Labor Market Fluctuations and the Role of Financial Shocks

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Abstract

We develop a model with both frictional labor markets and financial frictions to explore how the dynamics of real and financial variables are affected by 'financial shocks'. In particular, we evaluate how important the inclusion of financial shocks is in accounting for labor market fluctuations by using a standard real business cycle model with search and matching as a benchmark. We find that the inclusion of financial frictions and financial shocks improves a standard matching model's ability to account for the observed dynamics of labor market variables. Financial frictions are able to generate more volatile hours per worker, labor shares, and employment relative to our benchmark matching model, bringing simulated moments closer to observed fluctuations.

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1 Introduction

The financial turmoil that began with the subprime mortgage crisis in 2007 brought about not only one of the largest decreases in real GDP in the US since the Great Depression, but also a substantial increase in the rate of unemployment. The unemployment rate jumped from 4.7% in 2007:Q4 to 9.9% in 2009:Q4 while real GDP decreased at an astonishing -1.7% annualized rate over the same time period. High unemployment has persisted and continues to be a challenge today, even after real GDP has recovered to pre-recession levels. It seems natural to assess the role credit markets have played in the sharp decrease in employment and its sluggish recovery to pre-recession levels.

The financial crisis and resulting Great Recession have fostered renewed interest in the incorporation of financial frictions in macroeconomic models. Many recent studies have emphasized the importance of employing such frictions to account for macroeconomic fluctuations in key variables over the business cycle. In particular, so called 'financial shocks' have been deemed significant contributing factors for the observed dynamics of real and financial variables over the business cycle. Financial shocks directly affect the financial sector of the economy as opposed to standard productivity shocks that are merely propagated through the financial sector. However, applicable studies have been silent about how unemployment and job postings interact with the deterioration of credit market conditions. In order to address this shortcoming, we evaluate just how important financial shocks are in accounting for movements in key labor market variables by using a standard real business cycle (RBC) matching model which incorporates financial frictions via an enforcement constraint. We assess the importance of incorporating financial shocks into our model by comparing our results to those of a standard matching model without financial frictions. We take our benchmark matching model without financial frictions to be the model developed by Andolfatto (1996) (simply Andolfatto hereafter). We refer to this as the standard matching model throughout.

While analyzing the role of the financial sector over the business cycle is not a new topic, most previous studies utilized the credit channels formalized by Bernanke and Gertler (1989), Kiyotaki and Moore (1997), and Bernanke, Gertler, and Gilchrist (1999) and treated the financial sector as an accelerator of productivity shocks. This standard credit channel differs from those developed more recently by Perri and Quadrini (2011) and Jermann and Quadrini (2012) (JQ hereafter), which incorporate financial shocks that directly affect the financial sector's ability to lend. That is, the financial sector not only propagates productivity shocks originating from other sectors of the economy, but it also acts as a source of the business cycle itself via financial shocks. The latter studies have emphasized the impact of financial shocks in their explanations for labor market fluctuations but offer no means for analyzing the extensive margin of employment in their framework.

Some authors have already highlighted the need for addressing the role of financial frictions on unemployment. Petrosky-Nadeau (2011) uses asymmetric information and costly state verification between financial intermediaries and borrowers which increases both the magnitude and persistence of unemployment fluctuations relative to a standard neoclassical growth model. Chugh (2009) uses a similar credit channel but builds a model with capital accumulation. Monacelli, Trigari, and Quadrini (2011) use a model with linear utility and no capital accumulation and show that borrowing more from financial intermediaries shifts bargaining weight from the worker to the firm which can explain why firms cut hiring after a negative financial shock even in the absence of a liquidity shortage. Our study departs from previous approaches and employs the credit channel used in JQ in order to compare the gains of adding financial frictions over a standard matching model as developed by Merz (1995) and Andolfatto (1996). Our model framework is somewhat related to that of Garin (2012), but his study neither utilizes the intensive margin nor compare the results to a standard RBC matching model. This distinction is important since the response along the intensive margin to financial frictions and shocks in our model is quite different from that along the extensive margin.

We start by documenting the cyclical properties of key variables for the US economy over the period 1984:Q1-2012:Q1 in Table 1. We chose this period for our analysis since JQ have

Variable (x)	$\sigma_x\%$	$\rho\,(x, Output)$	$\rho\,(x_t, x_{t-1})$
Output	1.12	–	0.87
Total Hours	1.26	0.85	0.89
Employment	0.88	0.82	0.93
Hours per Worker	0.45	0.77	0.61
Wages	0.91	-0.18	0.77
Labor Productivity	0.66	0.07	0.59
Labor Share	0.73	-0.28	0.78
Vacancies	11.26	0.86	0.91
Equity Payouts/GDP	1.39	0.69	0.91
Debt Repurchases/GDP	2.23	-0.84	0.93

Table 1: Business Cycle Statistics, 1984:Q1-2012:Q1

argued that 1984 corresponds to a break in the volatility in many business cycle variables and that this time period also saw the stabilization of structural change in US financial markets compared to previous periods. All variables are deflated by population, logged (except debt repurchases and equity payouts), and HP-filtered. Debt repurchases and equity payouts statistics are computed after detrending with a band-pass filter that preserves cycles of 1.5-8 years (Lawrence J. Christiano and Terry J. Fitzgerald (2003)). Wages are defined as real labor compensation per labor-hour. A detailed description of the data used in Table 1 and throughout our study can be found in the Data Appendix.

A few elements in Table 1 deserve some discussion. First, employment is much more volatile than hours worked per worker. While total hours fluctuate more than output itself, most of this is adjusts along the extensive margin. The relative contribution of variance in hours per worker to total hours worked is 32%. Thus, the intensive margin is one that should be incorporated into any model seeking to understand fluctuations in total hours worked in the US economy. Employment and total hours tend to lag output by one quarter while hours worked and vacancies are coincident variables which suggests firms are able to adjust the intensive margin and post vacancies quicker than they can adjust the stock of employees. We will incorporate this fact into our model. Second, real wages are almost as volatile as output, but are surprisingly countercyclical over our sample period. Third, the labor share is countercyclical, implying that during periods of expansion, labor is allocated relatively less of the gains. Finally, note that equity payouts are strongly procyclical while debt repurchases are strongly countercyclical. As JQ pointed out, there seems to be substitutability between equity payouts and debt repurchases over the business cycle. It is our goal to see what gains can be made in accounting for the fluctuations in the variables reported in Table 1 once financial shocks are incorporated into a standard matching model.

The paper is structured as follows. Section II proposes a model with labor market frictions, financial frictions, and financial shocks. Section III discusses the calibration of the models. Section IV studies the quantitative properties of our benchmark model and our proposed model. Section IV studies the importance of financial shocks by comparing our model's results to those of a standard matching model. Section VI concludes

2 Model

Our model framework follows closely the models developed by JQ and Andolfatto. Since the Andolfatto model has a matching framework but no financial frictions, we take this to be our benchmark model to compare our results to. We will refer to the benchmark model as the Andolfatto model, the standard matching model, or simply Andolfatto. Note that the equations characterizing the solution to our model with financial frictions can quickly be mapped into the Andolfatto model by shutting down both the financial shock processes and the Lagrange multipliers on the enforcement constraint. For this reason, we do not lay out the Andolfatto model explicitly but choose to develop our model with financial frictions first.

2.1 Matching

Time is discrete and goes on forever. The timing of our model is as follows: (i) shocks are realized, (ii) wages and hours are bargained over, (iii) firms take our intra-period loans,

(iv) production takes place and vacancies are posted, and then (v) separations and matches occur.

Labor markets are frictional and the law of motion of total employment, N, depends on the number of matches that occur at the end of each period. We take one model period to be one quarter. We assume that the number of matches is dictated by a constant returns-to-scale matching technology which depends on the total number of unemployed, $U \equiv 1 - N$, and on the total number of vacancies, V, posted by firms: $M(V, 1-N)$. Defining $V/(1-N) \equiv \theta$ as labor market tightness, we then define the job-finding rate as $\Psi(\theta) = M(\theta, 1)$ and the job-filling rate as $\Phi(\theta) = M(1, 1/\theta)$. Assuming that jobs are destroyed at the exogenous rate $\chi \in (0, 1)$, it follows that employment evolves according to:

$$N' = (1-\chi)N + \Psi(\theta)(1-N)$$

2.2 Households

There is a continuum of identical and infinitely lived households each of measure one. Each household is endowed with a unit of time to split between working hours and leisure hours and each household derives utility from consumption and leisure. Households discount the future by the factor $\beta \in (0, 1)$. We model a representative household similar to Merz (1995) and Andolfatto (1996), which allows for perfect unemployment insure across households. This, along with the assumption that there are no search costs, implies that every unemployed household will always be searching for a job. Households trade uncontingent bonds, a_H, and shares in firms, s. Unemployed households receive the unemployment benefit $b \geq 0$ from the government and each household pays the lump-sum tax T. We can then write the program of the representative household as:

$$V(S, s_H) = \max_{c, s', a'_H} \{u(c) + n\nu(1-h) + (1-n)\nu(1) + \beta E[V(S', s'_H)]\} \tag{2.1}$$

s.t.

$$c+\frac{a_H'}{1+r\left(S\right)}+p\left(S\right)s'=w\left(S,s_H\right)nh\left(S,s_H\right)+(1-n)b+a_H+\left[p\left(S\right)+d\left(S\right)\right]s-T\left(S\right)$$

$$n'=(1-\chi)n+\Psi\left(S\right)\left(1-n\right)$$

$$S'=G(S),\ c\geq 0,\ \text{No-Ponzi condition}$$

The aggregate state of the economy is given by $S=\{z,\xi;K,B,N,D_{-}\}$, where z is total factor productivity and ξ is the financial shock which both evolve stochastically. K is the aggregate capital stock, B is total bond holdings of the household sector, N is total employment, and D_{-} is the amount of dividends paid out last period. $s_H=\{s,a_H,n\}$ is the individual state, and G is the law of motion for aggregate state variables. d is the dividend paid to shareholders, and p is the share price of the representative firm.

