ENTRY COSTS AND LABOR MARKET DYNAMICS*

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Abstract

We study the cyclical dynamics of the value of a vacant position in labor markets characterized by search and matching frictions. We present a model of aggregate fluctuations in which firms face sunk costs to enter the production process. Our specification of sunk costs gives rise to a counter-cyclical value of a vacancy. We find that this overlooked object has important quantitative implications for the study of labor markets and business cycles. It affects the cyclical dynamics of the surplus division between workers and firms, and provides a better characterization of the movements in income shares over recessions and expansions. Understanding movements in the value of a vacant position helps to link the dynamics of income shares with recent volatility puzzles found in models of search and matching in labor markets.

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1 Introduction

This paper studies the interaction between entry costs and the uncertainty a firm faces, upon entry, about matching with appropriate workers. The goal is to investigate the role of that interaction in explaining observed cyclical dynamics in the labor market. To that end we have developed an equilibrium environment in which a firm's production decision is the outcome of a multi-period process. In the initial period, firms enter the market by paying a sunk cost. Paying this cost gives the firm the option to undertake investments in recruiting activities. These investments increase the probability of matching with a worker. Loosely speaking, this multi-period process resembles a time-to-build technology: a sequence of investments in entry costs and recruiting activities yields profits several periods hence. We find that, as with earlier models of fluctuations, these investment delays help to generate cyclical patterns in the time series that are consistent with empirical counterparts. The interaction between entry costs and a frictional labor market generates fluctuations in factor prices, factor income shares, and labor market variables, with properties similar to those observed in U.S. data.

Prior to any decision regarding production or hiring, potential entrants research product demand, shop for low financing costs, or engage in costly negotiations with market regulators. Once these costs are expended, firms are uncertain about their ability to find appropriate workers. Production takes place only when firms are successfully matched to workers. Elsewhere[1], work has shown that entry costs propagate shocks in otherwise standard equilibrium models of fluctuations, but literature has assumed frictionless markets for capital and labor. We construct an environment in which firms produce commodities employing workers and capital and enjoy monopoly power when selling their output. Monopoly power results from each firm producing a differentiated variety of a consumption good. As firms enter and exit the market, the total number of varieties available varies over time. We assume that firms

[1] See Bilbiie, Ghironi, and Melitz (2012).

are required to pay an entry cost by renting capital and producing a certain amount of goods. After paying the entry cost, firms search for workers in a frictional labor market. In that market, firms post vacancies or ads in order to attract workers. The novel aspect of our setup is that it gives rise to an endogenously time-varying value of a vacant position. To see why, note that in typical models with frictional labor markets, the value of a vacancy is zero due to the free entry assumption. In the environment that we construct, a vacancy has positive value because firms need to incur entry costs before they are allowed to post a vacancy and hire workers. The equilibrium value of a vacancy is such that firms are indifferent between paying the sunk cost, allowing them to post a vacancy and staying out of the market. This equilibrium value is also time-varying. The reason is that entrants rent factors of production to pay for the sunk cost, and the efficiency of these factors is affected by the same shocks that generate aggregate fluctuations. As the prices and quantities of these factors vary with aggregate conditions, so do the expenditures that entrants undertake. In equilibrium, these expenditures must equal the value of a vacancy.

Sunk costs result in amplification and propagation effects: they slow the adjustment of vacancy postings and job creation as entrants react sluggishly to a shock. The efficiency of factors of production rises in booms, accelerating the entry of firms and making the posting of vacancies and as a result employment more responsive to positive aggregate shocks. In other words, total vacancy creation results from both the hires of existing firms and the hires of new entrants. Moreover, assuming some degree of monopolistic competition increases the amplification and propagation of shocks relative to a perfectly competitive economy. The degree of market power matters because the prospect of higher profits increases the ability of firms to face the cost of entry.

An important element in search and matching models is the surplus division between workers and firms. In the data, we proxy this division using labor's share in total output. We use the cyclical dynamics of that variable as an additional dimension on which to judge our model. In models where entry of firms is free, the adjustment of labor market variables is too abrupt. This rapid adjustment makes the reaction of wages and profits too strong, forcing the correlations of labor's share to be close to minus one. In the models we present below, the moderate adjustment brought about by sunk costs of entry tame that correlation, generating more realistic dynamics.

We find that the amplification and propagation effects are largest (and the model's implications are closest to the data) when the value of a vacancy is countercyclical. Parameterizations that result in a procyclical value of a vacancy behave much like an environment where firms face no entry costs. This result does not imply that the mechanism that amplifies shocks in our environment is isomorphic to having a countercyclical vacancy posting cost in a model with free entry. The analogy made earlier between sunk entry costs and a time-to-build technology should make that point clear. Vacancy posting costs that exogenously drop in booms will amplify shocks, but the persistence and propagation effects that are prominent here are absent.

This paper's focus is not to explain the behavior of a different set of variables than that of previous literature. Rather, we continue with a well-established tradition of using equilibrium business cycle models to explain quantitatively the statistical properties observed in aggregate time series. The first examples in that literature have focused on series such as consumption, investment, and output. More recently, labor markets have taken a prominent role with the advent of equilibrium search and matching models. Although the interest here has been mostly on the dynamics of wages, unemployment, and vacancies, studies in this area have not disregarded the behavior of series that were the focus of earlier literature. This paper contributes to that body of equilibrium business cycle studies. The framework that we construct improves existing models by matching the behavior of factor prices and factor shares. But the mechanism also amplifies productivity shocks at the firm level into cyclical movements in labor market variables, bridging the gap between model and data. The level of amplification our mechanism achieves is in line with that of Hagedorn and Manovskii (2008). Their calibration, while successful in matching the volatility of labor market variables, is somewhat controversial as it implies a small difference between the values of employment and unemployment for the average worker. We view our mechanism as providing an alternative which does not rely on a large workers' threat point and which still describes the data remarkably better than standard parameterizations (e.g. Shimer (2005)). The success in matching labor market dynamics does not come at the expense of failing to match business cycle dynamics of consumption or output. With its better fit of the data, our study highlights the importance of fluctuations in the value of a vacancy and, as a result, it also highlights a shortcoming of the extant literature. The existing body of work in search and matching models emphasizes fluctuations in the value of a filled job, eliminating the possibility of any kind of dynamics in the value of a vacancy by the free entry assumption. Studies in this area include Andolfatto (1996), Merz (1995), Shimer (2005), and many others.[2] The dynamics in the value of a vacancy are center to our analysis, in particular how those dynamics interplay with those of other variables in the labor market. Regarding the emphasis on the value of a vacancy, a possible exception in the literature is Fujita and Ramey (2007). These authors posit exogenously a cost for firms to enter the labor market that is increasing in the level of aggregate employment. That exogenous procyclicality in the value of a vacancy does not generate much amplification or a better fit of the dynamics of labor's share. We do not take a position *ex-ante* on the cyclicality of the value of a vacancy. With our parameterization, the interaction between inputs employed in the production of goods and services and inputs used for paying the cost of entry, delivers a countercyclical capital value of a vacancy. We show how this countercyclicality, and in particular, the negative initial response of this capital value to a shock in productivity, is a crucial feature when it comes to improvement over

[2]Some other examples are Hagedorn and Manovskii (2008), Hall (2005), and references in Rogerson, Shimer, and Wright (2005).

existing models.

