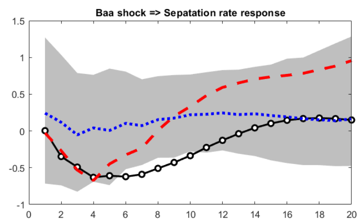
(f)

Figure 2.4: IRFs (Interest rate shock using STVAR)

Notes: The figures show impulse responses to a 1% increase in corporate interest rate (Baa). Shaded region is the 90 percent confidence interval for the linear model. Dashed red lines show the responses in high rate phase (long dash) and Dashed bleu lines show the responses in low rate phase (short dash) regimes. The solid line with circles shows the response in the linear model.



(a)



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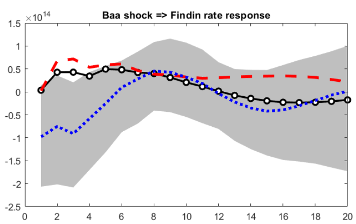

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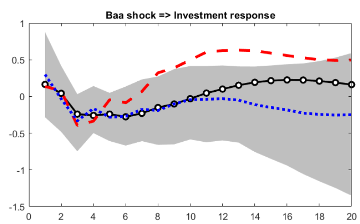

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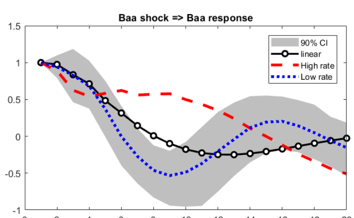

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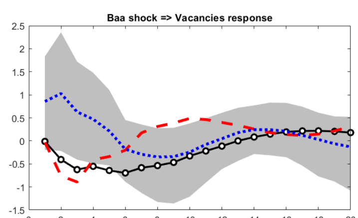
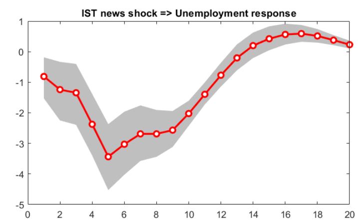


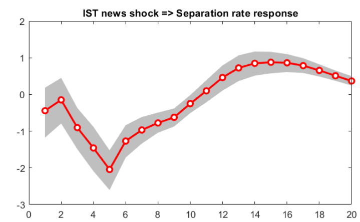
(f)

Figure 2.5: IRFs (Interest rate shock using STVAR)

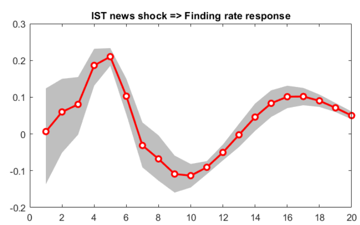
Note: The figures show impulse responses to a 1% increase in corporate interest rate (Baa). Shaded region is the 90 percent confidence interval for the low rate phase. Dashed red lines show the responses in high rate phase (long dash) and Dashed bleu lines show the responses in low rate phase (short dash) regimes. The solid line with circles shows the response in the linear model.



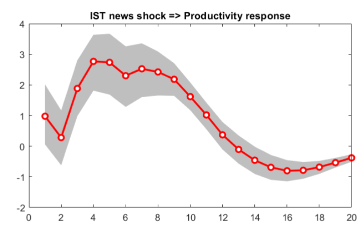
(a)



(b)



(c)



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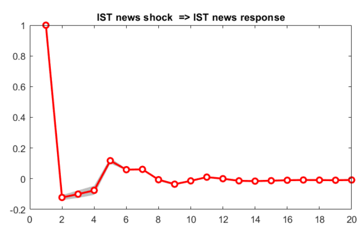

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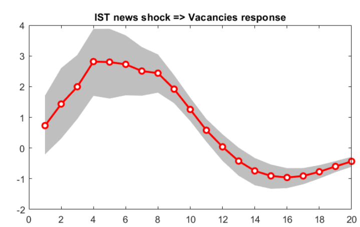


(f)

Figure 2.6: IRFs (Investment-specific technology news shock using SVAR)

Notes: The figures show impulse responses to a 1% increase in the investment-specific technology news shock. Shaded region is the 90 percent confidence interval for the linear model.

2.2 Model

In this section, we combine two approaches to examine whether investment and its adjustment and capital costs can be a proposal explanation of the equilibrium unemployment and vacancies and therefore under which states (high or low rates states or regimes), the labor productivity coincides with the predictions of most matching models.

First, Ljungqvist and Sargent (2017) points out that fundamental surplus is a solid determinant of the elasticity of matching tightness and argue that small fundamental surplus can coincide with small match surplus $y - x$ or firm's profit but the reserve may be not reliable under Nash bargaining models.

In this section, in the same vein with the authors, using a basic matching model with capital, we prove that the argument behind is that small fundamental surplus explaining market tightness coincides with the evidence of matching model under periods featured by a strong capital quality (low rate state or regime); when labor productivity seems to be more correlated to labor market aggregates (as, for example, Michaillat, 2012). Second, we extend the same matching model as to draw conclusions on the business cycle implications (volatility of unemployment and vacancies) of both investment, adjustment and capital costs.

2.2.1 Fundamental surplus, investment, adjustment and capital costs

We assume a discrete time matching model. There are a continuum of identical workers who are either employed or unemployed. Workers are infinitely lived and risk neutral with discount factor $\beta = (1+r)^{-1}$. Workers maximize the expected utility of sum of labor income plus the value of leisure given their holding assets at the end of the period. The budget constraint for the employed workers is $c_t + a_t = w_t + (1+r)a_{t-1}$ and that of unemployed workers $c_t + a_t = b + (1+r^a)a_{t-1}$. The equilibrium ensures that both rates equal r^f. b is workers outside option which includes home production, unemployment benefits and the like [5].