Wages and hours are the result of a Nash-bargaining problem between workers and the firm at the beginning of each period, so from the household's perspective $w\left(S,s_H\right)nh\left(S,s_H\right)$ is given before any consumption or savings decisions take place. Since we have assumed separable utility between consumption and leisure, the intra-household consumption level doesn't depend on employment status as noted in Merz (1995) and Andolfatto (1996). Note that this has the implication that unemployed households are better off than those that are employed since they receive the same consumption level as those that are employed but enjoy all the leisure. This implication is discussed in detail in Cheron and Langot (2004). The first order conditions (dropping the dependence on states) from the household's problem give:

$$1 = E\left[m'\left(1+r\right)\right] \tag{2.2}$$

$$1 = E\left[m'\left(\frac{p'+d'}{p}\right)\right] \tag{2.3}$$

where $m'=\beta u_c\left(c'\right)/u_c\left(c\right)$ is the stochastic discount factor. These equations taken together simply give us the no-arbitrage condition between shares and bonds. All derivations of first order conditions for all agents can be found in the Appendix.

2.3 Firms

We model the firm and derive an enforcement constraint similar to JQ. There exists a representative firm with gross revenue $F(z, k, nh)$, where z is the stochastic level of aggregate productivity. Capital evolves according to the standard law of motion $k' = (1-\delta)\,k + i$, where i is investment and $\delta \in [0,1]$ is the rate of depreciation. Firms discount the future via the stochastic discount factor m' and pay the fixed cost $c_v > 0$ to post a vacancy. The firm also pays the equity payout cost $\varphi(d, d_{-})$ to pay dividends to shareholders. We impose this dividend adjust cost to capture the observation that firms tend to smooth dividends as well as to formalize the financial friction. Firms use equity and debt with debt preferred to equity due to the subsidy $\tau \in (0,1)$. Therefore, the *effective* gross interest rate that the representative firm faces every period is given by $R = 1 + r\,(1-\tau)$.

After negotiating wages and hours, firms take out the intra-period loan l_t to finance working capital. Before receiving any revenue from production, the firm pays the wage bill wnh, chooses investment, chooses the equity payout d and the associated adjustment cost, the number of vacancies v to post, and new intertemporal debt a'_F. Since all payments are done before the realization of revenues, the firm must take out the intra-period loan:

$$l = wnh + i + c_v v + \varphi(d, d_{-}) + a_F - \frac{a'_F}{R}$$

The firm's budget constraint every period is

$$i + a_F + \varphi(d, d_{-}) = F(z, k, nh) - wnh - c_v v + \frac{a'_F}{R}$$

It follows that the intra-period loan is simply total expected revenue, $l = F(z, k, nh)$.

The firm has the option to default after total revenues are realized but before the working capital loan l is paid back. At this moment in time, the firm holds liquidity l and total liabilities $l + a'_F/\,(1+r)$. Since firms can easily abscond with the liquidity l, the lender can only recover the firm's physical capital stock k' with probability ξ, which is stochastic.

With probability $(1-\xi)$, the lender's recovery value is zero. One can be interpret this probability as the probability of finding a buyer of the firm's capital stock.

In the case of default, the lender and the firm can negotiate a payment after the liquidation value of the capital stock is realized. We assume that the firm has all the bargaining power in this negotiation process and the lender will only get the threat value.

If the liquidation value is zero, the lender will not shutdown the firm because it is better off waiting for the intertemporal loan a'_F to come due. The firm keeps the liquidity l in this case. Therefore, the total ex-post value of default in the case when the liquidation value is zero is:

$$l + E\left[m'J'\right]$$

where m' is the stochastic discount factor and J' is the value of the firm tomorrow. That is, $E\left[m'J'\right]$ is the expected present value of the firm if the firm continues to operate.

If the liquidation value is k', the firm will negotiate the payment P to prevent the lender liquidating the firm. The net surplus to the firm of avoiding liquidation is:

$$l + E\left[m'J'\right] - P$$

The lender's net surplus of reaching an agreement is:

$$P + \frac{a'_F}{1+r} - k'$$

Assuming the firm holds all the bargaining power, the firm must pay $P = k' - a'_F/\left(1+r\right)$ to avoid liquidation. It follows that the total net surplus of reaching an agreement is:

$$l + E\left[m'J'\right] + \frac{a'_F}{1+r} - k'$$

Since the liquidation value is not known until after the default takes place, when the intra-period loan is contracted, the expected total net surplus to the firm (since they have all the bargaining power) is

$$
\begin{aligned}
& \xi\left(l+E\left[m'J'\right]+\frac{a_F'}{1+r}-k'\right)+(1-\xi)\left(l+E\left[m'J'\right]\right) \\
= \; & \xi\left(\frac{a_F'}{1+r}-k'\right)+l+E\left[m'J'\right]
\end{aligned}
$$

Incentive compatibility requires that the expected surplus of defaulting not exceed the value of not defaulting. This requires that

$$
\begin{aligned}
E\left[m'J'\right] & \geq \xi\left(\frac{a_F'}{1+r}-k'\right)+l+E\left[m'J'\right] \\
\xi\left(k'-\frac{a_F'}{1+r}\right) & \geq l=F(z,k,nh) \qquad (2.4)
\end{aligned}
$$

The firm's ability to borrow is limited by the enforcement constraint derived above. Higher debt in the form of either inter-temporal or intra-temporal loans is associated with a tighter enforcement constraint while a higher capital stock loosens the enforcement constraint. Since employment (due to the lack of endogenous separations), productivity, the probability ξ, and the capital stock are given, the firm only has control over k', a_F', and the intensive margin h. We refer to innovations in ξ as 'financial shocks' since it directly affects the firm's capacity to borrow from lenders. Negative innovations can be viewed as a deterioration in credit market conditions.

We can then write the program of the representative firm as:

$$
J(S,s_F)=\max_{d,k',a_F',v,n'}\left\{d+E[m'J(S',s_F')]\right\} \qquad (2.5)
$$

s.t.

$$
\begin{aligned}
& k'+a_F+\varphi(d,d_-)=F(z,k,nh\left(S,s_F\right))+(1-\delta)k-w\left(S,s_F\right)nh\left(S,s_F\right)-c_v v+\frac{a_F'}{R\left(S\right)} \\
& \xi\left(k'-\frac{a_F'}{1+r\left(S\right)}\right)\geq F(z,k,nh\left(S,s_F\right)) \\
& n'=(1-\chi)n+\Phi\left(S\right)v \\
& S'=G(S),\; k',v\geq 0
\end{aligned}
$$

where $s_F = \{k, a_F, n, d_-\}$ is the individual state, $R = 1 + r(1 - \tau)$, and the firm's equity payout cost is $\varphi(d, d_-)$. Once again note that wages and hours are bargained at the beginning of the period and are treated as given in the program described above.

The first order conditions (dropping state dependencies) to the firm's problem gives:

$$1 = \lambda\varphi_d + E[m'\lambda'\varphi'_{d\_}] \tag{2.6}$$

$$\lambda c_v = \Phi E\left[m' J'_n\right] \tag{2.7}$$

$$\lambda - \gamma\xi = E\left[m'\left[\left(\lambda' - \gamma'\right) F'_k + (1 - \delta)\, \lambda'\right]\right] \tag{2.8}$$

$$\lambda\,(1 + r) - \gamma R = R\,(1 + r)\, E\left[m'\lambda'\right] \tag{2.9}$$

where λ and $\gamma \geq 0$ are the Lagrange multipliers on the budget constraint and enforcement constraint, respectively. To see how these equations relate to the Andolfatto model, simply consider the equations above and set $R = 1 + r, \lambda = 1$, and $\gamma = 0$.

