Risk-Averse Firms and Employment Dynamics

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Abstract

In this paper we reconsider the standard assumption that firms are risk neutral in the context of employment dynamics. By altering this assumption in a turnover-training model of Hoon and Phelps (1992, 1996) we show that high risk-aversion implies that firms are eager to return speedily to the steady-state profit levels in the face of temporary or permanent shocks and hence restore *quicker* employment levels to pre-shock levels. We present some anecdotal evidence of such behavior on the U.S. by linking firm risk-aversion with corporate behavior.

JEL Classification: E24, E27

Keywords: Employment Dynamics; Risk-Aversion; Uncertainty

1 Introduction

A standard assumption in theories of unemployment is that firms are risk-neutral. However, there are several reasons why firms may in fact be risk averse. Some factors that can be invoked are nondiverisified ownership, liquidity limitations or costly financial distress. And even if maximizing profits is the preferred objective of firm owners, the entrustment of firm control to a risk-averse manager whose wages are linked to performance may induce the firm to behave risk-aversely as output may be subject to uncertainty. Moreover, the firms' incentive schemes may change her attitude towards risk-taking. This may happen when firm owners heavily rely on stock options which arguably have fundamentally changed the incentive landscape in the U.S. in that most managers' pay is now thought to be convex in stock value (Hall and Liebman (1998), Guay (1999)). Therefore, risk-incentives to managers are greater than they were ever before.

There are other uncertainties a firm may face. Contribution such as Booth, Chen and Zoega (2001) and Booth and Zoega (1999) consider employment dynamics with the effect of quitting on the hiring and training by firms when productivity is uncertain. Chen and Funke (2004) consider the effect on firm's decision making in terms of employment and working hours using real option theory. In the light of the above discussion, surprisingly little work has focused on uncertainties and their possible (direct) affect on firm behavior in the form of risk-aversion.

Altering the assumption of risk-neutrality in firm has several implications for the labour market. Important work by Grossman and Hart (1983) shows in the context of a static model that the probability of unemployment is higher when firms are risk averse and it increases as risk-aversion rises. In their model firms have more information than workers and firm risk-aversion creates more unemployment then a Walrasian economy when times are bad as firms attempt to exploit asymmetric information. Similarly, Frank (1990) show that risk-aversion implies firm operate too cautiously at low levels profit levels and as a result the economy can get stuck in an equilibrium recession. While, these paper suggest firm risk-aversion having a negative impact on unemployment levels, we suggest that this may not be the case during transitional dynamics.

We consider a dynamic version of the turnover-training model in the tradition of Hoon and Phelps (1992), Orszag and Zoega (1996, 1995). The firm faces worker's turnover uncertainty and is risk-averse in her profit function. In line with turnover-training literature, the firm invests in the training of new workers and uses wages to reduce quitting and hence the costs associated with labour turnover. The firm also has a constant-returns-to-scale technology; an assumption commonly used in this literature. In the presence of firm risk-aversion and uncertainty we show that in the aftermath of a random transitory (or permanent) shock to either productivity or interest rates which drive the economy's employment level below its steady-state, a high risk-aversion in firms tends to speed-up adjustment process of employment back to its steady-state. In this sense, risk-aversion serves as a self-adjusting device in that cautious managers steer their firms to regain the pre-shock employment levels, in the case of a temporary shock, in a bid to stay closer to their steady-state profit levels; thereby minimizing fluctuations in profits. This *close tracking* of the 'steady-state,' however, comes at a cost in the form of altering wages, hiring or losing workers during the period where adjustment is taking place.

The result we obtain is independent of the levels of labour market rigidities characterized by high training cost and low quit rates in our model and extends the literature in three ways: (i) situations where firm risk-averse behavior affect (un)employment dynamics have received little attention but, as we have argued, are clearly appropriate, (ii) we examine the problem in a dynamic framework which generalizes the existing turnover-training models, (iii) anecdotal evidence is discussed that links employment dynamics with corporate governance.

