E C O N O M I C S B U L L E T I N

Entrepreneurship and labour market fluctuations

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Abstract

This paper modifies the standard Mortensen and Pissarides model by introducing an endogenous decision of individuals to either become entrepreneurs or workers. This modification has little impact upon the qualitative properties of the standard Mortensen and Pissarides model. However, it can substantially amplify the impact of productivity shocks upon the level of unemployment and vacancies and provide a partial explanation for the lack of unemployment volatility identified by Shimer (2005).

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1 Introduction

In recent work, Shimer (2005) argues that the Mortensen and Pissarides model is unable to match key cyclical features of the U.S. labour market. Shimer's critique notes that a model subject to productivity fluctuations of a realistic magnitude generates unemployment and vacancy movements that are significantly less than those observed in the data. Moreover, in the model shocks to the job separation rate create a positive relationship between unemployment and vacancies, contradicting empirical evidence. Previous studies that claimed the search model of the labour market matched the business cycle facts either relied upon excessively large fluctuations in productivity (e.g. Mortensen and Pissarides (1994)) or failed to account for the existence of a Beveridge Curve (e.g. Pries (2004)). An interpretation of these results is that the standard model lacks an amplification mechanism via which productivity shocks can have a substantial impact upon vacancies and unemployment.

This paper addresses this lack of amplification by introducing the concept of entrepreneurship. In particular, an environment is considered where individuals participate in the labour market by becoming entrepreneurs or by entering the workforce. Entrepreneurs are responsible for creating job vacancies but must hire a worker for production to take place. This modification enriches the qualitative nature of the standard search model by considering seriously how individuals allocate their time between job creation and work. Furthermore, the introduction of entrepreneurship magnifies the quantative effect of shocks in a reasonably calibrated model. Technically, this paper is closely related to that of Fonseca, Lopez-Garcia and Pissarides (2001) and Pissarides (2003). They develop a similar framework in which individuals choose to become entrepreneurs or workers. However, this paper extends their work by evaluating the quantative implications of the model, and by doing so, provides a partial explanation of how small fluctuations in productivity can generate large equilibrium movements in unemployment and vacancies while at the same time generating a Beveridge Curve relationship.

This paper belongs to a growing literature, surveyed by Hornstein, Krusell and Violante (2005) and Mortensen and Nagypal (2007), that attempts to quantatively explain labour market fluctuations in a search framework. Among this literature, our paper is perhaps most closely related to that of Hagedorn and Manovskii (2006). They retain the standard model but provide an alternative calibration in which workers have a high value of leisure. This assumption leads productivity shocks to generate large fluctuations in the surplus value of a match and consequently magnifies unemployment and vacancy fluctuations. However, their calibration is criticised by Hall (2006) and Mortensen and Nagypal (2007) for relying upon an implausibly large value of leisure. The approach in this paper retains a value of leisure similar to that of Shimer (2005) but alters the model so that the formation of a job match requires the joint collaboration of an entrepreneur and a worker. In a model calibrated to the U.S. data, this implies that the average match surplus is small and realistic shocks to productivity generate large movements in both vacancies and unemployment.

Section 2 outlines a model in which ex ante homogeneous agents allocate their time to either creating vacancies or searching for vacancies. The key equilibrium condition of the model requires that individuals be indifferent between these two activities. Necessary conditions for an equilibrium to exist are provided and the equilibrium is characterised. Furthermore, the comparative static results associated with changes in the exogenous variables are analysed. Section 3 provides a quantative evaluation of an economy subject to shocks to productivity and the job separation rate. Due to the technical difficulties associated with the introduction of entrepreneurship, the analysis is restricted to examining the comparative statics associated with different steady states. Considering joint shocks to productivity and the job separation rate of a reasonable magnitude generates fluctuations in unemployment and vacancies that are roughly 3 and 5 times greater than those produced by the standard model as evaluated by Shimer (2005) but result in a counterfactually upward sloping Beverdige Curve. However, small changes in the value of leisure have a large impact upon the quantative results; amplifying the volatility of labour market variables and also producing a negative relationship between unemployment and vacancies. Section 4 concludes.

2 The Model

The economy is populated by a continuum of ex ante homogenous individuals with population size normalised to one. All individuals are risk neutral and seek to maximise the present value of future consumption, discounted at an exogenous rate of r. The crucial economic decision within the model is one of career choice, with individuals able to become workers or entrepreneurs. Workers supply labour to entrepreneurs offering vacancies, while entrepreneurs create vacancies that require workers. Production is a process that requires the joint cooperation of an entrepreneur and a worker. A worker receives a flow utility associated with leisure of z when unemployed and a flow utility equal to the the wage rate, w, when employed. An entrepreneur searching for a worker receives a flow utility of $z-c$, which is equal to the value of leisure less the cost of vacancy production, $c \geq 0$. Once a vacancy has been filled an entrepreneur receives the residual profits from a firm, $p-w$, where p is the output per unit of time.