2.4 Nash Bargaining

Wages and hours are bargained over at the beginning of each period via a Nash bargaining problem between the representative household and the representative firm. Employing the notation from above, the value of an additional worker to the representative household is (in terms of consumption units):

$$\frac{V_n}{u_c} = \frac{\nu\,(1 - h) - \nu\,(1)}{u_c} + wh - b + (1 - \chi - \Psi)\,\beta\left[\frac{V'_n}{u_c}\right]$$

The value to the representative firm of an additional worker is:

$$J_n = (\lambda - \gamma)\, F_{nh} h - \lambda wh + (1 - \chi)\, E\left[m' J'_n\right]$$

where λ and γ are, again, the Lagrange multipliers on the firm's budget constraint and enforcement constraint, respectively. Following Andolfatto (1996), it is assumed that the each worker is so small such that $F_{nh} \equiv \partial F / \partial (nh)$ is taken as given by both the household and the firm during the bargaining process. Given the worker's bargaining weight $\mu \in (0, 1)$, the wage and hours are the result of the Nash bargaining problem:

$$(w, h) = \arg\max_{w,h} \left(\frac{V_n}{u_c} \right)^{\mu} (J_n)^{1-\mu} \tag{2.10}$$

Taking the derivatives with respect to wages and hours gives us the sharing rule of the production surplus and the static condition determining the number of hours.

$$\begin{aligned} \mu J_n &= \lambda (1-\mu) \left(\frac{V_n}{u_c} \right) \\ \frac{\nu_{(1-h)} (1-h)}{u_c} &= \left(1 - \frac{\gamma}{\lambda} \right) F_{nh} \end{aligned}$$

Using the sharing rule, $\mu J_n = \lambda (1-\mu) (V_n / u_c)$, along with the definition of V_n / u_c and J_n, gives the wage bill per worker:

$$\begin{aligned} wh &= \mu \left[\left(1 - \frac{\gamma}{\lambda} \right) F_n + (1-\chi) E \left[m' \frac{J_n'}{\lambda} \right] + \frac{V}{1-N} \Phi E \left[m' \frac{J_n'}{\lambda'} \right] \right] \\ &\quad + (1-\mu) \left[\frac{\nu(1) - \nu(1-h)}{u_c} + b - (1-\chi) E \left[\beta \frac{V_n'}{u_c} \right] \right] \end{aligned} \tag{2.11}$$

This is simply a weighted average of (i) the effective marginal productivity of a worker plus the expected future value of maintaining the match plus the average discounted savings to the firm of not having to post a vacancy next period and (ii) the endogenous outside option of the worker which is simply the forfeited leisure in terms of consumption units as well as the unemployment benefit b minus the future value of maintaining the match. The marginal productivity of each worker F_n is driven down by the effective tightness of the enforcement constraint γ / λ. This is the key equation driving our results.

According to Hagedorn and Manovskii (2008) (HM hereafter), in order to increase the volatility of vacancies and employment, we need to increase the volatility of the firm's surplus per worker. In order to achieve this, they calibrate a low bargaining weight and a high value of the outside option for workers. The low value of the bargaining weight of workers makes the wage bill per worker less volatile in response to the marginal productivity of each worker F_n. The workers' higher outside option makes the firm's surplus small. These two properties taken together makes the firm's surplus per worker more sensitive to the marginal productivity of each worker F_n, which means firms have a greater incentive to post vacancies. Financial frictions have a similar effect by generating an additional wedge between the wage bill per worker and the marginal productivity of each worker F_n. When financial frictions are present, capital is more 'valuable' to the firm than an additional worker since capital has the added benefit of loosening the enforcement constraint in this model.

In our setup, positive financial shocks and negative productivity shocks will increase the outside option of workers endogenously. For these shocks, firms will choose to increase hours per worker since both shocks will relax the enforcement constraint and hours can be increased instantly unlike the stock of employees or capital. Since workers will work more on average, the outside option of not working increases. As a result, the firm's surplus per worker becomes more sensitive to the marginal productivity of each additional worker F_n, which gives the firm more of an incentive to change vacancy postings in response to shocks.

To see the effect of the enforcement constraint on the wage bill more clearly, consider the case in which the equity payout is simply $\varphi(d, d_{-}) = d$. In this case, there are no costs associated with adjusting the dividend and $\varphi_d = 1/\lambda = 1$. It follows that we can write the wage bill in (2.12) as

$$\begin{aligned} wh &= \mu\left[(1-\gamma) F_n + \left(\frac{V}{1-N}\right) c_v\right] \\ &\quad + (1-\mu)\left[\frac{\nu(1) - \nu(1-h)}{u_c} + b\right] \end{aligned}$$

Since $\gamma \geq 0$, the tighter the enforcement constraint, the lower the effective marginal productivity of each worker to the firm becomes. That is to say, in situations in which the shadow price of the enforcement constraint increases, the bargaining weight shifts away from workers to the firm due to the fact that the firm would like to decrease the number of employees in order to loosen the enforcement constraint. However, since there are no endogenous separations, the firm is inhibited from decreasing either the capital stock or the stock of workers and must do so along the intensive margin. The shadow price of our enforcement constraint will increase during positive shocks to total factor productivity and in situation in which the credit market conditions deteriorate.

If there were no credit market frictions in our environment or during situations in which our enforcement constraint becomes nonbinding ($\gamma = 0$), our wage bill would collapse to the standard matching model sharing rule:

$$\begin{aligned} wh &= \mu \left[F_n + \left(\frac{V}{1-N} \right) c_v \right] \\ &\quad + (1-\mu) \left[\frac{\nu(1) - \nu(1-h)}{u_c} + b \right] \end{aligned} \tag{2.12}$$

This last equation will correspond to the wage bill in the Andolfatto benchmark model. The derivation of the equations above is detailed in the Appendix.

2.5 Government

The government in this model simply raises revenue in order to subsidize firm's borrowing and to pay out the unemployment benefits b to the mass of unemployed households. This is simply:

$$T(S) = \left(\frac{1}{R(S)} - \frac{1}{1+r(S)} \right) a'_F(S, s_F) + (1-N) b$$

where S once again denotes the aggregate state.

2.6 Equilibrium

A *recursive competitive equilibrium* is defined as a set of functions for (i) the household's policies $c(S, s_H), s'(S, s_H)$, and $a'_H(S, s_H)$; (ii) the household's value function $V(S, s_H)$;

(iii) the firm's policies $d(S, s_F), k'(S, s_F), a'_F(S, s_F)$, and $v(S, s_F)$; (iv) the firm's value function $J(S, s_F)$; (v) aggregate prices $r(S), R(S), p(S)$, and $m'(S, S')$; (vi) taxes $T(S)$; (vii) the law of motion for aggregate states $S' = G(S)$. Such that: (i) the household's policies are optimal and $V(S, s_H)$ satisfies the Bellman's equation (2.1); (ii) the firm's policies are optimal and $J(S, s_F)$ satisfies the Bellman's equation (2.4); (iii) $m' = \beta u_c(c') / u_c(c)$; (iv) the government's budget is balanced; (v) wages and hours $(w(S, s_H, s_F), h(S, s_H, s_F))$ is the solution to the bilateral Nash bargaining problem given by equation (2.9); (vi) markets clear, $s' = 1, a'_F = a'_H$; (vii) the law of motion $G(S)$ is consistent with individual decisions and the stochastic processes for z and ξ.

3 Calibration of the Model

We must now specify some functional forms in order to evaluate our model's quantitative results. We define the matching technology, the aggregate production technology and the equity payout cost to be:

$$\begin{aligned} M(V, 1-N) &= \omega V^{\psi}(1-N)^{1-\psi} \\ F(z, K, Nh) &= zK^{\alpha}(Nh)^{1-\alpha} \\ \varphi(d, d_{-}) &= d + \kappa(d - d_{-})^2 \end{aligned}$$

where $\psi \in (0,1), \alpha \in (0,1)$ and $\kappa \geq 0$. The representative household's preferences take the form:

$$u(c) = \log(c)$$

$$\nu(\ell) = \begin{cases} \phi \frac{\ell^{1-\eta}}{1-\eta} & \text{if } \ell \in [0,1) \\ \phi_u & \text{if } \ell = 1 \end{cases}$$

and the stochastic processes follow an autoregressive system:

$$\begin{pmatrix} z' \\ \xi' \end{pmatrix} = \mathbf{A}\begin{pmatrix} z \\ \xi \end{pmatrix} + \begin{pmatrix} \varepsilon_z \\ \varepsilon_\xi \end{pmatrix}$$
$$\begin{pmatrix} \varepsilon_z \\ \varepsilon_\xi \end{pmatrix} \sim N(0, \Sigma)$$

where ε_z and ε_ξ are normally distributed innovations with variance-covariance matrix Σ. We now left to determine twenty-one parameters in the model.

Our parameters can be categorized into three groups based on the way we chose to calibrate them. The first set of parameters are predetermined outside model. The second group is a set of parameters for the shock processes which are estimated from the constructed Solow residual and financial shock series. The last group of parameters consists of parameters determined endogenously in the model. We calibrate these parameters using simulated method of moments with a number of targets to be matched. To jointly choose this group of parameters, we minimize the distance between seven moments in the data and the in the model.