Studies on the cyclical behavior of income shares have employed a different framework. For instance, Gomme and Greenwood (1995) build a model in which wage payments include a component that partially insures workers against shocks. Labor markets are frictionless, and the entry of firms plays no role. Ambler and Cardia (1998) show that imperfect competition improves the ability of models of aggregate fluctuations to explain some stylized facts in the movements of wages and profits over the business cycle.

2 The Model Economy

2.1 Environment

Our economy is populated by a large extended household comprised of a continuum of members of total mass equal to $\bar{N}$ and an infinite mass of firms.[3]

Members in the household can either be employed or unemployed. Unemployed agents receive an unemployment benefit while they search for jobs with the hope of finding a job opportunity. This opportunity will allow them to enter into a relationship with a firm, to negotiate a contract that stipulates the retribution for their services, and to produce output during the following period. A fraction N_t of employed agents works and gets paid the negotiated wage. Members of the household have preferences over a sequence of a composite of goods over time, $\{C_t\}_{t=1}^{\infty}$. The per-period utility function is of the relative risk aversion class. The household's (expected) discounted lifetime utility as of time 0 is given by,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} \right], \tag{1}$$

where $\beta \in (0,1)$ is the discount factor and $\sigma > 0$ is the coefficient of relative risk aversion.

[3] The description of the environment follows Shao and Silos (2011).

We assume that each firm produces a differentiated commodity. At each point in time, there is a subset of goods, $X_t \subseteq X$, available to consumers, and the composite good is made up of commodities from that subset. The available set is time-varying as not all firms will produce every period. To aggregate over the different commodities, we use a Dixit and Stiglitz (1977) aggregator:

$$C_t = \left(\int_{x \in X_t} [c_t(x)]^{\frac{\gamma-1}{\gamma}} dx \right)^{\frac{\gamma}{\gamma-1}}, \tag{2}$$

where $\gamma > 1$ is the symmetric elasticity of substitution between commodities. If $p_t(x)$ is the price[4] of product x, then the level of $c_t(x)$ chosen to minimize the cost of acquiring C_t given prices $\{p_t(x)\}$ for all x is:

$$c_t(x) = \left(\frac{p_t(x)}{P_t} \right)^{-\gamma} C_t, \tag{3}$$

where P_t is the cost of acquiring one unit of the composite good, or the price index [5]:

$$P_t = \left(\int_{x \in X_t} [p_t(x)]^{1-\gamma} dx \right)^{\frac{1}{1-\gamma}}.$$

The relative price of a differentiated commodity in terms of consumption is then $\rho_t(x) \equiv p_t(x)/P_t$.

Each firm uses one unit of labor to produce its commodity. The job market in our economy is characterized by the existence of search and matching frictions (see Rogerson, Shimer, and Wright (2005) for a survey of this literature). In order to hire a worker, a firm

[4] As the subset of goods changes over time, it is more convenient to express this price in terms of "money" than to use any of the consumption goods as the numeraire. This is done for convenience only, and this "money" acts as a unit of account. It is not valued for facilitating trades or for any other quality.

[5] P can be obtained by solving the consumer expenditure minimization problem for constructing one unit of composite good:

$$\begin{aligned} P &= \min_c \int_{x \in X_t} p(x)\, c(x)\, dx, \\ s.t. \quad C &= \left(\int_{x \in X_t} [c(x)]^{\frac{\gamma-1}{\gamma}} dx \right)^{\frac{\gamma}{\gamma-1}} = 1. \end{aligned}$$

must post a vacancy and undertake a recruiting expense of ω per vacancy posted.[6] Firms and potential workers match in a labor market according to a constant-returns-to-scale matching technology $M(\bar{N}-N,V)$ given by:

$$M(\bar{N}-N,V)=\frac{(\bar{N}-N)V}{((\bar{N}-N)^{\xi}+V^{\xi})^{\frac{1}{\xi}}}. \tag{4}$$

This matching function takes as inputs the total number of unemployed individuals who are searching, $\bar{N}-N$, and the total number of vacancies posted by firms, V. The output is a number of matches M. Denoting by θ the vacancies to unemployment ratio $\frac{V}{\bar{N}-N}$, the probabilities that a vacancy gets filled, q_t, and that a worker finds a job, f_t are given by[7],

$$q_t=\frac{M(\bar{N}-N,V)}{V} = \frac{1}{(1+\theta_t^{\xi})^{\frac{1}{\xi}}}, \tag{5}$$

$$f_t=\frac{M(\bar{N}-N,V)}{\bar{N}-N} = \frac{\theta_t}{(1+\theta_t^{\xi})^{\frac{1}{\xi}}}. \tag{6}$$

A match between a firm and a worker results in a wage contract that specifies a wage $w_t(x)$ paid in exchange for labor services. We assume that firms and workers split the surplus from their relationship according to a Nash bargaining rule. We will be more specific about this rule later in this paper, after we have addressed some notation regarding workers' and firms' value functions. The relationship between a firm and a worker can break either because the firm exogenously ends production (which happens with probability τ) or for any other reason (which happens at rate s).

[6]We assume that productivity shocks do not affect the cost of posting a vacancy but they do affect the costs of entry. The reason for this assumption is that by recruiting costs we have in mind the costs of posting an ad to attract workers. The analog of our entry costs is something more involved, such as analysis of market conditions, constructing a building to begin operations, etc.

[7]We depart from the more frequent Cobb-Douglas specification for the matching function to bound the job-finding and vacancy-filling probabilities to be between 0 and 1. This functional form was chosen by den Haan, Ramey, and Watson (2000).

Firms need to pay a sunk cost to begin the goods production process.[8] Opening a firm or starting a new product variety needs y^E effective units of capital, i.e. $y^E = Z_t K_t^E$. The productivity shock Z_t follows a first-order Markov process. Denoting by r_t the rental rate of capital and noting that one unit of capital produces Z_t units of the composite good, the sunk cost of entry is $\frac{r_t y^E}{Z_t}$ or $r_t K_t^E$ (in units of the composite consumption good). We denote the number of entrants (i.e. the number of firms that pay the sunk cost) by $N_{E,t}$.