The rest of this paper is organized as follows. In Section 2 we briefly present the related literature. In Section 3 we develop the basic structure of the model and solve for the steady-state. In Section 4 we analyze, using both theory and numerical simulations, the dynamic properties of the model with respect to the firm risk-aversion and the speed of adjustment of unemployment. The model has the empirical implication that the economies with more risk-averse firms are quicker to adjust to various shocks and this is discussed in Section 5. Finally, in Section 6 we present the concluding remarks.

2 Related Literature

A brief review of the existing literature on unemployment dynamics is useful at this stage. Generally, there are two dominant views on the behavior of unemployment dynamics. The persistence view[1] argues that the interplay between current and past nominal and real shocks explain the adjustment process of the unemployment towards its natural-rate. For example, Henry, Karanassou and Snower (2000) and Karanassou and Snower (1998 a, b) show that a chain of past transitory but long-lasting shocks to labour demand and supply and real wages delay the adjustment of unemployment to its steady-state levels.

An alternative view is that of Hoon and Phelps (1992), Phelps (1994), Phelps and Zoega (1998) argue that the natural unemployment-rate has a time path that is generated by the structure of the economy: its technological factors, institutions, laws and individual and social preferences. Real disturbances are met by changes in the structure of the economy (labour tax laws, working hours, etc.) which then permanently shifts the natural unemployment rate. In this context of shifting equilibria, the economy takes a while to adjust for a variety of reasons. For example, Bentolila and Bertola (1990) and Bertola (1990) argue that hiring and firing cost create inertia in the unemployment rate. Lindbeck and Snower (1988) and Blanchard and Summers (1986) argue that in that the employees - the insiders - bargain for higher wages with little regard to the unemployed – the outsiders– delaying the recovery process. Finally, Blanchard and Diamond (1994) and Layard and Nickell (1987) argue that prolonged durations of unemployment erodes the sharpness of job-

[1] See Turner et al., (2001) for a survey.

seekers. Such workers then take a while before they get back employment creating inertia in the unemployment levels.

More recently, Pries (2004) show that during bad times a series of short-lived employment spells, due to a complex firm-worker matching process, can generate persistence in the unemployment rate. Chang, Gomes and Schorfheide (2004), show when they control for past skill accumulation, the propagation mechanism in the employment series can be better explained.

This paper is very much complimentary to the research on unemployment behavior. We generalize the influential core model in the literature, in particular Hoon and Phelps (1992, 1997) and Orzag and Zoega (1995, 1996), to the case where firms are truly risk averse. In particular, our result show that risk-aversion in firms may be as important a determinant as factors such as hiring and firing costs play in explaining the speed of adjustment to the natural unemployment-rate.

3 The Basic Model

Consider a firm that invests in the training of new workers and engineers wages so as to reduce quitting and hence turnover costs. Production is carried out by n identical atomistic firms using labour as the only factor of production. Firms are endowed with a constant returns to scale technology with the production function

$$Y = f(\frac{E}{n}) = \Lambda \frac{E}{n}, \tag{1}$$

where, Y, E and E/n denote firm's output, aggregate employment and the stock of employees per firm respectively. The constant Λ measures labour productivity. The number of firms is exogenous.

The firm faces worker's turnover uncertainty as a consequence of which she is risk-averse in her profit function, as we see shortly. Therefore, the dynamics of employment evolve according to the difference between the total number of trainees, H, hired and number of people who quit, qE. This is captured by

$$dE = \left[H - q(\frac{\overline{w}}{w})\right] Edt + dv\,;\; q' > 0,\, q'' \geq 0\,;\; dv \sim N(0, \sigma^2 dt). \tag{2}$$

The quit rate, q, is a function of the to the firm's real wage, w, relative to the expected industry wage, $\bar{w}$. Thus, when wage prospects are better elsewhere the employees leave the firm at the rate of $\frac{1}{w}q'(\cdot)$, while when the employing-firm offers wages that are better than the industry average the employee quit rate drops by $-\frac{\bar{w}}{w^2}q'(\cdot)$. The additive disturbance dv in (2) captures randomness in employment dynamics due to turnover and is a Wiener process. We simplify the model by assuming a continuum of workers of measure one. With this simplification, the variables Y, H and E can be measured in per capita terms and imply that E is the employment rate while H is the the hiring rate.