3.1 Predetermined Parameters (7)

We set the unemployment benefit $b = 0$, so this plays no role in our analysis. We basically follow Andolfatto (1996) for the discount factor $\beta = 0.99$, the depreciation rate $\delta = 0.025$, the separation rate $\chi = 0.15$ and the matching elasticity $\psi = 0.60$. Since we focus on an economy where the wage in the labor market is determined in a non-competitive fashion, we cannot use labor share data to pin down α. Rather, we choose a value for $\alpha = 0.64$, which is common across the macroeconomic literature and it is also the same as Andolfatto (1996). We choose the tax benefit of debt in a similar to JQ, $\tau = 0.35$. Finally, we set the bargaining weight of workers $\mu = 0.35$, which is a middle of HM (2008) and Shimer (2005). To summarize:

All these parameters, except τ, will also be used in the Andolfatto model.

Parameter	*Description*	*Value*	*Remarks*
β	Discount factor	0.99	annual rate of return 4%
δ	Depreciation rate	0.025	Andolfatto (1996)
χ	Job-separation rate	0.15	Andolfatto (1996)
ψ	Matching elasticity	0.60	Andolfatto (1996)
α	CD parameter for capital	0.36	Andolfatto (1996)
τ	Tax benefit (subsidy)	0.35	JQ (2012)
μ	Bargaining weight of workers	0.35	middle of HM (2008) and Shimer (2005)

Table 2: Predetermined Parameters

3.2 Parameters for the Shock Processes (7)

We construct our z series using the definition of our aggregate production function. In order to construct a series of the measured Solow residual, we must first specify a series for Y_t, K_t, N_t, and h_t. We use Current Population Survey data on the level of employment (N_t) and the average weekly hours worked (h_t). Y_t is simply real GDP taken from the Bureau of Economic Analysis. We construct our capital stock using Flow of Funds data for the nonfinancial business sector and deflate the level of investment each period by the business GDP price index taken from the Bureau of Economic Analysis. Depreciation is taken to be the consumption of fixed capital of nonfinancial business Since we only have flows of net capital expenditures and not a level, we pick K_0 in 1952 such that the capital-output ratio displays no trend. Since we begin the recursion in 1952 and our analysis begins in 1984:Q1, it is not relevant for our results based on the time period for our analysis. Log-linearizing our aggregate production function gives:

$$\hat{z}_t = \hat{y}_t - \alpha\hat{k}_t - (1-\alpha)\,\hat{N}_t - (1-\alpha)\,\hat{h}_t$$

where hats denote log-deviations from a linear trend for each variable estimated over the period 1984:Q1-2012:Q1. We normalize $\bar{z} = 1$.

For the construction of our financial shocks, we make the assumption that the enforcement constraint is *always* binding. Of course, the validity of this assumption is critical for the construction of our financial shock series. We verify ex-post: after constructing the series for the shocks and feeding them into the model to verify that the Lagrange multiplier is always strictly greater than zero. This assumption is strong and open for debate. However, we feel that viewing the nonfinancial business sector in the aggregate as always being constrained is not an outrageous assumption to make. Log-linearizing the enforcement constraint (equation (2.4)), gives us:

$$\hat{\xi}_t = \frac{\bar{\xi}\bar{b}^e}{\bar{y}}\hat{b}^e_{t+1} - \frac{\bar{\xi}\bar{k}}{\bar{y}}\hat{k}_{t+1} + \hat{y}_t$$

where we construct $\hat{b}^e_{t+1}$ using Flow of Funds data for net borrowing in credit market instruments in the nonfinancial business sector deflated by the business GDP price index. $\hat{y}_t$ in this case is not total GDP but real business GDP. Details of the data can be found in the Data Appendix. The capital stock is as defined previously. We fix $\bar{b}^e/\bar{y} = 3.37$ to match the liabilities-output ratio over our sample period. This, in turn, gives us $\bar{\xi}\bar{k}/\bar{y} = 1.4362$ and $\bar{\xi}\bar{b}^e/\bar{y} = 0.4361$. We then use the constructed series for $\hat{z}_t$ and $\hat{\xi}_t$ and estimate a vector-autoregressive process over the time period 1984:Q1-2012:Q1. This gives us the matrix of coefficients and the variance-covariance matrix:

$$\begin{aligned} \mathbf{A}\begin{pmatrix} z \\ \xi \end{pmatrix} &= \begin{pmatrix} 0.9910 & -0.0351 \\ 0.2403 & 0.8978 \end{pmatrix}\begin{pmatrix} z \\ \xi \end{pmatrix} \\ \Sigma &= \begin{pmatrix} 0.0050^2 & 0.000027 \\ 0.000027 & 0.0079^2 \end{pmatrix} \end{aligned}$$

For our Andolfatto benchmark model without financial frictions, we simply have a AR(1) process for the productivity given by:

$$\begin{aligned} \rho_z &= 0.9426 \\ Var\left(\varepsilon_z\right) &= 0.0051^2 \end{aligned}$$

3.3 Parameters Determined Using Targets (7)

For our remaining seven parameters, we use the simulated method of moments to minimize the distance between seven moments from the data and from the model. Our seven targets are:

1. Frisch elasticity of hours for those employed: 0.5
2. Steady-state employment to population ratio: 62%
3. Steady-state hours per worker: 0.39 (weekly potential hours are assumed to be 100)
4. Steady-state job-filling rate: 90%
5. Vacancy expenditures-output ratio: 2.18%
6. Debt to GDP ratio: 3.37
7. Standard deviation of the equity payout-GDP ratio: 1.39

According to Silva and Toledo (2009), the average cost of time spent hiring one worker is approximately 3.6%-4.3% of total labor costs. We target the median, 3.9%, of these estimates. In terms of our model, this implies $\frac{c_v v}{\Phi w n h} = 0.039$, which in turn gives $\frac{c_v v}{y} = 0.218$ given our targets for the job-filling rate $\Phi = 0.9$ and the labor share $= 0.62$, which is the average labor share over our sample period. κ is chosen to have a standard deviation of the equity payout-GDP ratio generated by the model equal to that of data.

For the calibration of the Andolfatto model, we omit the last two targets listed above from the calibration since κ and $\bar{\xi}$ are not present in that model environment. These targets give the following set of parameters for both our model (KS model, which stands for Kim and Seliski) and the Andolfatto model:

Parameter	*Description*	*KS*	*Andolfatto*
η	Curvature parameter for leisure	3.1166	3.1166
ϕ	Scale parameter for leisure	0.7814	0.7797
ϕ_u	Leisure for unemployed	0.2525	0.2554
c_v	Cost of posting a vacancy	0.1960	0.1875
ω	Matching efficiency	0.5349	0.5349
$\overline{\xi}$	Mean of credit process	0.1294	–
κ	Equity payout cost	0.1460	–

Table 3: Calibrated Parameters

4 Results & Discussion

We solve both the KS and Andolfatto models using 2nd order approximation around the steady-state. The derivation of the nonlinear equations characterizing both models' equilibriums can be found in the Appendix. We first show the resulting impulse response functions for the KS model in order to develop some intuition underlying our results.