Banks intermediate capital by borrowing at cost r^a from workers, supporting z_t as intermediate cost. Banks per-period earnings are $(r_t - \zeta_t z_t - r^f)k$ (ζ_t capture capital quality and follows a Markov process).

The production technology has constant elasticity of substitution with labor and capital. Workers produce y unit of output. Firms employ workers for the wage w_t, negotiating under Nash bargaining. For simplicity and transparency, we assume that all workers are exogenously destroyed with per-period probability s. Firms borrow capital k from banks and pay the cost r_t and it depreciates at rate δ. The aggregate capital is $K_t = k$ and thus $K_{t+1} = (1-\delta)K_t + I_t - \Psi(I, K)$ (the function $\Psi(I, K)$ captures the adjustment costs, detailed below). Firms per-period earnings are $y - w_t - (r_t + \delta)k$ and support a vacancy cost c each period as to find workers.

[5] High calibrated value of b increases the volatility of unemployment.

We assume a matching function $M(u,v)$ following a Cobb-douglas, homogeneous of degree 1. This implies the ratio $\varrho = \frac{v}{u}$ of vacancies to unemployment, thus the job finding rate for workers is $\frac{M(u,v)}{u}$ and that of filling rate for firms is $\frac{M(u,v)}{v}$. With $M = u^{\alpha}v^{1-\alpha}$ and thus $\alpha = -q'(\varrho)\frac{\varrho}{q(\varrho)}$ is the elasticity of the matching tightness with respect to unemployment.

The firms value J of filling jobs and V a vacancy satisfy a Bellman equation (we get rid of t for simplicity)

$$J = y - w - (r+\delta)k + \beta\left\{sV + (1-s)J\right\} \tag{2.4}$$

$$V = -c + \beta\left\{q(\varrho)J + [1-q(\varrho)]V\right\} \tag{2.5}$$

Free entry ensures zero-profit condition V = 0. The equation (2.5) yields

$$J = \frac{c}{\beta q(\varrho)} \tag{2.6}$$

We can then rearrange above equations and (2.6) such as

$$w = y - (r+\delta)k - \frac{r^f + s}{\beta q(\varrho)}c \tag{2.7}$$

We assume workers value as employed E and as unemployed U satisfy the Bellman equation:

$$E = w + ar^a + \beta\left\{(1-s)E + sU\right\} \tag{2.8}$$

$$U = b + ar^a + \beta \left\{ \varrho q(\varrho) E + [1 - q(\varrho)] U \right\} \tag{2.9}$$

We then solve for the surplus split S between firms and workers. The maximum of Nash product $(E - U)\phi J^{1-\phi}$ satisfy

$$E - U = \phi S \qquad and \qquad J = (1 - \phi) S \tag{2.10}$$

with $\phi \in (0, 1)$ measures the workers bargaining power. Note that plugging $J = \frac{y - w - (r+\delta)k}{1 - \beta(1-s)}$ and $E = \frac{w + ar^a + sU}{1 - \beta(1-s)}$, into (2.10) and after rearranging we arrive to

$$w = \frac{r^f}{1 + r^f} U + \phi \left(y - ar^a - (r + \delta)k - \frac{r^f}{1 + r^f} U \right) \tag{2.11}$$

From (2.9), we rewrite E such as $E = \frac{b + ar^a + [1 - \varrho q(\varrho)]U}{\beta \varrho q(\varrho)}$ and substituting into (2.10) and using (2.6), yields

$$U \left[\frac{r^f + \varrho q(\varrho)}{\varrho q(\varrho)} \right] - \frac{b + ar^a}{\beta \varrho q(\varrho)} = \phi \frac{c}{(1 - \phi) q(\varrho)}$$

Thus by multiplying $\varrho q(\varrho)$, we arrive to

$$\frac{r^f}{1 + r^f} U = b + ar^a + \phi \frac{c}{(1 - \phi)} \varrho \tag{2.12}$$

Rearranging (2.11) such $w = \frac{r^f}{1 + r^f} U(1 - \phi) + \phi(y - ar^a - (r + \delta)k)$ and Plugging (2.12) into this expression yields

$$w = b + ar^a + (1 - \phi)(y - b - ar^a - (r + \delta)k + \varrho c) \tag{2.13}$$

Thus, the equilibrium value of the labor market tightness is determined by (2.7) and (2.13) such as

$$y - b - ar^a - (r + \delta)k = \frac{r^f + s + \phi\varrho q(\varrho)}{(1 + \phi)q(\varrho)}c \tag{2.14}$$

The number of unemployed workers evolves such as $u_t + 1 = (1 - \varrho q(\varrho))u_t + s(1 - u_t)$. In the steady state, u implies

$$u = \frac{s}{\varrho q(\varrho) + s} \tag{2.15}$$

Knowing the aggregate capital, we can then use the fundamental surplus (2.14) and unemployment rate (2.15) to find the elasticity of market tightness with respect to corporate interest rate r , investment I , and adjustment costs $\Psi(K, I)$. We then use sensitive analysis with classical parameter values to justify the reason behind the assumption that a small fundamental surplus can coincide with small match surplus $y - x$ or firm's profit but the reserve may be not reliable under Nash bargaining models; suggesting a consideration under which match surplus $y - x$ or firm's profit coincide with high or low state rate.