At time t, the representative firm employs the proportion E/n of the total workforce[2]. To simplify the analysis we assume that there are a continuum of firms of measure one. The implication is that we can ignore the presence of n in the analysis and (2) is equally valid at firm level. The firm decides on the rate of hiring and the wages to maximize the present discounted expected value of a concave profit function $\mathcal{E}_\tau[V(t)]$ subject to the stochastic environment given by (2).

$$\begin{aligned}\mathcal{E}_t V(\tau) &= \mathcal{E}_t \int_{t_0}^{\infty} u(\pi(t)) \exp\left(-r(t-t_0)\right) dt \\ \pi &= (\Lambda - w - T(H))E, \qquad T(0)=0,\ T', T'' > 0.\end{aligned}$$

The firm is lead by a risk-averse manager who faces a concave utility function in profits such that $u'(\cdot) > 0$ and $u''(\cdot) < 0$. The reason for manager's risk-aversion were discussed previously and are also justified by the inclusion of uncertainty in the model. In the profit function, π, the first term is the output produced by the firm where prices have been suppressed to unity. The second term is the wage bill of the firm. The final term $T(h)E$ is the total cost of training H new workers, where $h = H/E$ is the firms' hiring rate. The function $T(H)$ measures training costs captured by the lost output per worker given a hire rate H. Convexity implies that an increasing amount of output per worker is lost to training as the number of

[2]The proportion of workers employed by each firm is $\frac{E/L}{n}$. However, given our normalization $L = 1$ we arrive at $\frac{E}{n}$.

new recruits grow (as in Orszag and Zoega (1996)). The exogenous discount factor $\exp(-r(t-t_0))$ is the rate at which output can be traded intertemporally.

3.1 The Firm's Optimization Problem

To clarify intuition, we first solve the deterministic problem given by the current-value Hamiltonian below which describes a representative firm's optimization problem $\mathcal{E}_t[V(t)]$ with respect to $\{w(t), H(t)\}$, $t \geq t_0$ subject to (2)

$$\mathcal{H} = \exp(-rt)\left[u(f(E) - wE - T(H)E) + \lambda(H - q\left(\frac{\bar{w}}{w}\right))E\right] \tag{3}$$

The term λ is the shadow value of a trained worker. Using the Pontryagin's Maximum Principle, the first-order conditions are:

$$\begin{aligned}
T'(H)u'(\pi) &= \lambda & (4)\\
u'(\pi) &= \frac{\lambda\bar{w}}{w^2}q'(\frac{\bar{w}}{w}) & (5)\\
\dot{\lambda} - r\lambda &= -u'(\pi)\left[f'(E) - w - T(H)\right] - \lambda[h - q(\frac{\bar{w}}{w})] & (6)\\
\dot{E} &= \left[H - q\left(\frac{\bar{w}}{w}\right)\right]E & (7)\\
\lim_{t\to\infty}[\exp(-rt)\lambda(t)E(t)] &= 0 & (8)
\end{aligned}$$

Equation (4) says that the firm will sacrifice resources on training until it brings the value of a marginal trainee at parity with the value of the trained employee. Indeed, the right-hand-side is the value of a trained worker, while the left-hand-side is the sacrifice the firm makes – in the form of the output loss that occurs when trained workers spend time training the hirees instead of actively producing and the marginal change in the value of profits resulting from the output loss. One can also infer that an extra worker is worth more at lower levels of profits compared with higher profit levels due to the property of diminishing marginal utility in profits which in turn affects how the firm value its stock of employees; crucial for this model.

Equation (5) shows that at the optimum the marginal cost of raising wages by a unit – in the form of the direct wage increases by the amount E and the associated reduction in the marginal utility of profits– must equal the marginal benefit given by lower turnover costs due the retaining of employees valued at λ.