4.1 Innovations to Productivity

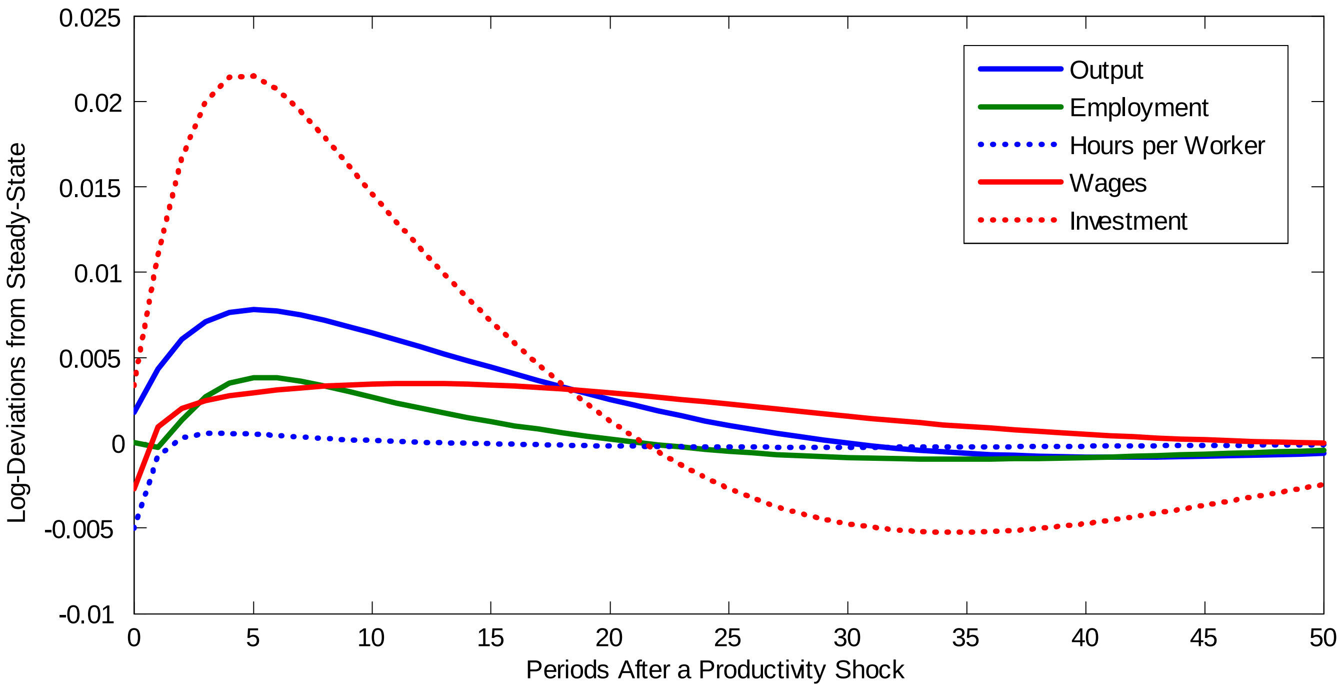

Figure 1: IRFs to a one standard deviation shock to TFP

When a productivity shock hits the KS model economy, the enforcement constraint instantly tightens. Since the stock of employees and capital are fixed, firms can only loosen the constraint via hours per worker and investing in a higher k_{t+1}. Hours in the model respond immediately because they can substitute for bodies that cannot be increased due to the nature of the hiring process. Once employees are separated exogenously, hours recovers back to its steady-state level.

In response to a positive productivity shock, the firm allocates resources away from labor input by decreasing both wages and hours and allocating the savings to investment. This is consistent with the countercyclical nature of the labor share reported earlier. The shift in bargaining power is due to the shock increasing the ratio of the Lagrange multipliers, effectively lowering the marginal product of each worker to the firm. The reason for the firm allocating more resources to capital is clear. After a tightening of the enforcement constraint, capital is deemed more 'valuable' to the firm because investment in capital tomorrow loosens the constraint. That is, labor and capital are imperfect substitutes not only due to their role in the production process, but also due to the added benefit of the higher capital stock loosening the enforcement constraint. The firm wishes to build up capital initially to loosen the constraint for future periods in order to take advantage of the persistence in the positive productivity shock. After employment begins to move (since it cannot move immediately), both wages and hours recover after the firm has effectively loosened the enforcement constraint by accumulating a higher capital stock.

To visually see what is going on with the effective marginal product per worker, recall from the wage bargaining solution that $(1 - \gamma/\lambda)\, F_n$ is the effective benefit to the firm of employing an additional worker. The interpretation of γ/λ is the shadow price of the enforcement constraint discounted by the firm's marginal cost of financing operations via equity. We plot the deviations of the effective shadow price below.

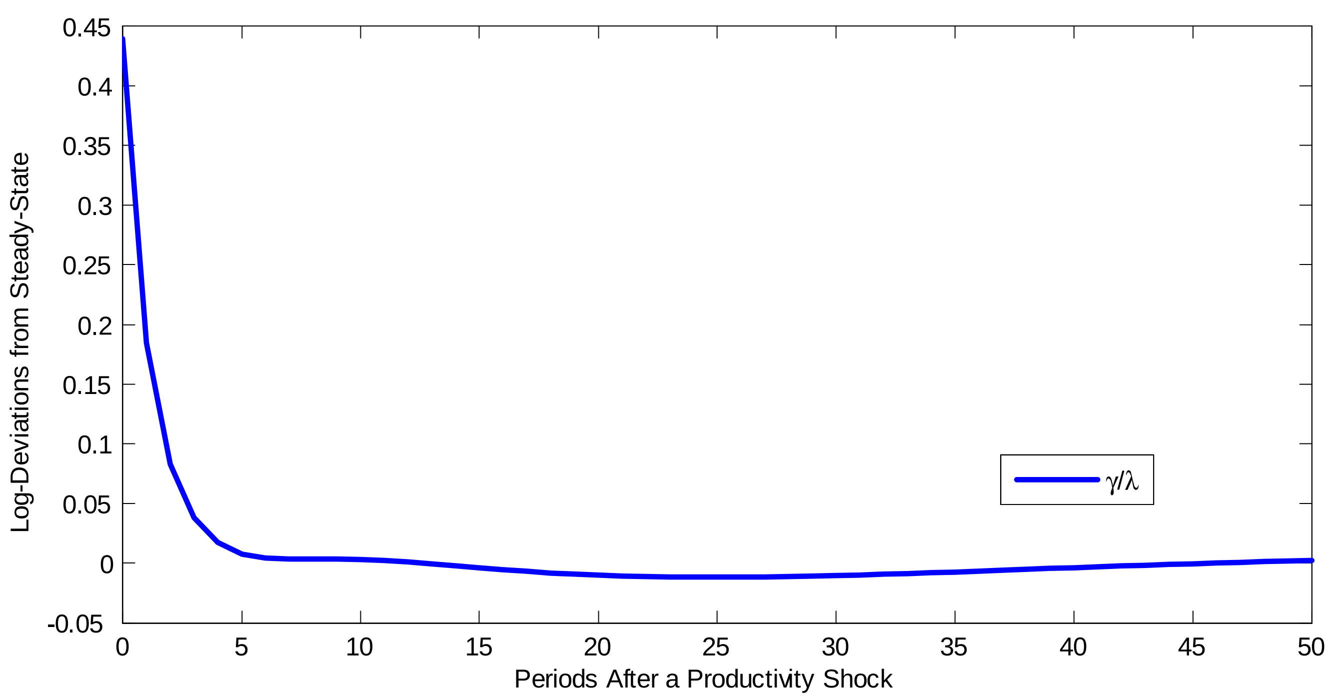

Figure 2: IRFs to a one standard deviation shock to TFP

The kinks are due to the frictional nature of employment (employment cannot adjust when the shock is initially realized). While the shadow price associated with the constraint is quite high initially, it quickly drops off as the firm accumulates capital in order to loosen the constraint. Once the constraint has been loosened, due to the higher k_{t+1}, the firm begins to accumulate employees once again by posting vacancies.

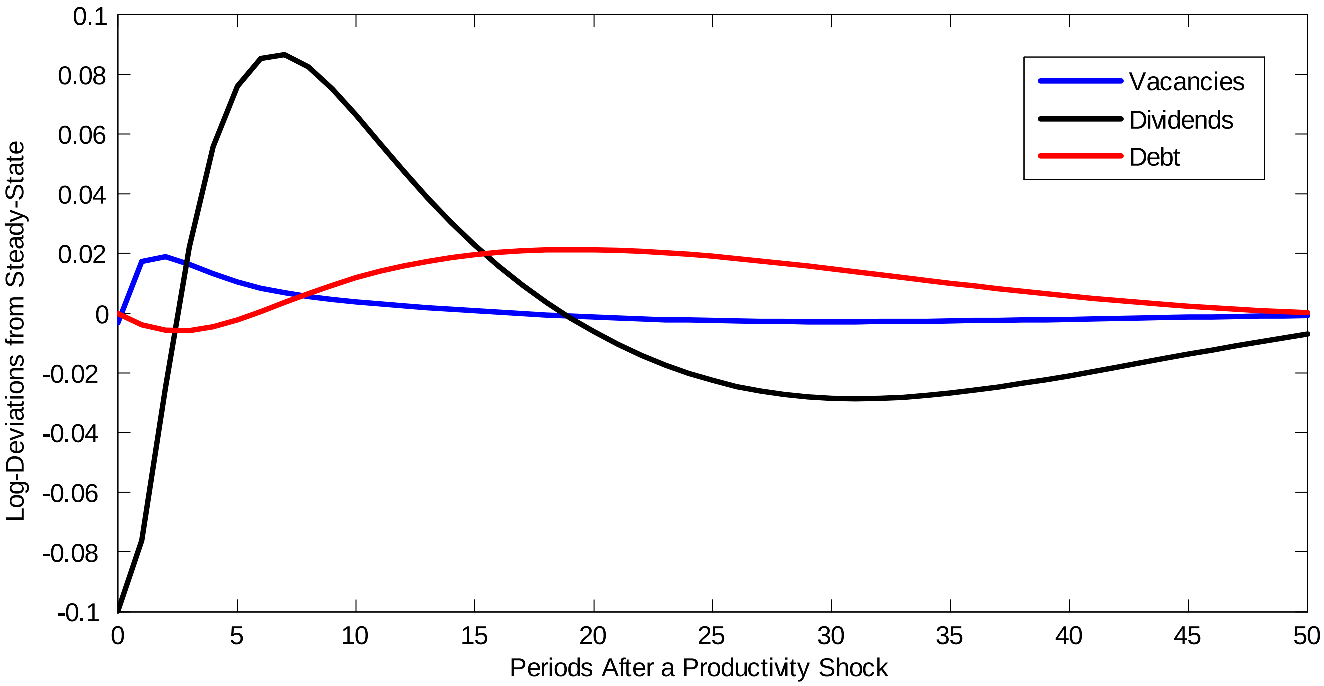

Figure 3: IRFs to a one standard deviation shock to TFP

Figure 3 shows how the firms finance their operations and how much of their resources are devoted to hiring purposes after a productivity shock. Once again, the kink is the result of the lagged nature of employment. Initially, the firm finance their capital accumulation not only by reducing labor inputs and labor costs, but also via reductions in equity payouts. The firms use internal finances briefly to accumulate capital resources. It is noteworthy that equity payouts reach their peak over a year after the TFP innovation. This can be viewed as the firm paying out the highest dividends once it has adjusted both employment and capital to a situation in which the enforcement constraint's shadow price reaches its minimum deviation. Dividend payouts reach its peak around the same time that γ/λ reaches its minimum deviation. That is, the opportunity cost associated with diverting resources to dividend payments is at its lowest level.