The formation of job matches occurs in a labour market with frictions. A matching function is used to model these frictions in a reduced form manner. Formally, the number of matches formed per unit of time is defined as $m(u,v)$ where u is the number of unemployed workers and v is the number of vacancies offered by entrepreneurs. It is assumed that the matching function is strictly increasing in both arguments and displays constants returns to scale (CRS) in u and v.

The CRS assumption implies that the rate of matching for entrepreneurs advertising a vacancy and for unemployed workers are functions of the vacancy-unemployment rate, $\theta = \frac{v}{u}$. Specifically, the rate at which an entrepreneur advertising a vacancy finds a worker is defined as

$$q(\theta) = \frac{m(u,v)}{v} = m\left(\frac{1}{\theta}, 1\right)$$

and the rate at which unemployed workers find employment is denoted

$$f(\theta) = \frac{m(u,v)}{u} = m\left(1, \theta\right).$$

Standard technical assumptions are assumed. In particular, $\lim_{\theta\to 0} q(\theta) = \lim_{\theta\to\infty} f(\theta) = \infty$ and $\lim_{\theta\to\infty} q(\theta) = \lim_{\theta\to 0} f(\theta) = 0$.

To ensure that unemployment exists in a steady state it is assumed that job destruction occurs at an exogenous rate of δ. These matching and job destruction rates allow us to describe labour market flows. Given an allocation in which n individuals are workers and the remaining $1-n$ individuals are entrepreneurs, unemployment and vacancies evolve as follows,

$$\dot{u} = \delta(n-u) - f(\theta)u \tag{1}$$

$$\dot{v} = \delta(1-n-v) - q(\theta)v \tag{2}$$

where the outflow from unemployment (or vacancies) depends upon the matching rate times the stock of unemployed workers (vacant jobs) and the inflow depends upon the rate of job destruction multiplied by the stock of matched workers (entrepreneurs).[1]

The expected present value of utility associated with workers will be denoted U and W for unemployed and employed workers, respectively. Similarly, the expected present value of utility for entrepreneurs will be denoted V and J depending upon whether a vacancy is empty or filled, respectively. In steady state, these values are described recursively through the use of Bellman equations provided below,

$$rU = z + f(\theta)(W-U) \tag{3}$$

$$rV = z - c + q(\theta)(J-V) \tag{4}$$

$$rW = w + \delta(U-W) \tag{5}$$

$$rJ = p - w + \delta(V-J). \tag{6}$$

The interpretation of these equations is standard within the literature. Taking the first equation, the value of unemployment, U, can be thought of as akin to the value of an asset. The flow payoff associated with this asset is a dividend of z per unit of time and a capital gain of $W-U$ when employment is accepted which occurs with a probability of $f(\theta)$. The other equations have similar interpretations.[2]

Wages are determined via a bargaining process and the outcome of this process is described by the Nash Bargaining Solution. Formally, wages satisfy,

$$w = \text{argmax}(W-U)^{\beta}(J-V)^{1-\beta}.$$

where the value of unemployment and the value of a vacancy are the threat values associated with failing to come to agreement. This condition can be used with the previous Bellman equations to derive the following results,

$$W - U = \beta S$$

$$J - V = (1-\beta)S$$

where $S = W-U+J-V$ is the surplus associated with forming a job match. Given this description of the environment, it becomes possible to reasonably define a steady state equilibrium.

[1] It would be possible to consider a more general model where individuals who find their job match destroyed, select x the probability of joining the workforce and $1-x$, the probability of becoming an entrepreneur. In this case, the evolution of unemployment and vacancies could be described as follows,

$$\dot{u} = \delta(1-u-v)x - f(\theta)u$$

$$\dot{v} = \delta(1-u-v)(1-x) - q(\theta)v$$

Imposing a steady state with $\dot{u} = \dot{v} = 0$ requires $x = 1/2$ otherwise $\dot{u} \neq \dot{v}$. However, with $x = 1/2$ we return to a world in which the evolution of unemployment and vacancies are explained by (1) and (2).

[2] See Pissarides (2000) for a full discussion of the Bellman values in a search framework.