To dip into it, we compute the steady state elasticity of market tightness with respect to both productivity, capital and adjustment costs. Thus, the implicit differentiation of (2.14) with respect to y and ϱ is

$$0 = -dy + \left\{ \frac{[\phi\varrho q'(\varrho) + \phi q(\varrho)](1 - \phi)q(\varrho) - (1 - \phi)q'(\varrho)\left[r^f + s + \phi\varrho q(\varrho)\right]}{[(1 - \phi)q(\varrho)]^2}c \right\} d\varrho$$

$$\frac{dy}{d\varrho} = \frac{[\phi\varrho q'(\varrho) + \phi q(\varrho)](1-\phi)q(\varrho) - (1-\phi)q'(\varrho)\left[r^f + s + \phi\varrho q(\varrho)\right]}{[(1-\phi)q(\varrho)]^2}c$$

After rearranging and dividing by $q(\varrho)$, we arrive to

$$\frac{dy}{d\varrho} = \frac{\phi q(\varrho) - q'(\varrho)(r^f + s)}{(1-\phi)q(\varrho)}c$$

By multiplying the numerator by ϱ and the denominator by y, we arrive to

$$\eta_{\varrho,y} = \frac{1}{y}\frac{\phi\varrho q(\varrho) + \alpha(r^f + s)}{(1-\phi)q(\varrho)}c \tag{2.16}$$

After solving (2.14) for the expression $(1-\phi)q(\varrho)$, we arrive to

$$\eta_{\varrho,y} = \frac{(r+s) + \phi\varrho q(\varrho)}{\phi\varrho q(\varrho) + \alpha(r+s)}\frac{y}{y - b - ar^a - (r+\delta)k} \tag{2.17}$$

Following Ljungqvist and Sargent (2017), we can rewrite $\eta_{y,\varrho}$ such as

$$\eta_{\varrho,y} = \Upsilon\frac{y}{y - b - ar^a - (r+\delta)k} \tag{2.18}$$

with $\Upsilon = \frac{(r+s)+\phi\varrho q(\varrho)}{\phi\varrho q(\varrho)+\alpha(r+s)}$. Ljungqvist and Sargent (2017) prove that Υ is less and approximate to 1 for different calibrations and thus the elasticity of the market tightness with respect to productivity is explaining by the expression $\eta_{y,\varrho} = \frac{y}{y-b-ar^a-(r+\delta)k}$. Thus, it contains forces that preclude the invisible hand from allocating resources to vacancy creation.

Ljungqvist and Sargent (2017) show that fundamental surplus implies match surplus or firm's profit but the reserve may be not reliable under Nash bargaining models. To dip into it, we first compute the elasticity of the market tightness and unemployment with respect to corporate interest rate. After implicit differentiation of (2.14), we can write

$$\frac{dr}{d\varrho} = \frac{1}{k}\frac{[\phi\varrho q'(\varrho) + \phi q(\varrho)](1-\phi)q(\varrho) - (1-\phi)q'(\varrho)\left[r^f + s + \phi\varrho q(\varrho)\right]}{[(1-\phi)q(\varrho)]^2}c \tag{2.19}$$

Following the same above reasoning, the elasticity of the market tightness with respect to corporate interest rate can be computed such as

$$\eta_{\varrho,r} = \Upsilon\frac{rk}{y - b - ar^a - (r+\delta)k} \tag{2.20}$$

Thus, equations (2.17) and (2.20) have straightforward implications. First, free entry in financial market ensures zero profit condition for banks as cyclical movement in corporate interest rate relates to the process of ζ_t. Both (2.18) and (2.20) analytically imply that the increase in parameters r^f, b, r, δ and k increase the elasticity of the ϱ with respect to either productivity or corporate interest rate and this can then results in strong volatility of unemployment.

After rearranging (2.18) and (2.20), we arrive to

$$\eta_{y,r} = \frac{rk}{y} \tag{2.21}$$

The implications of this equation are straightforwards. Next, we use the same reasoning as to compute the elasticity of investment and adjustment cost. We know the aggregate capital, $I = \gamma k + \Psi(K, I)$. and $\Psi(K, I) = \frac{\psi}{2}\left(\frac{I}{K}\right)^2 K$. After implicit differentiation of (2.14) and using the envelop theorem, we can write elasticity of the market tightness with respect to ψ such as

$$\eta_{\varrho,\psi} = \Upsilon \frac{\frac{1}{\eta_{\Psi,k}}(r+\delta)k}{y-b-ar^{a}-(r+\delta)k}$$

$$\eta_{\varrho,\psi} = \Upsilon \frac{(r+\delta)k}{y-b-ar^{a}-(r+\delta)k} \tag{2.22}$$

Following the same above reasoning, we can then compute the elasticity of the market tightness with respect to investment such

$$\eta_{\varrho,I} = \Upsilon \frac{\frac{1}{\gamma}(I-2\Psi)(r+\delta)}{y-b-ar^{a}-(r+\delta)k}$$

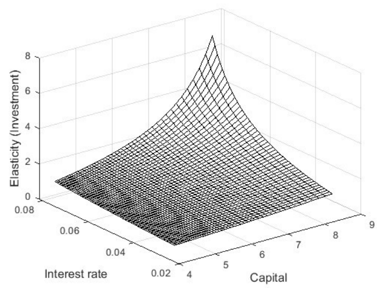
$$\eta_{\varrho,I} = \Upsilon \frac{\left(k-\frac{\Psi}{\gamma}\right)(r+\delta)k}{y-b-ar^{a}-(r+\delta)k} \tag{2.23}$$