4.2 Innovations to Credit Conditions

We now consider the situations in which our model economy is hit by a *negative* financial shock.

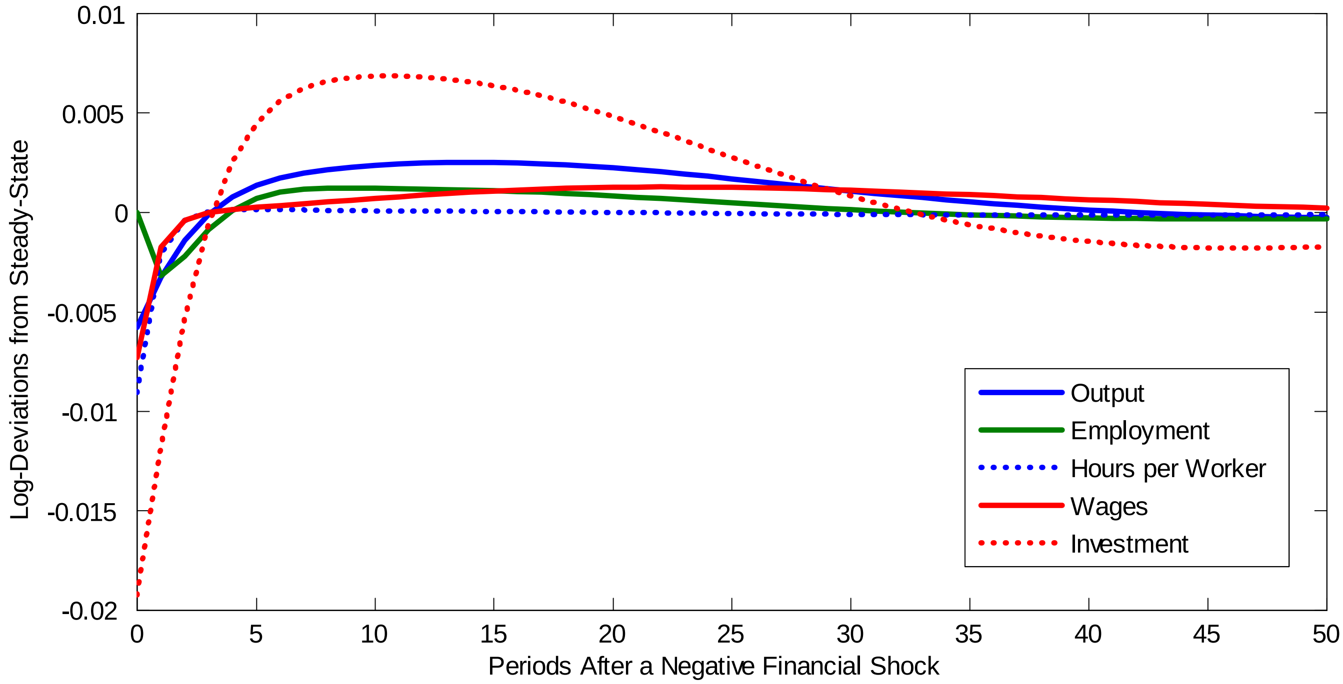

Figure 4: IRFs to a negative one standard deviation financial shock

Similar to the productivity case, investment is hit hardest by an innovation to the financial process. As the firm faces a tighter enforcement constraint due to the negative financial shock, it immediately cuts hours, wages and investment. Since the firm cannot immediately adjust employment, employment doesn't drop until the period after the shock. One of the key differences between the financial shock and the productivity shock, is the speed at which the economy recovers to its steady-state levels. This is in contrast to many findings that periods of financial distress lead to prolonged recessions. As in the positive productivity case, a negative financial shock shifts bargaining power away from the worker. Again, this is due to the tightness of the borrowing constraint driving down the effective marginal product of an additional worker to the firm.

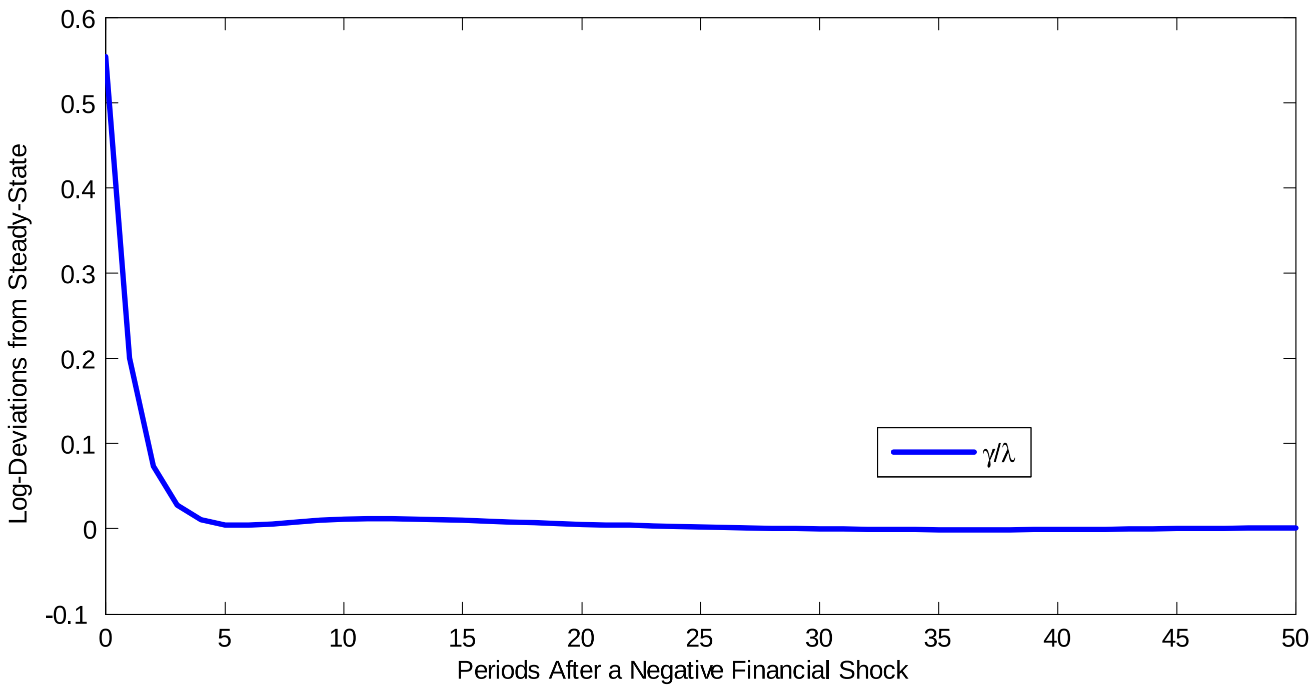

Figure 5: IRFs to a negative one standard deviation financial shock

The effective shadow price of the enforcement constraint displays a very similar pattern to the positive productivity case but drops off faster to return near to its steady-state ratio. Workers quickly recover their bargaining position as the ratio of the Lagrange multipliers returns near its steady-state level.