Production of the differentiated commodity involves capital and labor. Denoting the firm's output of the differentiated product x by $y_t^c(x)$, it is obtained with the following constant-return-to-scale technology,

$$y_t^c(x) = Z_t l_t(x)^{1-\alpha}(K_t^c)^{\alpha}, \tag{7}$$

where Z_t is the same random productivity process that determines the efficiency of capital when paying for the sunk cost, and $l_t(x)$ is the labor amount the firm uses, which will equal one if the firm produces and zero otherwise. In the definition of aggregate capital, we need to include capital used by commodity-producing firms. As a result,

$$K_t = N_t K_t^c + N_{E,t} K_t^E. \tag{8}$$

Within a given time period, capital is perfectly mobile and therefore the interest rate r_t is also the rental rate of capital in the commodity-producing sector. We denote $\lambda_t(x)$ as the marginal cost of producing one unit of product x. The cost minimization of producing y_t^c units of output taking r_t given yields

$$r_t = \alpha \frac{y_t^c(x)}{K_t^c} \lambda_t(x). \tag{9}$$

[8]Our approach for modeling firm entry follows Bilbiie, Ghironi, and Melitz (2012).

In units of consumption, the monopolistic firm will charge the price on x equal to $\rho_t(x) = \mu_t \lambda_t(x)$, where μ_t is the price markup over marginal cost. Given our CES preference, this markup is equal to $\gamma / (\gamma - 1)$. The firm's profits are given by $\pi_t(x) = \rho_t(x) y_t^c(x) - r_t K_t^c - w_t(x)$.

Finally, the government plays a very limited role in our economy. Its task is solely to tax the household a lump-sum quantity and rebate it in the form of a benefit for the unemployed.

2.2 Optimization and Equilibrium

Anticipating a symmetric equilibrium, we drop the notation depending on the product variety x. The relevant state vector for the firm is the quadruplet $(K_t, N_t, V_t, Z_t)'$. To save on notation, we also denote value functions without being specific about their dependence on the state vector.

Owing to firms' sunk costs of entry and time costs of finding employees, firms earn positive flows of economic profits. These profits should be distributed to someone and appear in the national accounts. To this end, we assume that households own a diversified portfolio of firms so that the profits are transferred to households at the end of each period in a lump-sum fashion. As a result, firms discount expected future flows, taking into account the household's inter-temporal condition. Consequently, a firm's appropriate discount factor between periods t and $t+1$ is

$$\Delta_{t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma}. \tag{10}$$

Let Q_t denote the value of a vacancy and J_t denote the value of a filled job. The following two recursive relationships must be satisfied:

$$Q_t = -\omega + (1-\tau) E_t \Delta_{t+1} [q_t J_{t+1} + (1-q_t) Q_{t+1}], \tag{11}$$

$$J_t(w_t) = \max_{K_t^c} (\rho_t y_t^c - w_t - r_t K_t^c) + (1-\tau) E_t \Delta_{t+1} [(1-s) J_{t+1} + s Q_{t+1}]. \tag{12}$$

Equation (11) states that the value of a vacancy (once the entry decision has been made) is the difference between two objects. First, the expected value of entering the labor market and trying to match with a worker. This matching happens with probability q_t, as long as the firm survives for one period, which happens with probability $1-\tau$. Second, the vacancy cost ω.

The interpretation of equation (12) is analogous: the value of a filled job is the profit flow π plus the expected continuation value of the relationship between the firm and the worker. Conditional on the firm's survival, the relationship ends with probability s and continues with probability $1-s$. The notation makes clear our implicit timing assumption: capital is chosen after the wage-setting stage. The value of a filled job depends on that pre-determined wage and the firm chooses the optimal capital level taking that wage as given.

In equilibrium, the entry of firms occurs until the value of vacancies is equal to the sunk cost,

$$Q_t = r_t K_t^E. \tag{13}$$

Due to entry costs, vacant jobs have positive value in equilibrium which in turn leads firms to repost vacancies following separations. The following two equations give the laws of motion for the stock of employment and vacancies:

$$N_{t+1} = (1-\tau)\left[(1-s)N_t + f_t(\bar{N} - N_t)\right], \tag{14}$$

$$V_{t+1} = (1-\tau)\left[(1-q_t)V_t + sN_t\right] + N_{E,t}. \tag{15}$$

Employment at time $t+1$ is the sum of matches $(1-s)N_t$ that were not destroyed either by the death of a firm or other form of separation and the newly-formed matches $f_t(\bar{N}-N_t)$ from a previous pool of unemployed people. The total number of vacancies in the economy, given by equation (15), is equal to vacancies that were not filled in the current period, $(1-q_t)V_t$

plus the number of separated matches sN_t. Of course, we need to include the fraction of firms which continue to operate for at least one more period. Finally, we need to add to that total the number of newly created firms $N_{E,t}$, each of which posts a vacancy. Both employment and vacancies are predetermined variables.

The household's problem is relatively straightforward. Given its current period resources, it chooses consumption and investment to maximize the expected discounted value of lifetime utility. In addition to wage income and unemployment benefits, the household gets interest from renting capital as well as a pay-out from its diversified ownership stake in firms. The aggregate dividends firms pay out equal to $d_t = N_t \pi_t - \omega V_t - Q_t N_{E,t}$. Finally, the household also gets taxed a lump-sum amount T_t which the government uses to finance the unemployment benefit program. Denoting by W_t the household's value function at time t, the optimization problem can be expressed as:

$$W_t = \max_{C_t, I_t} \frac{C_t^{1-\sigma}}{1-\sigma} + \beta E_t W_{t+1}, \tag{16}$$

subject to

$$\begin{aligned} C_t + I_t &= b\left(\bar{N} - N_t\right) + w_t N_t + r_t K_t + d_t - T_t, && (17) \\ K_{t+1} &= (1-\delta) K_t + I_t. && (18) \end{aligned}$$

The optimal inter-temporal condition is:

$$\beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} (r_{t+1} + 1 - \delta) \right] = 1. \tag{19}$$

Note that the household chooses total investment because from its point of view both types of capital (K_t^E and K_t^c) yield the same rate of return r_t. But the optimal choice of K_t^E as a fraction of total capital K_t is implicit in the value of $N_{E,t}$. The latter optimal choice is an intra-temporal allocation, in contrast to the standard inter-temporal allocation between consumption and investment. As discussed previously, wages for the employed workers are the result of Nash bargaining between each worker-firm pair. The surplus of the match for the household is captured by the change in welfare derived from having a marginal unemployed person employed. This change is given by $\frac{\partial W_t}{\partial N_t}$, which in units of the consumption good is $\frac{\partial W_t}{\partial N_t} C_t^{\sigma}$. The surplus for the firm is given by $J_t - Q_t$, the difference between the value of a filled job and the value of a vacancy. The Nash bargaining solution when the firm's bargaining parameter is given by ϕ satisfies the following surplus-splitting rule:

$$\frac{J_t - Q_t}{1 - \phi} = \frac{C_t^{\sigma} \frac{\partial W_t}{\partial N_t}}{\phi}. \tag{20}$$