Analytically, the elasticity of ϱ with respect to adjustment cost (2.22) and investment (2.23) increase with the rise in r^{f}, b, r, δ and k as they follow similar dynamics patterns. But in (2.23), the expression $\frac{\Psi}{\gamma}$ captures the economic wedge as it exerts a downward effects on the steady state level of capital through either the increase in adjustment cost or the decline in job destruction γ. For instance, small level of capital (small firms) may imply for some industries to offset capital with the rise in labor, implying by $\left(k-\frac{\Psi}{\gamma}\right)$. But in Figures below, we show that with reasonable parameter values, the change in γ as a result to that of u and v, slightly move $\eta_{\varrho,I}$. Notably, a large parameter value of γ, e.g. pandemic shock, can increase $\eta_{\varrho,I}$.

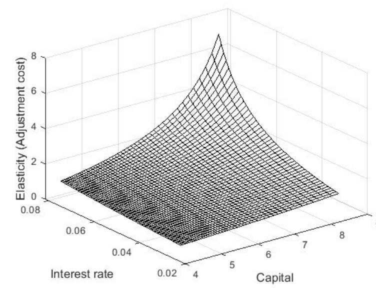
To shed light on this, we conduct a sensitivity analysis of $\eta_{\varrho,y}$, $\eta_{\varrho,r}$, $\eta_{\varrho,\psi}$ and $\eta_{\varrho,I}$ with respect to the change in r, and k. We calibrate the model at quarterly frequency. We set the average unemployment and vacancy rate in data across states (high and low states rates) and target u to 5% and its implied v to 3.9%. We prove that for our targeted value of unemployment, we can reach similar estimated value of vacancy rate from (2.15) when setting the daily s to 0.00081 as in Shimer (2005). We set outside option b to 0.4 and β to 0.991/3 as to estimate the risk free rate r^f. Following Winberry (2020), we set the adjustment cost Ψ to 2.950 and δ to 0.025. Notably, we make sure that our parameter values do not yield a high value of the elasticity of the market tightness as to isolate the relevance of the questions in discussion in this note and also to avoid Ljungqvist and Sargent (2017)'s critique. Using the data on corporate interest rate, we choose r from 0.0288 to 0.0814. To ensure that the equation (2.17), (2.20), (2.22) and (2.23) to be comparable, we assume that $y - ar^f - (r+\delta)k = 1$.

To do so, we assume the production function follows a cobb-douglas technology $y = Ak^\alpha$ and normalize l to 1. we use the total capital income $\alpha y(1-u)$, and $y = 1 + ar^f + (r+\delta)k$ to compute the steady sate value of k [6]. Our sensitivity analysis allows k to vary with the change in corporate interest rate as to account for both underlying states. Note that we intent to show how small fundamental surplus explaining market tightness matches with the evidence of most matching models under period featured by a strong capital quality; when labor productivity

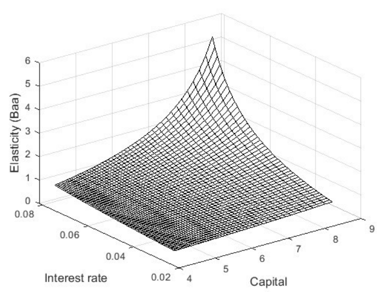
[6] At the steady state, the capital income can be written such as $((1-u)+v)k(r+\delta)$. We know that the capital share of income and output are given by $\alpha = \frac{1}{3}$ and $y(1-u)$. This implies that the capital income can be written such as $\alpha y(1-u)$. After the account of the normalization $y = 1 + ar^f + (r+\delta)k$ and solving for y, we arrive to the capital income $\alpha(1-u)(1+ar^f+(r+\delta)k)$. Formally, we can compute the steady state value of k by equaling both capital incomes such as $((1-u)+v)k(r+\delta) = \alpha(1-u)(1+ar^f+(r+\delta)k)$.



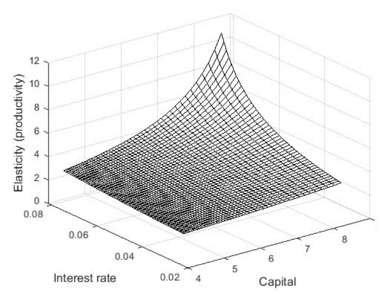
(a) Investment



(b) Adjustment cost



(c) Corporate Interest rate



(d) Productivity

Figure 2.7: Sensitivity analysis

Notes: Sensitivity analysis of the elasticity of matching tightness with respect to investment, adjustment cost, corporate interest rate and productivity, respectively.

seems to be more correlated to labor market aggregates. Thus the account of the state of firms balance sheet will allow to isolate the relevance of corporate interest, adjustment cost and investment as a proposal explanation of the cyclical variations of the unemployment and vacancies.

In the Figure 2.7, the panels (a), (b), (c) and (d) display the elasticity of market tightness with respect to investment, adjustment costs, corporate interest rate and productivity, respectively. The Figure (d) sensibly shows, that when the rate is bind at its low state, the elasticity of market tightness with respect to productivity varies between [0, 2] (flat area); that is under the state where firms financial conditions are not constrained. This range is consistent with mostly computed $\eta_{\varrho,y}$ in the literature. For instance, Shimer (2005) argues that search and matching model cannot account for the cyclical behavior of vacancies and unemployment unless labor productivity to be at least 10 times as volatile as the data suggest. In this note, we provide a proposal explanation of the cyclical movement of unemployment and vacancies.