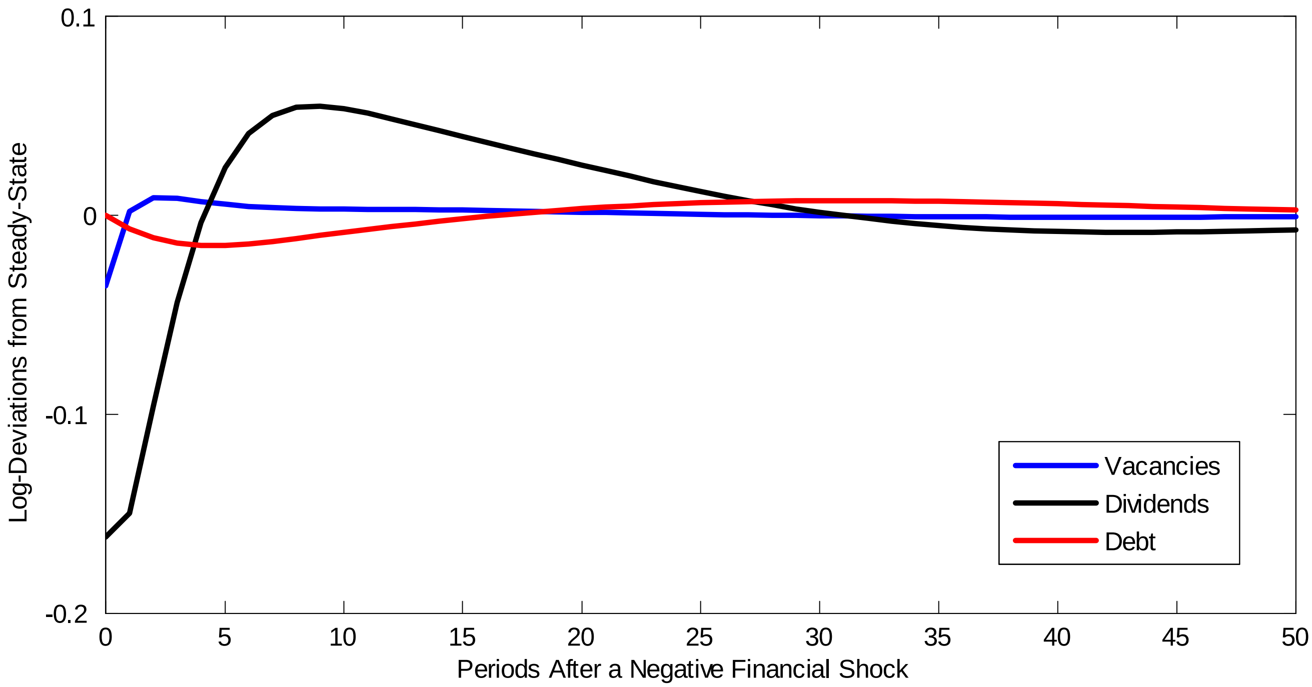

Figure 6: IRFs to a negative one standard deviation financial shock

The most pronounced difference between the productivity and financial shock cases is the movement of financial variables, which one would expect. The firm decreases its debt position and continues to decrease it for some time after the financial shock. The firm also reduces its equity payouts but eventually increases them after some time. This is consistent with the observation that both equity payouts and debt positions are reduced during periods of financial turmoil as reported in JQ. To highlight the contributions of each shock to key variables, we report the variance decomposition of each shock.

Financial shocks have a substantial impact on the volatility of both hours per worker and the labor share. The effects of financial shocks on the volatility of output and employment are relatively low. Despite equity and debt being financial variables, the impact of financial shocks on these is relatively similar to productivity shocks. While productivity shocks are still the main source of fluctuations along the extensive margin and seem to be the key driver in overall business cycle fluctuations, the impact of financial shocks is far from negligible on

Variable	$\hat{z}$	$\hat{\xi}$
Output	86.20	13.80
Total Hours	63.99	36.01
Employment	83.36	16.64
Hours per Worker	8.44	91.56
Wages	76.38	23.62
Labor Productivity	85.73	14.27
Labor Share	19.15	80.85
Vacancies	61.09	38.91
Equity Payouts/GDP	45.74	54.26
Debt Repurchases/GDP	48.69	51.31

Table 4: Variance Decomposition (percent)

hours worked per worker. Financial shocks account for 36% of the volatility in total hours worked, mostly due to the impact of financial shocks on hours worked per worker. This, along with the fact that vacancies, hours, and the labor share are quite sensitive to financial shocks, provides evidence that incorporating financial shocks into a matching model results in a measurable improvement in the overall understanding of labor market fluctuations.

4.3 Comparing Results

We now compare our results to the Andolfatto model (model without financial frictions) to see what gains and what shortcomings the incorporation of financial frictions provides. Both the KS and Andolfatto models are simulated for 350 periods 500 times. Eighty-eight periods of data are burned in order to strip out the importance of initial values.Variables are then logged and HP-filtered (except debt repurchases and equity payouts).

	$\sigma_x\%$			$\rho\left(x, Output\right)$			$\rho\left(x_t, x_{t-1}\right)$		
Variable (x)	Data	*KS*	*Andolfatto*	Data	*KS*	*Andolfatto*	Data	*KS*	*Andolfatto*
Output	1.12	1.15	0.94	–	–	–	0.97	0.78	0.81
Total Hours	1.26	0.94	0.50	0.85	0.86	0.93	0.89	0.66	0.90
Employment	0.88	0.60	0.45	0.82	0.77	0.81	0.93	0.83	0.86
Hours per Worker	0.45	0.64	0.14	0.77	0.54	0.72	0.61	0.15	0.48
Wages	0.91	0.62	0.41	-0.18	0.78	0.96	0.77	0.33	0.67
Labor Productivity	0.66	0.58	0.51	0.07	0.58	0.94	0.59	0.59	0.58
Labor Share	0.73	0.79	0.13	-0.28	0.18	-0.67	0.78	0.27	0.44
Vacancies	11.26	3.73	2.60	0.86	0.71	0.72	0.91	0.31	0.45
Equity Payouts/GDP	1.39	1.39	–	0.69	0.70	–	0.91	0.89	–
Debt Repurchases/GDP	2.23	2.07	–	-0.84	-0.78	–	0.93	0.88	–

Table 5: Business Cycle Moments

The addition of financial shocks into the matching model has a marked impact on key labor market variables. While the Andolfatto model generates high employment volatility, it is still orders of magnitude less than the data. The KS model improves the model's performance along this dimension. We are able to match the volatility of total hours and labor productivity quite well. However, our model performs poorly in replicating movements in wages and capturing the countercyclical nature of the labor share. Additionally, while the data has the intensive margin accounting for 32% of the variation in total hours worked, the KS model delivers 53%, overstating the importance of hours worked per worker while the Andolfatto model delivers only 14%.

Despite these shortcomings, our results comport to a greater extent with actual data than the Andolfatto model, indicating that the addition of financial frictions and financial shocks have a positive impact on matching moments from the data. This, taken together with the variance decomposition implies that financial shocks are an important dimension to incorporate into standard matching models. Our credit channel shows up through the multipliers associated with the enforcement constraint which drives down the marginal benefit of employees to firms. Financial frictions generate an additional wedge between the wage bill per worker and the marginal productivity of each worker F_n. Capital is more 'valuable' to the firm than an additional worker in this environment since capital has the additional benefit of loosening the enforcement constraint. This makes both investment and hours per worker sensitive to shocks originating in the financial sector or from TFP. Despite improving some labor market variables' volatilities via financial shocks, we are still quite far off from replicating the volatility displayed in the data, especially for vacancies.

5 Conclusion

Does the incorporation of financial shocks into a standard matching model better our understanding of fluctuations in hours, employment, and wages? Our analysis suggests that there are gains to be made by accounting for such shocks in a standard matching model. We proposed a model that uses Andolfatto as a our benchmark matching model and incorporate financial frictions and shocks into the environment similar to JQ. Within our model, we show that the credit channel has marked impacts on key labor variables via the shifting of bargaining power from workers to firms through the effective shadow price on the enforcement constraint.

Comparing our results to the Andolfatto model, calibrated to hit the same targets, demonstrates that our model can better replicate business cycle moments. Moreover, a variance decomposition of the shocks suggests that financial shocks play an important role in the fluctuation of both hours per worker and the labor share. While our results still support the notion that business cycle fluctuations are still largely due to productivity shocks, it also suggests that future research that employs a matching model framework should seriously consider the incorporation of financial shocks as well as the intensive margin to account for movements in key labor market variables. Without the incorporation of financial shocks, movements in employment, hours per worker, and the labor share are relatively muted over the business cycle.

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Appendix

Derivation of the Equilibrium Conditions

Households solves following dynamic programming problem.

$$V(S, s_H) = \max_{c,s',a'_H} \{u(c) + n\nu(1-h) + (1-n)\nu(1) + \beta E[V(S', s'_H)]\}$$

$$\text{s.t.}$$

$$c + \frac{a'_H}{1+r(S)} + p(S)\, s' = w(S, s_H)\, nh(S, s_H) + (1-n)b + a_H + [p(S) + d(S)]\, s - T(S)$$

$$n' = (1-\chi)n + \Psi(S)(1-n)$$

$$S' = G(S),\ c \geq 0,\ \text{No-Ponzi condition}$$

Let λ_H and π_H be the Lagrange multipliers on budget constraint and law of motion for employment respectively. Then, the we have the following first order conditions:

$$\begin{array}{cc} [c] & u'(c) - \lambda_H = 0 \\ [s'] & \beta E[V'_s] - \lambda_H p = 0 \\ [a'_H] & \beta E[V'_{a'_H}] - \lambda_H \frac{1}{1+r} = 0 \\ [n'] & \beta E[V'_n] = \pi_H \end{array}$$

Also, from the envelope conditions we have

$$\begin{aligned} V_{a_H} &= \lambda_H \\ V_s &= \lambda_H (p + d) \end{aligned}$$

By combining the first order conditions and envelope conditions, we get the following the no-arbitrage condition between shares and bonds.

$$\begin{aligned} 1 &= E\left[m'\left(1+r\right)\right] \\ 1 &= E\left[m'\left(\frac{p'+d'}{p}\right)\right] \end{aligned}$$

where $m' = \beta u_c\left(c'\right)/u_c\left(c\right)$ is the stochastic discount factor.