A step-by-step derivation of the Nash bargaining problem and solution is presented in the appendix. Here we simply state the bargaining outcome as:

$$w_t = (1 - \phi)b + \phi(\rho_t y_t^c - r_t K_t^c + \theta_t \omega) + \phi(1 - \theta_t)[(1 - \tau)E_t(\Delta_{t+1} Q_{t+1}) - Q_t]. \tag{21}$$

The first two terms of (21) are standard in most labor search and matching model. They show that part of the period t wage payment is a convex combination of the flow values to the firm and the household. Each value is given by the weighted value of vacancy posting plus the firm's revenue net of rental payments and unemployment benefits, respectively. What deviates from the standard model is the second term in (21), which captures the forward-looking aspect of firm entry, whose value also is capitalized in the wage payment. Any changes in productivity affect this forward-looking component. Moreover, if we substitute

(11) for ω and use the fact that $\theta_t = f_t/q_t$, we can rewrite the wage equation (21) as

$$\begin{aligned} w_t &= (1-\phi)b + \phi(\rho_t y_t^c - r_t K_t^c) \\ &\quad + \phi f_t(1-\tau)E_t\left[\Delta_{t+1}\left(J_{t+1} - Q_{t+1}\right)\right] + \phi\left[(1-\tau)E_t\left(\Delta_{t+1}Q_{t+1}\right) - Q_t\right]. \end{aligned} \tag{22}$$

Now the forward-looking part consists of two components. The first component, $\phi f_t(1-\tau)E_t\left[\Delta_{t+1}\left(J_{t+1} - Q_{t+1}\right)\right]$ is the option value of unemployment for the household. By having a worker employed at the firm, the household is giving up the chance of searching for a job and finding one with probability f_t in the next period, which yields $\phi E_t\left[\Delta_{t+1}\left(J_{t+1} - Q_{t+1}\right)\right]$ (obviously when the firm survives).[9] The second component represents the change in the value of the vacancy. Notice that this term can be positive or negative. It is negative if vacancies are expected to decline in value in the next period. Since the firm could use the current vacancy to search for workers today (and not tomorrow), it decreases the worker's wage. Alternatively if vacancies are expected to rise in value, the current wage rises to induce the worker to work in the current period, hence preventing a firm with a low-value vacancy to look for alternative workers. Note that if entry is free, then $Q_{t+1} = Q_t = 0$ so that the last term is absent and the option value of unemployment would not involve a positive vacancy value Q_t in equilibrium.

We restrict ourselves to a symmetric equilibrium in which all goods-producing firms charge equal prices, $\rho_t(x) = \rho_t$; demand one unit of labor which gets paid the same wage $w_t(x) = w_t$; and produce the same amount of output, $y_t^c(x) = y_t^c$. Given the CES structure of the consumption aggregate, the relative price ρ_t that firms charge is given by $N_t^{\frac{1}{\gamma-1}}$ and

[9] Recall that the surplus sharing rule requires that

$$\phi E_t\left[\Delta_{t+1}\left(J_{t+1} - Q_{t+1}\right)\right] = (1-\phi)\frac{\partial W_{t+1}}{\partial N_{t+1}}.$$

the per-firm profit is given by $\pi_t = \rho_t y_t^c - r_t K_t^c - w_t$.[10]

Definition 1. A symmetric equilibrium for our economy consists a sequence of prices ρ_t, w_t, and r_t ; a sequence of aggregate quantities $K_t, C_t, N_t, V_t, N_{E,t}, K^E$, and π_t; and a sequence of value functions, Q_t, J_t, and W_t, such that for any time period t, the following conditions hold:

1. (*Household Optimization*) Given prices ρ, w, r, the household's optimization results in decision rules for C_t and I_t and the value function W_t.

2. (*Factor Market Clearing*) The interest rate r_t equates the total capital demanded (the sum of capital by new entrants $N_{t,E}K_t^E$ plus capital employed by goods-producing firms $K_t^c N_t$) to that supplied by the household, and the wage w_t satisfies the Nash bargaining solution given by equation (21).

3. (*Goods Market Clearing*) $C_t + I_t + \omega V_t = \rho_t N_t y_t^c + N_{E,t} Q_t$.

4. (*Firm's Optimization*) Given the demand for a differentiated commodity given by equation (3), ρ_t is the profit-maximizing price for the monopolist. Aggregate labor demand and vacancies posted by all firms, $N_{E,t}$, N_t and V_t, satisfy equations (14) and (15), and the vacancy and filled position values satisfy equations (11) and (12).

5. (*Entry Condition*) $Q_t = r_t K_t^E$.

6. (*Government*) The government satisfies its budget constraint: $b(\bar{N} - N_t) = T$.

[10]Given that $p_t(x) = p_t$ and $\rho_t = \frac{p_t}{P_t} = \frac{p_t}{\left(\int_{x \in X_t} [p_t]^{1-\gamma} dx\right)^{\frac{1}{1-\gamma}}}$ implies that $\rho_t = \frac{p_t}{p_t \left(\int_{x \in X_t} dx\right)^{\frac{1}{1-\gamma}}}$ and as a result, $\rho_t = \left(\int_{x \in X_t} dx\right)^{\frac{1}{\gamma - 1}} = N_t^{\frac{1}{\gamma-1}}$, as N_t is both the fraction of firms producing as well as the number of workers in the goods-producing sector by our assumption of one job per firm.

2.3 Calibration

We calibrate the model to the monthly frequency by assigning values to parameters so that steady-state moments in the model match those observed in U.S. data. The risk aversion coefficient σ is set to 1.5, which is well within the range of values typically used in studies of aggregate fluctuations. The discount factor β is set to $0.99^{\frac{1}{3}}$, which implies a steady-state interest rate equal to 4.2% per annum. Lacking direct evidence on a reasonable value for the workers' bargaining parameter ϕ, we set it equal to 0.5 to make our results comparable to those in the existing literature.

We calibrate the exit probability τ following a procedure similar to that used by den Haan, Ramey, and Watson (2000). Let Σ be the total job separation rate caused either by a firm's death or by any other cause. The rate at which firms exit the market and do not repost vacancies is τ, while $(1-\tau)s$ is the rate at which workers separate from firms but where firms repost vacancies immediately after. Hence, $\Sigma = \tau + (1-\tau)s$. The fraction of vacancies that are reposted right after separations is then $\frac{(1-\tau)s}{\Sigma}$. Denote this quantity by Ω. Note also that ΣN gives the total flow out of employment, and as a result, $\Omega q \Sigma N$ gives the total number of posted vacancies filled. If we subtract the number of posted vacancies filled from the total flow out of employment, we get the steady-state mass of jobs that is destroyed permanently: $\Sigma N - \Sigma N \Omega q = \Sigma N(1-\Omega q)$. In a steady state, job destruction must equal job creation. The empirical evidence described by Shimer (2005) sets Σ equal to 0.1 at the quarterly frequency, which implies $1-(1-0.1)^{\frac{1}{3}} = 0.035$ at the monthly frequency. Therefore,

$$\Sigma = (1-\tau)s + \tau = 0.035 \tag{23}$$

In principle one could calibrate the value of s using turnover statics (e.g. values for job destruction as a fraction of employment reported by Davis, Haltiwanger, and Schuh (1998)).