To shed light on this, in Figure 2.7, we allow all elasticities to vary with the change in corporate interest rate r and its implied change in k. We first show that in Figure (d), beyond the flat area, allowing (2.17) to change with r reduces the resources that the invisible hand allocates to job creation and thus yields to high value of the elasticity of market tightness with respect to productivity y. Formally, $\eta_{\varrho,y}$ vary beyond the value that coincide with the flat rate. At the same time, the rise in k at the value that relates to high cost of capital increases $\eta_{\varrho,y}$. One can observe that using benchmark parameter values, k coincides with the the benchmark interest rate between [0.04, 0.06]. Under this range, the elasticities of market tightness slightly vary with the change in capital (higher values of k increases $\eta_{\varrho,I}$) [7]. This lines up with our previous suggestions under which most matching models match the behavior of the labor market under the low rate state; suggesting that most matching models can not explain the inflows to or outflows from unemployment.

This is consistent with our previous discussions in which fundamental surplus coincides with firms surplus or profit $y - x$ with $x = b + ar^f + (r + \delta)k$ under the low rate state; that is under the flat area. Analytically, one should abstract from capital in the matching models under Nash bargaining or allow for low value of corporate interest rate, risk free rate and depreciation rate. Thus, this sensitivity analysis provides a proposal explanation in which search and matching models without capital and investment adjustment costs cannot alone account for most cyclical behavior of vacancy and unemployment as productivity must interact with other factors in order to explain the $u - v$ ratio.

To dip into the contribution of this note, Figure (a), show that the elasticity of market tightness with respect to investment vary between [0, 1.5] and then spikes up to 8 when allowing for the change in corporate interest rate. But when allowing for the change in corporate interest rate, it suggests that labor market tightness

[7]The cost of tangible or intangible capitals act as a natural responses; in allowing for natural process of reallocation in labor market or other industries and also the learning process over time. In next section we discuss about these facts because any attempt of further interventions, outside the private sector, should internalize the underlying structural change in the economy (energy, auto sectors and the like). We show that using reasonable parameter values, there is no strong evidence in support of the high elasticity of matching tightness with respect investment when both capital and corporate interest rate vary.

sensibly varies with high cost of capital; that is under the underlying high state rate. Next, Figure (b) displays the sensitivity analysis of the elasticity of market tightness with respect to adjustment cost. It shows that when we let $\eta_{\varrho,\psi}$ to not vary with the change in r, the elasticity is approximately between [0, 1.5]. Yet, allowing $\eta_{\varrho,\psi}$ to change with either r and k, the $\eta_{\varrho,\psi}$ considerably increases. Note that we use r as to capture the state of firms balance sheet; thus huge parameter values of r would therefore increase the sensitivity of the labor market tightness with respect to Ψ.

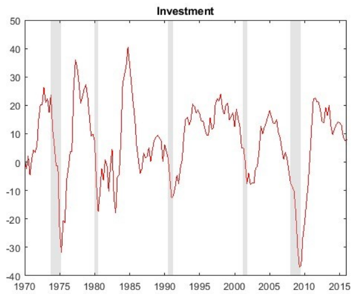
Figure (c) shows the elasticity of matching tightness with respect to corporate interest rate. It varies between [0, 0.8] under the low state rate. Similarly, when we account for the change in r and k, $\eta_{\varrho,y}$ considerably varies from above the flat area up to 5. Notably, under the low rate state, the upper bound value of $\eta_{\varrho,y}$, is more than that of $\eta_{\varrho,r}$, $\eta_{\varrho,\psi}$ and $\eta_{\varrho,I}$; suggesting that under this state, labor productivity seems to play a great role in explaining the cyclical movement of unemployment; implying that fundamental surplus is a solid determinant of the elasticity of matching tightness. Formally, these results are consistent with the cyclical correlation between labor market aggregates with r, I and y described in above Tables 1.1-1.3.

Chapter 3

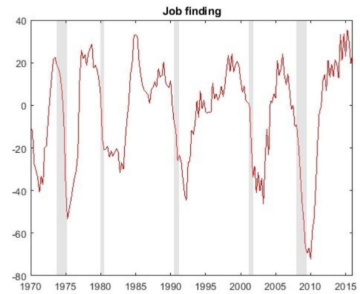
Suggested interpretation

Figure 3.1 plots the cyclical variations of investment, unemployment rate, corporate interest rate, productivity, vacancy rate, and the probabilities of job finding and separation rates. We reconsider a seminal question tackled in most search and matching models and then ask why unemployment increases and vacancies sharply declines over the sample periods and also why the path and pace of the recovery differ across recession periods. One of the proposal explanation of that focuses on the labor productivity shock; which is subjected to Shimer's critique. At the same time, Ljungqvist and Sargent (2017) point out that most features in the matching models that aim at avoiding Shimer's critique use different calibrated values as to force the labor market tightness to be more responsive to change in productivity; that is the Ljungqvist and Sargent (2017)'s critique.