Definition 1. *A steady state equilibrium is a set, $\{u, v, n, w\}$ such that*

- *individuals are making optimal career choices given θ;*
- *$\{u, v, n, w\}$ are not changing over time;*
- *wages are determined by Nash Bargaining.*

To characterise equilibrium, optimal career choices are examined. For an equilibrium to exist with a positive level of unemployment and vacancies, individuals must be indifferent between entering the workforce or becoming entrepreneurs. This implies the value of being unemployed will equal the value of advertising a job vacancy or equivalently,

$$z + f(\theta)(W - U) = z - c + q(\theta)(J - V). \tag{7}$$

The equilibrium vacancy-unemployment ratio can be pinned down using the above relationships. Combining the equations associated with the Nash Bargaining Solution with (7) generates the following result.

Lemma 1. *In any steady-state in which individuals are indifferent between becoming entrepreneurs and workers, the value of θ must satisfy the following equation,*

$$-q(\theta)(p - 2z)(1 - \beta) + c(r + \delta) + f(\theta)\beta(2c + p - 2z) = 0. \tag{8}$$

This equation determines the equilibrium level of θ as a function of the exogenous parameters and matching function. It is straightforward to verify given our previous assumptions that a unique equilibrium value of θ satisfies (8) if $p > 2z$. However, if $p < 2z$, no θ exists at which individuals would be willing to become entrepreneurs.[3]

Once the equilibrium vacancy-unemployment rate is known, it is possible to describe the allocation of individuals between entrepreneurship and the workforce. Denote u^*, v^*, n^* and θ^* as steady state values. In steady state with $\dot{u} = \dot{v} = 0$ it follows that,

$$u^* = \frac{\delta n^*}{\delta + f(\theta^*)} \tag{9}$$

$$v^* = \frac{\delta(1 - n^*)}{\delta + q(\theta^*)}. \tag{10}$$

For the steady state level of vacancies and unemployment to be consistent with the equilibrium level of θ it is necessary that the following relationship holds,

$$\begin{aligned} \theta^* &= \frac{v^*}{u^*} = \frac{\delta(1 - n^*)}{\delta + q(\theta^*)} \frac{\delta + f(\theta^*)}{\delta n^*} \\ &= \frac{(1 - n^*)}{n^*} \frac{\delta + f(\theta^*)}{\delta + q(\theta^*)}. \end{aligned}$$

[3]This condition arises since a job match generates p units of output but requires the input of a worker and an entrepreneur. Each individual may receive a flow utility of z when unemployed. For gain from production to exist, $p > 2z$ is necessary.

which allows us to pin down n^* given θ^*. In particular,

$$n^* = \frac{\delta + f(\theta^*)}{\theta^*(\delta + q(\theta^*)) + \delta + f(\theta^*)} = \frac{\delta + f(\theta^*)}{\delta(1+\theta^*) + 2f(\theta^*)} \quad (11)$$

These results lead us to the following proposition.

Proposition 1. *Given $p > 2z$ and our assumptions regarding the matching function, a steady state equilibrium exists and is unique. The equilibrium vacancy-unemployment ratio is determined by (8), the level of n in equilibrium is determined by (11) and the equilibrium level of unemployment and vacancies are determined by (9) and (10).*

The economy differs from the standard Mortensen and Pissarides model by allowing individuals to allocate their time to creating or searching for vacancies. However, many of the qualitative implications of the model remain unchanged. Examining the comparative statics associated with steady state changes implies the following,

Proposition 2. *In an economy in which $p > 2z$, the qualitative effect of exogenous shocks upon the equilibrium vacancy-unemployment rate are determined by the following,*

$$\frac{d\theta^*}{dz} < 0, \;\; \frac{d\theta^*}{dp} > 0, \;\; \frac{d\theta^*}{d\beta} < 0, \;\; \frac{d\theta^*}{dr} < 0, \;\; \frac{d\theta^*}{d\delta} < 0, \;\; \frac{d\theta^*}{dc} < 0. \quad (12)$$

Market tightness, as measured by the vacancy-unemploment rate, increases when there is an increase in productivity or a decrease in interest rates, the rate of job destruction, the value of leisure, the cost of creating a vacancy or the bargaining power of workers. These results are generally intuitive and provide similar qualitative results to the standard Mortensen and Pissarides model. For a given δ both the unemployment rate and the ratio of vacancies to entrepreneurs depend monotonically upon level of market tightness, hence it is straightforward to determine qualitatively how exogenous changes to parameters other than δ affect $\frac{u}{n}$ and $\frac{v}{1-n}$.