Since we are interested in comparing the model with costly entry against a free entry version, we choose s so that the steady state unemployment rate in the costly entry model is similar to that of the free entry version (roughly about 5.4%).

Consistent with estimates reported by Basu and Fernald (1997), we set $\gamma = 11$, which implies a markup of 10%. Changing the total mass of workers $\bar{N}$ only amounts to changing the levels, i.e., the scale of output and the mass of employment, etc., but the unit-free ratios, e.g., unemployment rate, v-u ratio, and consumption-output ratio etc., are unaffected. Therefore, a choice of $\bar{N}$ does not affect any of the second moments and the impulse responses. We just pick $\bar{N} > 1$ so that the monopolist's price is larger than the resulting price if markets are competitive, which is given by $\lim_{\gamma\to\infty} N_t^{\frac{1}{\gamma-1}} = 1$.

We are left with five parameters to calibrate: $(b, y^E, \delta, \omega, \xi)$. We choose five additional moments that the model needs to match in a steady state. Based on his own calculations, Shimer (2005) documents that the monthly job finding rate is 0.45. Blanchard and Diamond (1989) argue that vacancy postings have an average of three weeks, which implies that the vacancy filling rate is $1-(1-1/3)^4 = 0.802$ per month.[11] Note that the steady state value of market tightness can be written as $\theta = \frac{f}{q} = 0.56$. We choose to match the aggregate capital to aggregate output ratio, and we set it to a value of 36, which implies a value of 3 at the annual frequency. We set total recruiting costs as a fraction of GDP, given by $\omega V/Y$, to 0.015. Finally, a controversial choice is that of the value of the unemployment benefit b. Much of the literature argues that the value of non-work activities is far below what workers produce on the job. However, calibrations such as Hagedorn and Manovskii (2008) claim much success in terms of the cyclical properties of the model when the outside option for workers is very close to their productivity. Nevertheless, their calibration is not without controversy as, in a representative agent economy, the value of unemployment for the average worker (as

[11] Because of the possibility of the death of a firm before production takes place, the actual job-finding and vacancy-filling probabilities in the model are $f(1-\tau)$ and $q(1-\tau)$.

opposed to the marginal worker) is close that to that of being employed. This assumption implies unreasonably large responses of unemployment to minor changes in the level of unemployment benefits. We choose to interpret b as purely monetary unemployment benefits, and hence set b so that the steady-state replacement ratio b/w is 0.42, as in Shimer (2005) and Gertler and Trigari (2009). Conclusion, to assign values to the vector of parameters $(b, y^E, \delta, \omega, \xi)$, we choose the following five moments: $f(1-\tau) = 0.45$, $\theta = 0.56$, $\omega V/Y = 0.015$, $K/Y = 36$, and $b/w = 0.42$.

2.4 Calibration of the Free Entry Version

We compare our model economy with market entry costs to a version in which entry is free. The free entry version is similar to that described elsewhere in the literature (e.g. Shimer (2005) or Hagedorn and Manovskii (2008))[12]. In order for the models to be comparable, we calibrate some of the steady-state moments in the costly entry model with a counterpart in the model in which entry is free. We set the values for the discount factor β and the coefficient of risk aversion σ to be the same as in the costly entry model. We set α to 0.36, implying an income share of labor of 0.64. We follow Hagedorn and Manovskii (2008) in setting a value for b, targeting a ratio b/w of 0.95. The remaining parameters s, δ, ξ and ω are chosen so that the model delivers a job finding probability equal to 0.45, an average value of market tightness equal to 0.56, a ratio of recruiting costs to income equal to 1.5%, and the same capital-to-output ratio ($\frac{K}{Y} = 36$) as in the model with entry costs.

We assume that the productivity process Z_t follows an AR(1) process with persistence parameter ρ_z and a zero-mean normally distributed shock with variance σ_ϵ^2. We set $\rho_z = 0.964$ and $\sigma_\epsilon = 0.0052$, which are consistent with the cyclical persistence and variance in the observed Solow residual. In the costly entry model, we maintain the same persistence

[12] The working paper version (Shao and Silos (2008)) describes the free entry model (labeled the "MPK" model) in its appendix.

parameter (0.964), and we set the variance so that the standard deviation of output in the two economies coincides. This yields a value of σ_z equal to 0.009 in the costly entry model.

Table 1 summarizes the parameterization of the two environments.

Table 1: Summary of Parameterization

	Costly Entry	Free Entry
ϕ	0.500	0.100
ρ_z	0.964	0.964
σ_z	0.009	0.005
τ	0.018	.
s	0.017	0.026
γ	11	.
β	$(0.99)^{\frac{1}{3}}$	$(0.99)^{\frac{1}{3}}$
δ	0.002	0.007
b	0.390	4.443
y^E	2,933	.
ω	0.538	3.524
ξ	1.630	1.552
σ	1.500	1.500

3 Results

3.1 The Labor Market: Amplification and Propagation

Having assigned parameter values to the model, we solve it, simulate it, and judge its implications against U.S. data. Our solution technique is standard, linearly approximating the true solution around the model's deterministic steady state. Since the model is calibrated at the monthly frequency, we transform the model's output by aggregating its monthly data into quarterly data. We do this by taking three-month averages. We obtain a sample of data covering the period 1951:Q1-2007:Q1. We transform the model's output and U.S. data in the same way: we de-trend them by taking logs and applying a Hodrick-Prescott filter.[13] We organize results in three main tables, each of them containing summary statistics from U.S. data, and from simulated data from the two models.[14] Table 2 shows the standard deviation of some selected time series from the U.S. data. Since the focus on the paper is on labor market dynamics, we include the market tightness, unemployment, and vacancies. But we also include output, consumption, and investment so that the model economies can be compared by how well they match the dynamics of those time series. The two bottom panels of Table 2 show volatility results for the model-simulated time series. *Relative* volatilities refer to standard deviations normalized relative to the standard deviation of output while *Absolute* volatilities are the raw time series standard deviations. The costly entry model amplifies exogenous shocks to about the same level as the free entry model when the latter features a large workers' outside option. The volatility of market tightness relative to output is approximately 12 while it is 13 in the free entry environment. Consumption volatility is somewhat higher with costly entry than the empirical counterpart, while it is lower when entry is free. Finally, investment volatility is too high in the costly entry model (8 times as volatile as output). The linearity in the production function in the entry sector increases the sensitivity of capital to changes in productivity. Experimenting with alternative forms could prove fruitful in taming the excess volatility of investment. The amplification of shocks into labor market variables in the costly entry environment arises mostly from an increase in the volatility of unemployment and a little less so from vacancy creation.