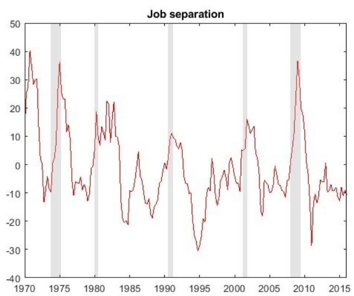
In same vein with both critiques, Figure 3.1 show that the standard deviation of the labor productivity is the least compared to that of other variables; while at the same time, all cyclical variations seem to match with that of different recession



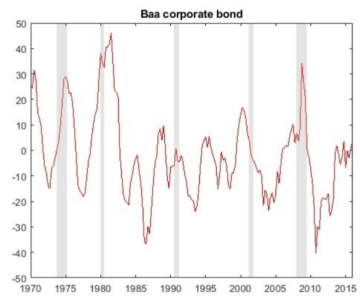
(a)



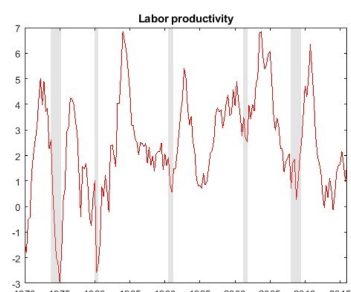
(b)



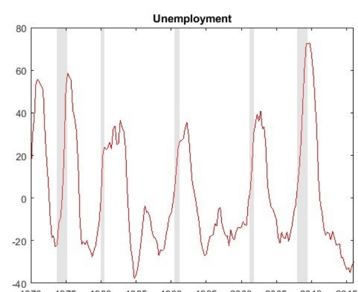
(c)



(d)



(e)



(f)

Figure 3.1: Cyclical variations

Notes: These Figures plot the cyclical variations in the job finding, job separation and vacancies, extracted using Hamilton-filter. Note that we use this filter to account for the stochastic trend. The shaded regions are NBER recessions. Appendix A provides details about the data.

periods. For instance, productivity together with investment, vacancy rate and job finding decline during the recession while corporate interest rate, unemployment and job separation increase during the recession. This suggests that the common factor shapely identified in these cyclical variations and the strong magnitude of the standard variation of other variables (investment and its implied adjustment cost and the cost of capital) during the recessions, are strong assumptions in support of the account of the state-dependence and the relevance of investment, its implied adjustment costs and capital costs as a proposal explanation for this seminal question.

First, based on results in previous sections, we suggest a more plausible way of accounting for the state-dependence of the labor market dynamics (inflows into and outflows from unemployment). Based on the standard deviation of the labor productivity as compared to that of the cost of capital (broadly the cost of holding a financial asset in the firms balance sheet), investment and its implied adjustment costs, we argue that the account of the state-dependence according to whether the cost of capital is low or high helps better capture the the cyclical behavior of the unemployment and vacancies and then explain which state coincides with the predictions of most search and matching models. We show both analytically (Figure c) and empirically that labor productivity can endogenously responds to change in the cost of capital. Notably, our results suggests a novel interpretation of the labor market tightness under which the low state coincides with the classical explanation that results from the most matching models under Nash bargaining.

Thus, this raises question about the relevance of investment and its adjustment costs, and the cost of holding capital within a matching model with capital. Our results also argue that the elasticity of the matching tightness with respect to productivity (2.17) may vary with the change in r, I and k. Next, we suggest that while accounting for the state dependence of the labor market dynamics, the cyclical variations in unemployment and vacancies are strongly explained by cost of capital, investment and its adjustment costs. (2.17), (2.20), (2.22) and (2.23) indicate that accounting for the cost of capital, investment and its adjustment cost within matching models captures the relevance of the cost of capital, capacity utilization of both labor and capital and adjustment costs.

Notably, our results can be interpreted such as while the behavior of the inflows into and outflows from unemployment that results from the change productivity is subjected to the state dependence, the account of the change in investment, capital quality shock and shock to the adjustment cost capture better that behaviors. Thus, not only $\eta_{\varrho,y}$, $\eta_{\varrho,r}$, $\eta_{\varrho,\psi}$ and $\eta_{\varrho,I}$ have straightforward implications in explaining why unemployment increases and vacancies sharply declines over the sample periods and also why the path and pace of the recovery differ across recession periods.

Absent from most models is the recognition of these features and the their implications on the path that drive the economy into full employment and the recovery process following shocks.

3.1 Conclusion

We show that the cyclical movement in unemployment and vacancies and its sensitivity to change in productivity are state-dependents. In the same vein with Shimer and Ljungqvist and Sargent's critiques, this implicates that most matching models cannot account for all cyclical variations in the $v-u$ ratio. The predictions of the traditional search and matching model coincide with the period featured by a lower cost of capital. Our results advocate for a revised understanding of labor market dynamics, emphasizing the importance of integrating investment and capital cost channels into existing models to better account for interactions that drive unemployment and vacancies.

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Appendix A

Appendix Chapter 1

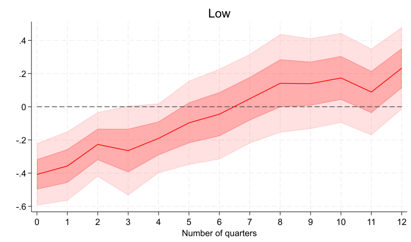
A. Data

- Unemployment rate: Seasonally Unemployment Rate, Quarterly, SAAR from Bureau of Labor Statistics (BLS)
- Unemployment rate: Seasonally Unemployment Rate, Quarterly, SAAR from Bureau of Labor Statistics (BLS)
- Investment: 'Real Gross Private Domestic Investment, Quarterly, SAAR From FRED.
- Corporate interest rate: 'Moody's Seasoned Baa Corporate Bond Yield', From FRED.
- Labor Productivity: computed output per workers; using data from FRED, Quarterly, SAAR.
- Output: Real Gross Domestic Product, Quantity Index (2000=100), SAAR.
- Employment (Level) Total seasonally adjusted employment level from FRED.
- Job finding rate: Computed job finding rate, following Shimer (2012).
- Employment (Level) Total seasonally adjusted employment level from FRED.