3 Productivity, Separation Rate Shocks and Volatility

To examine the quantative properties of the model, parameters are calibrated to match the U.S. economy. Since the dynamics associated with entrepreneurship are difficult to solve analytically, this section is restricted to comparing different steady states as the value of productivity and the job separation rate vary. In particular, p and δ are drawn from a bivariate normal distribution constructed to match the stylised business cycle facts. Given p and δ, the corresponding values of θ^*, u^*, v^* and n^* are calculated. This process is repeated 10,000 times and the correlations and standard deviations of the variables are interest are calculated. This methodology ignores transition dynamics associated with out-of-steady-state behaviour. However, as Hall (2005) argues, since the flow rates of matching are high, it is unlikely that much dynamic behaviour is lost through this simplification.

The calibration follows closely the work of Shimer (2005). Firstly, a quarterly time period will be considered which makes $r = 0.012$ an appropriate value. This paper follows the bulk of the existing literature and assumes a Cobb-Douglas matching function,

$$m(u, v) = \mu v^{\alpha} u^{(1-\alpha)}.$$

Given this functional form Shimer (2005) estimates α, the elasticity of matching with respect to vacancies, as being 0.28 while Mortensen and Nagypal (2007) suggest a value of 0.551 might be more appropriate. Given this broad range in possible values, this paper takes a moderate approach and sets $\alpha = 0.4$ which is in the middle of the range Petrongolo and Pissarides (2001) view as reasonable.

Shimer (2005) avoids taking a stand regarding the average vacancy-unemployment rate by implicitly normalising the unit of measurement of vacancies. However, Barron, Berger and Black (1997) show that the average duration of vacancy is roughly between 15-30 days which implies a quarterly matching rate for vacancies of between 3-6. Taking a mid-range value of 4.5 as the average job matching rate of vacancies and using Shimer's figure of 1.35 to describe the job finding rate for workers suggests an average value of $\theta = 0.3$ that we target in our calibrations. To generate an average (quarterly) matching rate of 1.35 for workers and 4.5 for firms, given $\alpha = 0.4$ and an average value of $\theta = 0.3$, requires that we set $\mu = 2.19$.

Productivity and the job separation rate are stochastic and are drawn from a bivariate normal distribution. The mean value of p is normalised to 1 and the standard deviation of productivity shocks is set to 0.019, to reflect the distribution of shocks in the actual economy. Consistent with the data presented in Shimer (2005) the mean of the separation rate is set to 0.1 while the standard deviation is set to 0.007 to match the volatility of the separation rate. Finally, the correlation between productivity and the separation rate is -0.6 as reflected in the data.

We have little prior information regarding bargaining strength which makes it difficult to pin down a reasonable value for β. However, since agents are ex ante identical it seems reasonable to set $\beta = 0.5$. Following Shimer, $z = 0.4$ is set to reflect the average replacement rate. The final parameter to be calibrated is c. Given our other parameters and our target of an average value of $\theta = 0.3$, requires setting $c = 0.215$.

With this set of parameters and description of stochastic shocks it is possible to examine the quantative properties of the model. The results are displayed in Table 1. The behaviour of the exogenous shocks to productivity and the separation rate match the actual economy, by construction. In particular, the standard deviation of log productivity, the standard deviation of the log of the separation rate and the correlation coefficient between productivity and the separation rate match the observed data patterns presented by Shimer (2005). The model generates significantly greater amplification of shocks than implied by the standard Mortensen and Pissarides model, as calibrated by Shimer (2005). In particular, the standard deviation of log unemployment is 0.091 which compares to a value of 0.031 in Shimer's calibration with both productivity and job separation shocks. There is also substantial amplification of the fluctuation in vacancies with the standard deviation of log vacancies equal to 0.055 compared to 0.011 in Shimer's model with comparable shocks. Despite increasing the volatility of unemployment by about a factor of three and vacancies by a factor of five, the model still generates less volatility than observed in the data with Shimer (2005) reporting the cyclical volatility of log unemployment and log vacancies equal to 0.190 and 0.202, respectively. Furthermore, the model fails to correctly predict a downward sloping Beveridge Curve relationship with the correlation coefficient between unemployment and vacancies equal to 0.609.

As Hagedorn and Manovskii (2006) demonstrate, the volatility of the standard model may be amplified by setting a high value of $z = 0.955$ and a low value of $\beta = 0.052$. Intuitively, with high values of z and low values of β, wages are rigid and the match surplus is relatively small. Hence, fluctuations in productivity generate large percentage fluctuations in match surplus and vacancies. Within this model, increases in z also magnify the volatility of vacancies and unemployment, however the increase in z required to generate greater labour market volatility and a downward sloping Beveridge Curve are more moderate. Table 2 demonstrates the effect of a small increase in the value of leisure from $z = 0.4$ to $z = 0.45$. This small change produces fluctuations in vacancies and unemployment that are significantly larger; the standard deviation of log unemployment is 0.124 and the standard deviation of log vacancies is 0.087. This remains roughly half the size of the fluctuations observed in the data but significantly greater volatility than the standard model. Furthermore, the same shocks to productivity and the job separation rate result in a negative correlation between unemployment and vacancies of -0.385, corresponding to a negatively sloped Beveridge Curve.