Table 3 reports correlations among the same variables of interest. Empirically, vacancies and unemployment are strongly but negatively correlated. This correlation represents the

[13] The HP smoothing parameter we use is 10^5, which is larger than the typical choice of 1,600. Given the large propagation in our model, much of the dynamics are in lower frequencies than those retained by a smoothing parameter equal to 1,600.

[14] All results presented in this paper have CES preferences; see equation (2). This specification features constant markups. To introduce time-varying markups, we changed the utility function to be translog type, see Feenstra (2003). The results are similar to the baseline CES case, and they are available upon request.

slope of the Beveridge curve. Unemployment is strongly countercyclical and vacancies are procyclical. The costly entry model generates a correlation between vacancies and unemployment that matches the data. In general, correlations look reasonable, except those of investment. For example, investment is procyclical (as in U.S. data), but its correlation with market tightness is negative while it is roughly 0.8 in the data. Overall, the free entry model seems to be consistent with most correlations reported although it misses the correlation between unemployment and vacancies. It is negative, but weak (-0.68) compared to the one observed in actual data.

Finally, Table 4 reports the first four autocorrelations for the set of endogenous variables. The structure follows that of the previous two tables. The first panel reports statistics for U.S. data, and the lower two panels report the same statistics for model-simulated data. In actual data, most first order correlations hover around values between 0.88 and 0.93, decaying to values around 0.3 and 0.4 when the correlation is of order four. Both the costly entry and the free entry models generate this large persistence. An exception is the persistence in vacancy creation. The first order correlation of vacancies is 0.90 in the data but only 0.63 in the free entry model. Introducing costs to market entry increases the persistence of vacancies generating a first-order autocorrelation equal to 0.98.[15] Most other statistics are fairly similar across the two models, but in general, the degree of propagation is larger in the costly entry model.

To understand the intuition behind the amplification and propagation effects, we perform the following experiment. We consider the exact same environment as above, but we assign parameter values so that instead of achieving a ratio of recruiting costs of 1.5%, we achieve a value for entry costs (measured by the ratio $\frac{N_E Q}{Y}$) to be only 5% of that obtained with the baseline calibration.[16] The new parameter vector implies a volatility of V/U to be 2.7 times

[15] This result was also obtained in Fujita and Ramey (2007).

[16] The resulting recruiting costs are approximately 3% of output.

that of output. The first-order autocorrelation of vacancies is only 0.64. In other words, the amplification effect largely disappears, and the degree of propagation is close to that of the environment with free entry. Figure 1 shows the response of firm entry, vacancies, unemployment, and the value of a vacancy, to a one standard deviation productivity shock. The response in the baseline calibration is represented by the green (solid) line. The blue (dotted) lines depict the responses in the low-entry-cost calibration. The first graph shows the response of entrants. When entry costs are low, virtually all entry is concentrated in the first periods. This result is intuitive as firms want to take advantage of the higher efficiency of productive factors for as long as possible. As a result of these new firms entering, vacancies rise following the same pattern: an initial spike in vacancy creation that quickly dies off as the flow of entrants diminishes. Unemployment also falls suddenly but it takes somewhat longer to adjust as matching frictions prevent the immediate filling of the vacant positions. Finally, the value of a vacancy rises slightly because the interest rate rises. As the entry costs are low, the economy uses most of the available capital stock to produce commodities and little of it to pay for entry costs. The rise in interest rates is a consequence of our assumption in the technology for producing goods.

When entry costs are larger (our baseline case), the response of entrants is longer lived. The opportunity cost of using capital for paying for the entry cost is to use capital to produce commodities. The mechanism to prevent too large a number of firms entering in equilibrium is a drop in the interest rate and the resulting drop in the value of a vacancy. As in the low cost environment, the number of new entrants also peaks in the first period. However, the magnitude of the response is lower. Firm entry persists for quite a while, and as a result, vacancy creation takes longer to peak. Overall, the sluggishness in the entry decision by firms causes the responses of both market tightness and unemployment to be more persistent as well. In the low cost entry model and the baseline case, vacancy creation peaks at about the same level. The only difference is that the peak occurs later in the baseline case. When entry

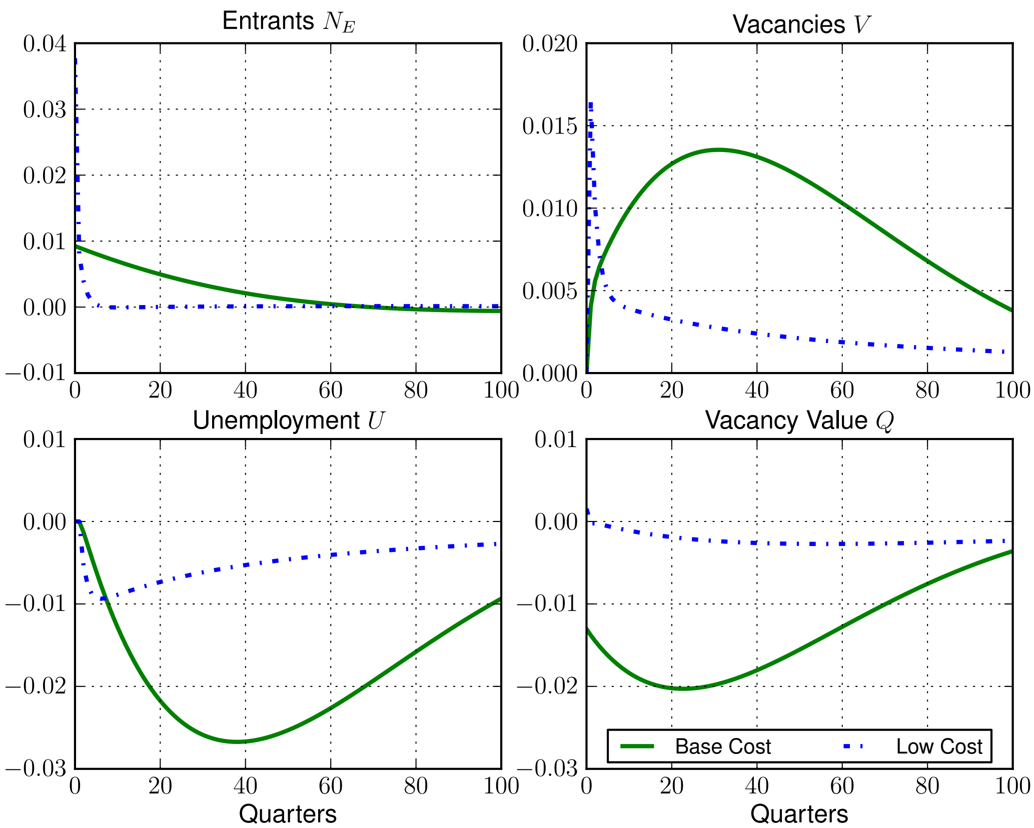

Figure 1: Responses in the two costly entry models: baseline (green solid line) and low-cost calibration (blue dotted) line.

costs are low, the peak occurs in the second period, and the effect dies off quickly thereafter. The amplification is not through the magnitude of the impulse but in the persistence of the response. This stands in contrast with the free entry model with the Hagedorn-Manovskii type calibration. In that environment, the amplification in vacancy creation is the result of a large initial response that dies off quickly. The latter effect is evident by the low first-order autocorrelation in vacancies. In actual data, the persistence of vacancies is much higher than in the free entry model, helping to validate the mechanism in our model, which emphasizes an amplification effect by a large persistence in the response to shocks.