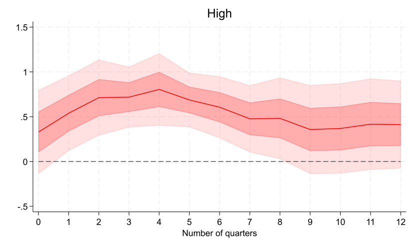
- Hours: Total hours from Bureau of Labor Statistics (BLS).
- Employment exit rate: Computed job separation rate, following Shimer (2012).
- Risk free rate: average yield on 3-months Treasury bills from FRED.
- Chicago Financial Conditions Index from FRED.
- Short Term Unemployment: Number Unemployed for Less Than 5 Weeks, Monthly, Seasonally Adjusted.
- Unemployment (level) from BLS.
- Job creation: Total business sector hires from Bureau of Labor Statistics (BLS).

Appendix B

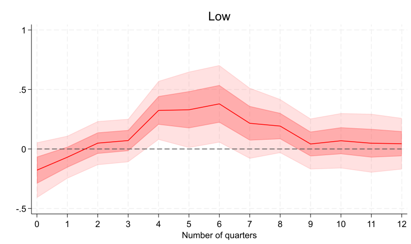
Appendix Chapter 2



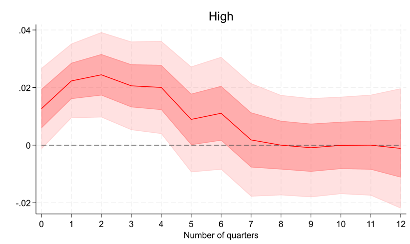
(a) Unemployment rate



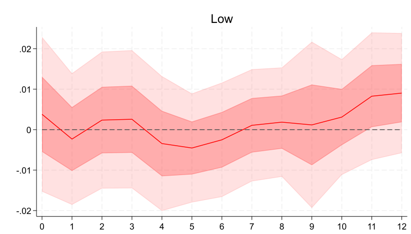
(b) Unemployment rate



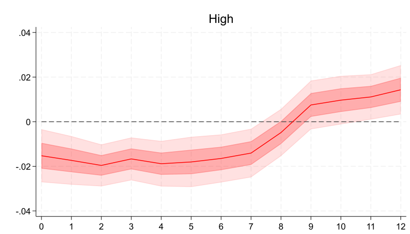
(c) Unemployment level



(d) Unemployment level



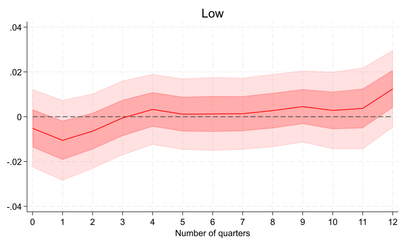
(e) Vacancies rate



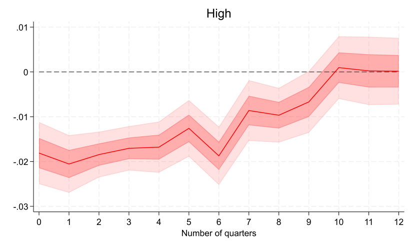
(f) Vacancies rate

Figure B.1: IRFs (Interest rate shock)

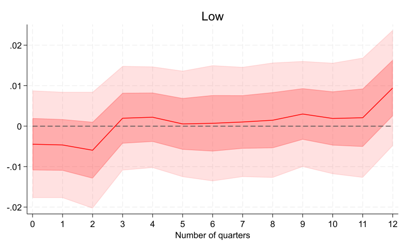
Notes: The solid line shows the estimated effects, with the dark and light shade areas representing 66% and 95% confidence bands. The estimated cyclical variations are extracted using Hamilton-filter.



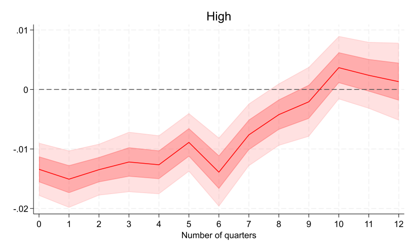
(a) Job finding rate



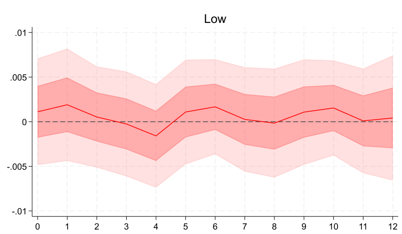
(b) Job finding rate



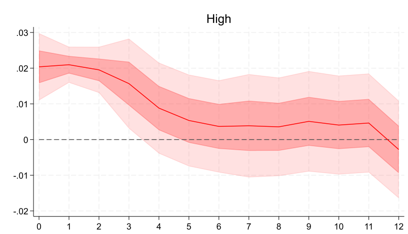
(c) Finding Probabilities



(d) Finding Probabilities



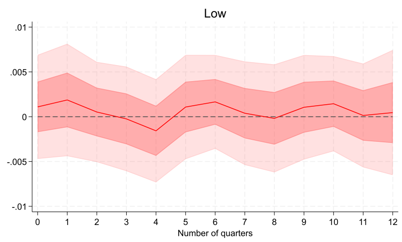
(e) Separation rate



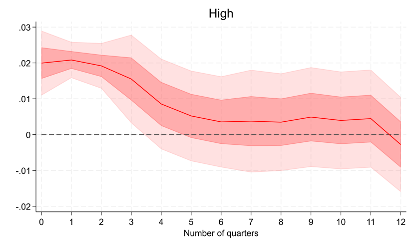
(f) Separation rate

Figure B.2: IRFs (Interest rate shock)