Using (4), we rewrite (6) as

$$\dot{\lambda} = -u'(\pi)\,[\Lambda - T(h) + hT'(h)] + [\lambda q(\frac{\bar{w}}{w}) + wu'(\pi) + r\lambda].$$

This equation shows that the shadow value of workers evolves according to the marginal benefits and marginal costs associated with increasing employment by a unit. The marginal benefits – the first set of first terms on the right-hand side– come in the form of the net marginal product of a newly employed worker and the change in the marginal utility in profits that is associated with this marginal product. The net marginal product is composed of: the marginal product from extra employment, $f'(E)$, the loss in the output in having to train the new employee instead of actively producing, $T(H)$, and the savings in the marginal costs of training made possible by our new employee sharing the burden of training of the trainees, $HT'(H)$. The marginal costs, the second set of terms, are composed of the wage of employing a worker and the marginal loss in the utility of profits associated with the wage, $u'(\pi)w$, the quit rate evaluated at the worker's shadow value, $\lambda q(\frac{\bar{w}}{w})$, and the opportunity cost of investing on an employee, $r\lambda$.

By standard stochastic optimization methods the sufficient first-order conditions for the firm's problem in a stochastic environment are

$$T'(H)u'(\pi) = \lambda \tag{9}$$

$$u'(\pi) = \frac{\lambda\bar{w}}{w^2}q'(\frac{\bar{w}}{w}) \tag{10}$$

$$\mathcal{E}_t[d\lambda] = [r - H + q(\frac{\bar{w}}{w})]\lambda\,dt - u'(\pi)\,[f'(E) - w - T(H)]\,dt \tag{11}$$

$$dE = \left[H - q\left(\frac{\bar{w}}{w}\right)\right]E\,dt + dv \tag{12}$$

$$\lim_{t\to\infty}\mathcal{E}_t[\exp(-rt)\lambda(t)E(t)] = 0 \tag{13}$$

where we recall our definition of profits:

$$\pi = [\Lambda - w - T(H)]E \tag{14}$$

Equations (9) to (12) and (14) give five equations for stochastic processes $\{H(t)\}$, $\{w(t)\}$, $\{\lambda(t)\}$, $\{E(t)\}$ and $\{\pi(t)\}$ and describe the firm's behavior given $\{\bar{w}(t)\}$, functional forms $q(\cdot)$, $T(\cdot)$ and the constants r and Λ. In a stochastic environment (9), (10) and (14) are now state-contingent rules linking the decision variables w, h and state variables, given the realization of the latter. The state variable $\lambda(t)$ is a forward-looking non-predetermined (at time t) variable, whilst $E(t)$ is predetermined at time t. The interpretation of Eqs. (9) to (13) is the same as in the deterministic case.

3.2 The Macroeconomic Equilibrium

To complete our model of employment, hiring rate and wages we recall that our normalization of the workforce at unity implies that E and $1-E$ are the employment and unemployment rates respectively. Given the individual firm's optimization problem, we endogenize the expected average industry wage as $\bar{w} = \bar{w}\times$ (probability of employment) $= wE$, as in Calvo (1979), Salop(1979) and Hoon and Phelps (1992). This equilibrium relationship implies that the wage of the representative firm, w, is larger than the expected industry wage if there is unemployment (i.e., if $E < 1$). The implication is that the model does not allow job-to job changes.