3.2 The Dynamics of Labor's Share

The environment can propagate and amplify shocks in production into labor market variables. Entry costs induce time variation in the equilibrium value of a vacancy. Parameterizations of the environment consistent with the data, generate a value of vacancy that falls in response to a technology shock. Absent direct empirical counterparts for that value, we bring more evidence supporting the empirical relevance of the mechanism we propose.[17] More specifically, we focus on the cyclical dynamics of labor's share. By labor's share, we refer to the share of output that is devoted to compensating labor. In the data, we compute it by dividing the total wage payments over real GDP, and in the model, we compute it as $\frac{wN}{Y}$.

Previous research has found an intriguing response of the aggregate labor's share to an exogenous change in technology. It also has emphasized the inability of search and matching models to replicate the estimated response. In particular, Rios-Rull and Santaeulalia-Llopis (2010) focus on the response of labor's share to an exogenous change in productivity. Using data on labor's share and the Solow residual, they fit a bivariate VAR to these two series and identify a "fundamental" innovation to the technology process by assuming that the labor's share does not affect technology contemporaneously. In other words, they assume that the "structural" representation of the reduced-form VAR takes the following form,

$$lsh_t = \alpha_0 + \beta_0 z_t + \alpha_{11} lsh_{t-1} + \alpha_{12} z_{t-1} + \epsilon_{lsh,t}$$

$$z_t = \alpha_1 + \alpha_{21} lsh_{t-1} + \alpha_{22} z_{t-1} + \epsilon_{z,t}.$$

We fit that same VAR to our data and compute the response of labor's share to a change in technology. The solid line in Figure 2 plots the result of this estimation. The vertical axis represents the deviation from labor's share steady state-value, and the horizontal axis

[17] A recent paper by Davis, Faberman, and Haltiwanger (2009) provides some evidence of the vacancy yield consistent with a countercyclical value of a vacancy.

represents the number of quarters. Labor's share drops on impact but subsequently rises well above the steady state, eventually converging from above. Besides this "over-shooting" property, the two most noticeable features are the magnitude of the rise (significantly above the steady-state level) and the persistence of the response. In their quest for models that can match this feature of the data, Choi and Rios-Rull (2009) focus on a family of search and matching models of the labor market in which wages are the result of Nash bargaining. They find that the standard free entry model matches only the initial drop. After the first period, the response of the labor's share is rather muted when compared to the data. It never rises above its steady-state level, and it displays virtually no persistence. As our framework belongs to the same family of search and matching models, we perform a similar analysis. [18]

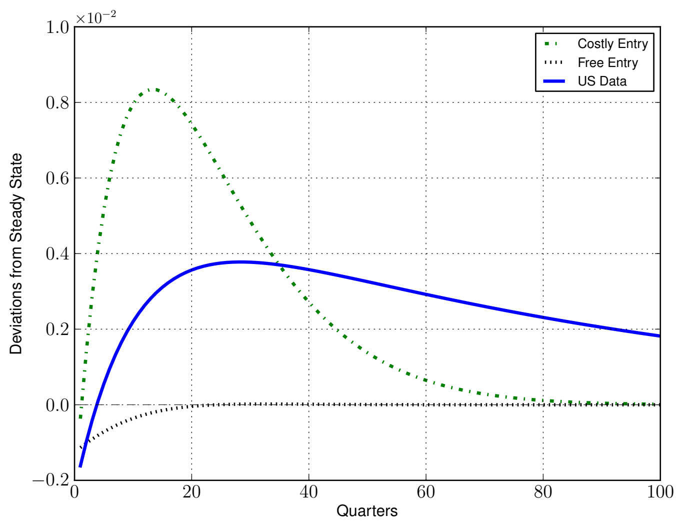

Figure 2: Response of the labor's share to a one standard deviation (orthogonalized) innovation to technology in the data and in the two model economies.

The two dotted lines in Figure 2 display the response of the labor's share in the two model economies and the data. To generate these impulse responses, we proceed with model simulated data as we do with actual data. We construct quarterly data from the models by

[18]For a more thorough analysis regarding the cyclical dynamics of income shares in the context of a similar model, see Shao and Silos (2011).

taking three-month averages. We calculate a Solow residual in the exactly same manner as we do in the data (by assuming an aggregate Cobb-Douglas function), and the labor's share is constructed using $\frac{wN}{Y}$. Both models, almost by construction because employment does not adjust immediately, generate the initial drop. Given that N is a state-variable and that the rise in income is larger than the rise in wages (because of diminishing marginal returns to labor), labor's share falls. It falls somewhat less in the model with costly entry because the rise in output gets dampened by the inclusion of output generated for paying for the sunk costs. The response in the free entry model shows little persistence and fails to generate anything resembling overshooting. Moreover, the period with the largest magnitude in the response is the first. In contrast, the response once entry costs are introduced gets closer to the empirical response along at least two dimensions. First, the effect peaks 15 quarters after the shock (it is about 20 in the data), and it is more persistent than with free entry. It does seem, nonetheless, that generating substantial volatility in market tightness makes the labor share too volatile relative to the data: the response is quite large. The intuition behind these results follows from the general discussion of the propagation and amplification of shocks into the labor market. The sunk costs of entry introduce sluggishness in the decision of firms, generating persistence and helping achieve the longer duration in the response to a shock. The subsequent rise in labor's share is a consequence of output in the setup-sector falling initially, relative to its long-run value and the gradual reallocation of capital from the setup-sector to the goods-producing sector.

4 Final Remarks

In this paper, we have found that relaxing the assumption of free entry of firms in search and matching models of the labor market has important implications for the study of aggregate fluctuations. In a model where there is costly entry of firms, the asset value of a vacancy ceases to be zero and has positive value. Investigating its cyclical dynamics provides several insights on the failures of existing models and where to look for amendments. We have shown that with a time-varying value of a vacancy, there is a link between the ability of the search and matching framework to explain the dynamics of labor's share and some of recent volatility and propagation "puzzles". A key to some of the improvements over existing models is the slower adjustment resulting from the costly entry decision.