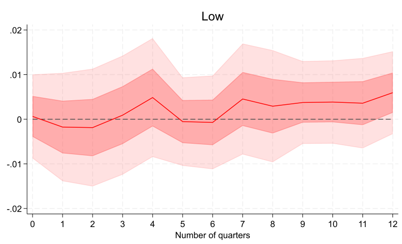
Notes: The solid line shows the estimated effects, with the dark and light shade areas representing 66% and 95% confidence bands. The estimated cyclical variations are extracted using Hamilton-filter.



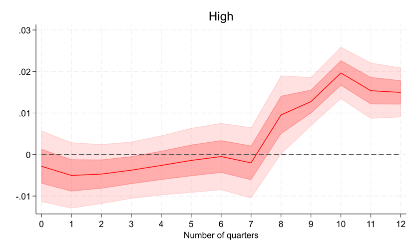
(a) Separation probabilities



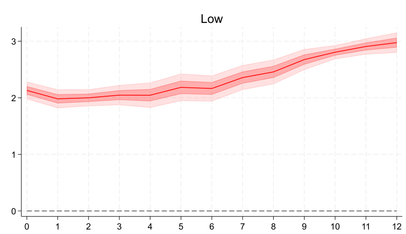
(b) Separation probabilities



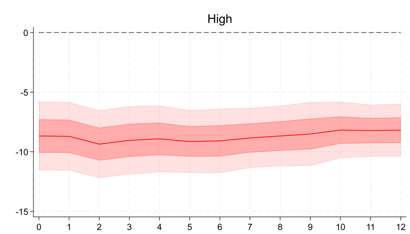
(c) Investment (level)



(d) Investment (level)



(e) Investment in log level



(f) Investment in log level

Figure B.3: IRFs (Interest rate shock)

Notes: The solid line shows the estimated effects, with the dark and light shade areas representing 66% and 95% confidence bands. The investment in log level because of the irreversible hypothesis. The estimated cyclical variations are extracted using Hamilton-filter.

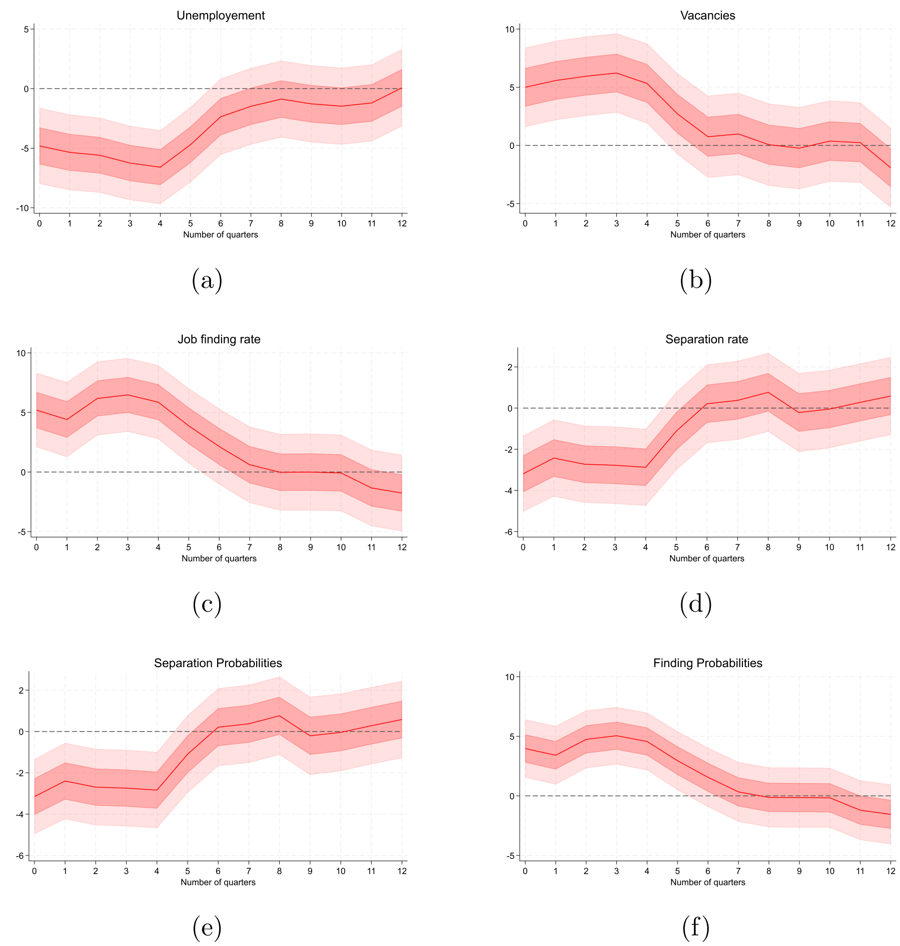


Figure B.4: IRFs (Investment-specific technology news shock)

Notes: The solid line shows the estimated effects, with the dark and light shade areas representing 66% and 95% confidence bands. The estimated cyclical variations are extracted using Hamilton-filter.