4 Conclusions

This paper modifies the standard search model of the labour market to incorporate career choice of individuals to either becoming an entrepreneur (and creating vacancies) or entering the labour force (and searching for vacancies). This model is closely related to the Mortensen and Pissarides model and many of the qualitative implications of the model remain unchanged. However, when subjected to shocks to productivity and the separation rate, fluctuations in unemployment and vacancies are amplified. In addition, only small changes in the value of leisure significantly increase labour market volatility and with shocks of reasonable magnitudes to productivity and the job separation rate, create a downward sloping Beveridge Curve that is consistent with the data.

5 Appendix

Table 1: Productivity and Job Separation Shocks, $z = 0.4$

	u	v	f	s	p
Std Deviation	0.091	0.055	0.029	0.075	0.019
Correlations:					
u	1	0.609	-0.796	0.969	-0.769
v		1	-0.008	0.786	0.025
f			1	-0.622	0.997
s				1	-0.592
p					1

All variables are measured in logs.

Table 2: Productivity and Job Separation Shocks, $z = 0.45$

	u	v	f	s	p
Std Deviation	0.124	0.087	0.071	0.075	0.019
Correlations:					
u	1	-0.385	-0.897	0.887	-0.874
v		1	0.743	0.078	0.740
f			1	-0.606	0.993
s				1	-0.592
p					1

All variables are measured in logs.

Proof of Lemma 1

Indifference requires,

$$z + f(\theta)(W - U) = z - c + q(\theta)(J - V).$$

using the implications of the Nash Bargaining Solution, this implies,

$$z + f(\theta)\beta S = z - c + q(\theta)(1 - \beta)S. \tag{13}$$

Note that $S = W - U + J - V$ combined with our Bellman equations implies,

$$\begin{aligned} rS &= rW - rU + rJ - rV \\ rS &= p + \delta(V - J + U - W) - (z - f(\theta)(W - U)) - (z - c + q(\theta)(J - V)). \end{aligned}$$

Simplifying and rearranging,

$$S = \frac{p - 2z + c}{r + \delta - \beta f(\theta) + (1 - \beta)q(\theta)} \tag{14}$$

which when combined with (13) implies,

$$\frac{f(\theta)\beta(p-2z+c)}{r+\delta-\beta f(\theta)+(1-\beta)q(\theta)} = -c + \frac{q(\theta)(1-\beta)(p-2z+c)}{r+\delta-\beta f(\theta)+(1-\beta)q(\theta)} \tag{15}$$

This can be simplified in a straightforward manner to

$$-q(\theta)(p-2z)(1-\beta)+c(r+\delta)+f(\theta)\beta(2c+p-2z)=0. \tag{16}$$

Proof of Proposition 1

Lemma 1 implies that any equilibrium in which vacancies and unemployment coexist must satisfy equation (8). There is a unique θ that satisfies (8) as long as $p > 2z$ given our assumptions on the matching function. To see this, define

$$g(\theta) = -q(\theta)(p-2z)(1-\beta)+c(r+\delta)+f(\theta)\beta(2c+p-2z)$$

and note that as long as $p-2z > 0$ that $\lim_{\theta\to\infty} g(\theta) = -\infty$ and that $\lim_{\theta\to 0} g(\theta) = \infty$. Furthermore, $g'(\theta) = -q'(\theta)(p-2z)+f'(\theta)\beta(2c+p-2z) > 0$ implies that $g(\theta)$ is strictly increasing and continuous. Then the intermediate value theorem implies existence of a solution to (8) and the monotone nature of $g(\theta)$ guarantees uniqueness. Once the equilibrium level of θ is known, in steady state it is known that u^* is determined by (9) and v^* is determined by (10). For u^* and v^* to be consistent with the equilibrium level of θ, the argument in the text implies n^* must satisfy (11). This value of n^* is unique given any value of θ^*. Finally, once n^* and θ^* are known, steady state implies that u^* and v^* must satisfy (9) and (10) and that the implied u^* and v^* are unique.

Proof of Proposition 2

The proof of these proposition follows from repeated application of the implicit function theorem to equation (8). Detailed proofs are available on request from the author.

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