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A Derivation of the Wage Equation

Recall that the solution to the Nash bargaining problem is given by

$$\frac{J_t - Q_t}{1-\phi} = \frac{C_t^{\sigma}\frac{\partial W_t}{\partial N_t}}{\phi}. \tag{24}$$

To find the bargained wage, we need expressions for the marginal value of having one more member of the household employed, $\frac{\partial W_t}{\partial N_t}$, and the difference between a filled job J_t and having an unfilled vacancy Q_t. The marginal value of employment for a household is given by

$$\frac{\partial W_t}{\partial N_t} = C_t^{-\sigma}\frac{\partial C_t}{\partial N_t} + \beta E_t\left[\frac{\partial W_{t+1}}{\partial N_{t+1}}\frac{\partial N_{t+1}}{\partial N_t}\right]. = C_t^{-\sigma}(w_t - b) + \beta(1-\tau)(1-s-f_t)E_t\left(\frac{\partial W_{t+1}}{\partial N_{t+1}}\right) \tag{25}$$

From the equation determining the value of Q_t, (equation (11)), we can derive,

$$E_t\left[\Delta_{t+1}(J_{t+1} - Q_{t+1})\right] = \frac{\omega + Q_t - (1-\tau)E_t(\Delta_{t+1}Q_{t+1})}{(1-\tau)q_t}. \tag{26}$$

Forwarding the optimality condition in the Nash bargaining problem one period, we get,

$$\frac{\partial W_{t+1}}{\partial N_{t+1}} = \frac{\phi}{1-\phi}\left(C_{t+1}\right)^{-\sigma}\left(J_{t+1} - Q_{t+1}\right).$$

Taking expectations on both sides of the previous expression and using both (26) and the definition $\Delta_{t+1} = \beta\frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}}$, we arrive at

$$\beta E_t\left(\frac{\partial W_{t+1}}{\partial N_{t+1}}\right) = \frac{\phi}{1-\phi}\frac{C_t^{-\sigma}[\omega + Q_t - (1-\tau)E_t(\Delta_{t+1}Q_{t+1})]}{(1-\tau)q_t}, \tag{27}$$

where the right-hand side is derived by replacing $E_t[\Delta_{t+1}(J_{t+1} - Q_{t+1})]$ using (26). Plugging (27) into (25) gives,

$$\frac{\partial W_t}{\partial N_t} = C_t^{-\sigma}\left\{(w_t - b) + \frac{\phi}{1-\phi}\frac{1-s-f_t}{q_t}[\omega + Q_t - (1-\tau)E_t(\Delta_{t+1}Q_{t+1})]\right\}. \tag{28}$$

From equations (12) and (11) he difference between J_t and Q_t is given by,

$$\begin{aligned} J_t - Q_t &= \rho_t y_t^C - w_t - r_t K_t^C + \omega + (1-\tau)(1-s-q_t)E_t[\Delta_{t+1}(J_{t+1} - Q_{t+1})], \\ &= \rho_t y_t^C - w_t - r_t K_t^C + \omega + \frac{1-s-q_t}{q_t}[\omega + Q - (1-\tau)E_t(\Delta_{t+1}Q_{t+1})]. \end{aligned} \tag{29}$$

Equations (28) and (29) are the marginal value of having one more worker employed and the difference in a filled job and an unfilled vacancy. Substituting those two expressions into the Nash bargaining solution yields the following wage equation after simple manipulation:

$$w_t = (1-\phi)b + \phi(\rho_t y_t^c - r_t K_t^c + \theta_t\omega) + \phi(1-\theta_t)[(1-\tau)E_t(\Delta_{t+1}Q_{t+1}) - Q_t] \tag{30}$$

Table 2: Volatilities: Model Economies vs. Data

	Data	*Costly Entry*	*Free Entry*
Absolute Volatilities			
C	0.011	0.014	0.007
I	0.059	0.154	0.066
V/U	0.315	0.213	0.269
U	0.170	0.127	0.150
V	0.151	0.061	0.089
Y	0.019	0.018	0.021
Relative Volatilities			
C	0.570	0.808	0.350
I	3.031	8.658	3.214
V/U	16.295	11.955	13.058
U	8.808	7.136	7.291
V	7.813	3.398	4.296
Y	1.000	1.000	1.000

Notes: The table displays volatilities (i.e time series standard deviations) for some selected variables for quarterly U.S. data (1951:1-2007:1) and simulated data from the two economies. Actual and simulated data are HP-filtered with a parameter equal to 100,000. Relative volatilities are raw (or absolute) standard deviations measured as a fraction of the standard deviation of output Y in model simulated data and GDP in actual data.

Table 3: Cross-Correlations: Model Economies vs. Data

Data

	C	I	V/U	U	V	Y
C	1.000	0.617	0.637	-0.641	0.609	0.810
I		1.000	0.813	-0.748	0.840	0.837
V/U			1.000	-0.978	0.983	0.865
U				1.000	-0.921	-0.846
V					1.000	0.851
Y						1.000

Costly Entry

	C	I	V/U	U	V	Y
C	1.000	0.179	0.523	-0.479	0.706	0.876
I		1.000	-0.549	0.659	-0.482	0.628
V/U			1.000	-0.836	0.926	0.140
U				1.000	-0.918	-0.063
V					1.000	0.322
Y						1.000

Free Entry

	C	I	V/U	U	V	Y
C	1.000	0.628	0.698	-0.784	0.563	0.775
I		1.000	0.894	-0.905	0.842	0.978
V/U			1.000	-0.773	0.827	0.907
U				1.000	-0.676	-0.940
V					1.000	0.850
Y						1.000

Notes: The table displays cross-correlation for some selected variables for quarterly U.S. data (1951:1-2007:1), and simulated data from the two economies. Actual and simulated data are HP-filtered with a parameter equal to 100,000.

Table 4: Autocorrelation: Model Economies vs. Data

Lag	1	2	3	4
Data				
C	0.904	0.7838	0.6393	0.4768
I	0.913	0.7724	0.6031	0.4265
V/U	0.917	0.7501	0.5378	0.3205
U	0.925	0.769	0.5677	0.3551
V	0.898	0.7126	0.4902	0.2755
Y	0.885	0.711	0.5134	0.3308
Costly Entry				
C	0.926	0.822	0.721	0.624
I	0.856	0.679	0.528	0.397
V/U	0.987	0.953	0.904	0.843
U	0.990	0.963	0.921	0.868
V	0.984	0.950	0.902	0.845
Y	0.848	0.658	0.498	0.363
Free Entry				
C	0.965	0.910	0.848	0.782
I	0.911	0.765	0.625	0.498
V/U	0.866	0.715	0.581	0.462
U	0.923	0.790	0.660	0.543
V	0.630	0.449	0.364	0.291
Y	0.912	0.777	0.650	0.533

Notes: The table displays the autocorrelations up to four lags of some selected variables. The autocorrelations of the exogenous TFP shock is the same across both model economies.