Now, the representative firm solves following problem.

$$J(S, s_F) = \max_{d,k',a'_F,v} \{d + E[m'J(S', s'_F)]\}$$

$$\text{s.t.}$$

$$\begin{aligned} k' + a_F + \varphi(d, d_{-}) &= F(z, k, nh\left(S, s_F\right)) + (1-\delta)k - w\left(S, s_F\right) nh\left(S, s_F\right) - c_v v + \frac{a'_F}{R\left(S\right)} \\ \xi\left(k' - \frac{a'_F}{1+r\left(S\right)}\right) &\geq F(z, k, nh\left(S, s_F\right)) \\ n' &= (1-\chi)n + \Phi\left(S\right) v \\ S' &= G(S),\ k', v \geq 0 \end{aligned}$$

Let λ, γ, and π be the Lagrange multipliers on the budget constraint, enforcement constraint, and law of motion for employment respectively. Then, the we have the following first order conditions.

$$\begin{array}{cc} [d] & 1 + E[m'J'_{d_{-}}] - \lambda\varphi_d = 0 \\ [k'] & E[m'J'_k] - \lambda + \gamma\xi = 0 \\ [a'_F] & E[m'J'_{a_F}] + \lambda\frac{1}{1+r(1-\tau)} - \gamma\xi\frac{1}{1+r} = 0 \\ [v] & -\lambda c_v + \pi\Phi = 0 \\ [n'] & E[m'J'_n] = \pi \end{array}$$

Also, from the envelope conditions we have

$$
\begin{aligned}
J_k &= (\lambda - \gamma) F_k + (1-\delta)\lambda \\
J_{a_F} &= -\lambda \\
J_n &\equiv (\lambda - \gamma) z F_{nh} h - \lambda w h + (1-\chi) E[m' J_n'] \\
J_{d\_} &= -\lambda \varphi_{d\_}
\end{aligned}
$$

By combining the first order conditions and envelope conditions, we simply get the following first order conditions of the firm.

$$
\begin{aligned}
1 - E[m'\lambda'\varphi_{d\_}'] &= \lambda \varphi_d \\
\lambda c_v &= \Phi E[m' J_n'] \\
\lambda - \gamma\xi &= E[m'[(\lambda' - \gamma') F_k' + (1-\delta)\lambda']] \\
\lambda(1+r) - \gamma\xi R &= R(1+r) E[m'\lambda']
\end{aligned}
$$

where $R = 1 + r(1-\tau)$ is the *effective* gross interest rate.

Derivation of Nash Bargaining Solutions

Given the worker's bargaining weight $\mu \in (0,1)$, the wage and hours are the result of the Nash bargaining problem:

$$
(w,h) = \arg\max_{w,h} \left(\frac{V_n}{u_c}\right)^{\mu} (J_n)^{1-\mu}
$$

The first of conditions for this problem are

$$
[w] \quad \mu J_n = (1-\mu)\lambda(\tfrac{V_n}{u_c})
$$

$$
[h] \quad \begin{aligned}
\mu J_n \left(-\tfrac{v_{(1-h)}(1-h)}{u_c} + w\right) &= -(1-\mu)\tfrac{V_n}{u_c}((\lambda-\gamma)F_{nh} - \lambda w) \\
(1-\mu)\left(\tfrac{V_n}{u_c}\right)\left(-\tfrac{v_{(1-h)}(1-h)}{u_c} + w\right) &= -(1-\mu)\left(\tfrac{V_n}{u_c}\right)((\lambda-\gamma)F_{nh} - \lambda w) \\
\left(-\tfrac{v_{(1-h)}(1-h)}{u_c} + w\right) &= -(1-\tfrac{\gamma}{\lambda})F_{nh} + w \\
\tfrac{v_{(1-h)}(1-h)}{u_c} &= \left(1-\tfrac{\gamma}{\lambda}\right)F_{nh}
\end{aligned}
$$

The equilibrium wage bill can be derived from the sharing rule and the definition of $\frac{V_n}{u_c}$ and J_n.

$$
\mu J_n = (1-\mu)\lambda\left(\frac{V_n}{u_c}\right)
$$

$$
\mu((\lambda-\gamma)F_{nh}h - \lambda wh + (1-\chi)E[m'J_n']) = (1-\mu)\lambda\left(\frac{v(1-h)-v(1)}{u_c} + (wh-b) + (1-\chi-\Psi)E\left[\beta\frac{V_n'}{u_c}\right]\right)
$$

$$
\begin{aligned}
wh &= \mu\left(\left(1-\frac{\gamma}{\lambda}\right)F_{nh}h\right) + (1-\mu)\left(\frac{v(1)-v(1-h)}{u_c} + b\right) \\
&\quad +\mu(1-\chi)E\left[m'\frac{J_n'}{\lambda}\right] - (1-\mu)(1-\chi-\Psi)E\left[\beta\frac{V_n'}{u_c}\right] \\
&= \mu\left(\left(1-\frac{\gamma}{\lambda}\right)F_{nh}h\right) + (1-\mu)\left(\frac{v(1)-v(1-h)}{u_c} + b\right) \\
&\quad +\mu(1-\chi)E\left[m'\frac{J_n'}{\lambda}\right] + \mu\Psi E\left[m'\frac{J_n'}{\lambda'}\right] - (1-\mu)(1-\chi)E\left[\beta\frac{V_n'}{u_c}\right]
\end{aligned}
$$

Using the sharing rule $\mu J_n = \lambda(1-\mu)(V_n/u_c)$ and $F_{nh}h = F_n$, along with the definition of V_n/u_c and J_n, gives the wage bill per worker:

$$
\begin{aligned}
wh &= \mu\left[\left(1-\frac{\gamma}{\lambda}\right)F_n + (1-\chi)E\left[m'\frac{J_n'}{\lambda}\right] + \frac{V}{1-N}\Phi E\left[m'\frac{J_n'}{\lambda'}\right]\right] \\
&\quad + (1-\mu)\left[\frac{\nu(1)-\nu(1-h)}{u_c} + b - (1-\chi)E\left[\beta\frac{V_n'}{u_c}\right]\right]
\end{aligned} \tag{5.1}
$$

Data Appendix

Data for Employment, Average Weekly Hours Worked and the Labor Force are taken from the Bureau of Labor Statistics. Total GDP and business GDP are taken from the National Income and Product Accounts (NIPA) published by the Bureau of Economics Analysis. Real wages are defined as labor compensation to plus labor's share of proprietors income deflated by the GDP deflator and divided by total hours (employment multiplied by average weekly hours). Labor productivity is defined as total GDP divided by total hours. Vacancies are constructed using the Conference Board's Help-Wanted Index and the composite Help-Wanted Index by Barnichon (2010).

Equity Payouts and Debt Repurchases are taken from the Flow of Funds published by the Federal Reserve Board. Equity Payouts are defined as Net dividends of nonfinancial business minus Net increase in corporate equities of nonfinancial business minus Proprietors' net investment of nonfinancial business.

Debt Repurchases are the negative of Net increase in credit markets instruments of nonfinancial business. Both Equity payouts and Debt repurchases are divided by business GDP from NIPA. Total GDP is used to compute the correlations reported in Table 1.

The capital stock is constructed similar to JQ. Using the law of motion of capital

$$k_{t+1} = k_t + Investment - Depreciation$$

we define *Depreciation* as Consumption of fixed capital in nonfinancial corporate business plus Consumption of fixed capital in nonfinancial noncorporate business taken from the Flow of Funds. *Investment* is measured as Capital expenditures in non financial business, also from the Flow of Funds. Both variables are deflated by the price index for business GDP from NIPA. The initial capital stock is chosen so that the capital-output ratio in the business sector does not display any trend over the period 1952:Q1-2012:Q1.

The stock of debt is constructed (again, similar to JQ) using the law of motion

$$b_{t+1}^{e} = b_{t}^{e} + Net\,New\,Borrowing$$

where *Net New Borrowing* is defined as the Net increase in credit markets instruments of nonfinancial business taken from the Flow of Funds. $b_{t+1}^{e} = b_{t+1}/\left(1 + r_{t}\right)$ since this is the model equivalent of the end-of-period debt reported in the data. We take the initial value of the stock of debt to be the nonfinancial business sector's stock of debt in 1952:Q1 from the balance sheet data reported in the Flow of Funds. We deflate the constructed series by the price index for business GDP from NIPA.