Upon substituting $\bar{w} = Ew$ and dividing (9) by (10) we obtain wages as function of employment and the hiring rate

$$w = Eq'(E)T'(H) = \omega(E, H) \tag{15}$$

Substituting into (9) we then have

$$u'([\Lambda - \omega(E, H) - T(H)]E)T'(H) = \lambda \tag{16}$$

Hence solving (16) implicitly for h and substituting back into (15) we arrive at w and H expressed in terms of E and λ:

$$H = h(E, \lambda) \tag{17}$$

$$w = \omega(E, h(E, \lambda)) \equiv w(E, \lambda) \tag{18}$$

Using (18), (17) and (9), the dynamic system (11) and (12) in (E, λ) space can now be written as

$$
\begin{aligned}
dE &= [h(E,\lambda) - q(E)]\, Edt \equiv F(E,\lambda)dt + dv && (19)\\
\mathcal{E}_t[d\lambda] &= \left[r - h(E,\lambda) + q(E) + \frac{1}{T'(h(E,\lambda))}(\Lambda E - w(E,\lambda) - T(h(E,\lambda))\right] dt \\
&\equiv G(E,\lambda)dt && (20)
\end{aligned}
$$

say, plus the transversality condition, (13). One state variable, E, is predetermined at time t with initial condition $E(0)$ given exogenously. The second state variable, λ, is non-predetermined or 'free' and satisfies the terminal condition (13).

We follow Hoon and Phelps (1992), section III, in interpreting this macro-model with a exogenous constant interest rate as that of a small open economy facing an exogenous world interest rate. Current account dynamics are excluded by conducting our stability analysis in the vicinity of a steady state in which trade is balanced and net foreign assets are zero.[3]

3.3 The Deterministic Steady State

In the deterministic steady state with $dv = 0$ and $\dot{E} = \dot{\lambda} = 0$ we have

$$
\begin{aligned}
H &= q(E) && (21)\\
w &= Eq'(E)T'(H) = Eq'(E)T'(q(E)) && (22)\\
r &= \frac{1}{T'(H)}\left(\Lambda - w - T(H)\right) && (23)
\end{aligned}
$$

giving us three equations for H, w and E. Then λ is given by (4).

We first examine the wage-employment relationship in (22). At the steady-state the wages depend on the investment made on the marginal worker– in the form of training costs – and their marginal propensity to quit. Differentiating (21) with $H = q(E)$, we get

$$w'(E) = (q'(E) + Eq''(E))T'(q(E)) + Eq'(E)T''(E) > 0 \qquad (24)$$

[3] Without these simplifying assumptions involving a constant real interest rate and a linearization in the vicinity of a balanced trade steady state, we would be faced with a third-order derivatives, analytically intractable dynamic system.

since T', T'', $q'(E)$, $q''(E) \geq 0$. The first term gives the marginal change in labour turnover as employment rises, $q' + Eq''$, where each quitting worker must be replaced at the cost, T'. The second term is the rise in training costs associated with higher employment. Thus, higher wages and higher (lower) employment (unemployment) are proportional and this relationship is concave (convex). This ensures that our model is consistent with the Phillip's curve wage-employment (or wage-unemployment) relationship.

Proposition 1.

In the deterministic steady state, the wage is an increasing function of the employment rate.

The steady-state is at the intersection of the $\dot{E} = 0$ curve, (21), and the $\dot{\lambda} = 0$ curve. The former is upward-sloping in (h, E) space as $q' > 0$. To show that the latter is downward-sloping, implicitly differentiate (23) to get

$$\frac{dh}{dE} = -\frac{w'(E)}{T' + rT''} < 0. \tag{25}$$

Assuming that the conditions in Proposition 1 hold (where $w'(E) > 0$), and recalling that $T', T'' > 0$. The derivative implies that, higher levels of steady-state employment are associated with lower levels of hiring rate. Finally we observe that the steady state given by (21) to (23) is independent of the functional form $u(\cdot)$.

Proposition 2.

There exists a unique deterministic steady state that is independent of the degree of risk aversion of the firm.

Figure 1 shows the 'E-stationary' curve ($\dot{E} = 0$) and the 'λ- stationary' curve ($\dot{\lambda} = 0$) in (h, E) space for functional forms and parameter values discussed in section 3.1. Notice that the equilibrium unemployment rate stands as 5%. In the dynamic analysis that follows, we consider permanent shocks to underlying parameters that change the steady state. We then examine the subsequent dynamic transition from the old to the new steady state. These are discussed in section 3.2.

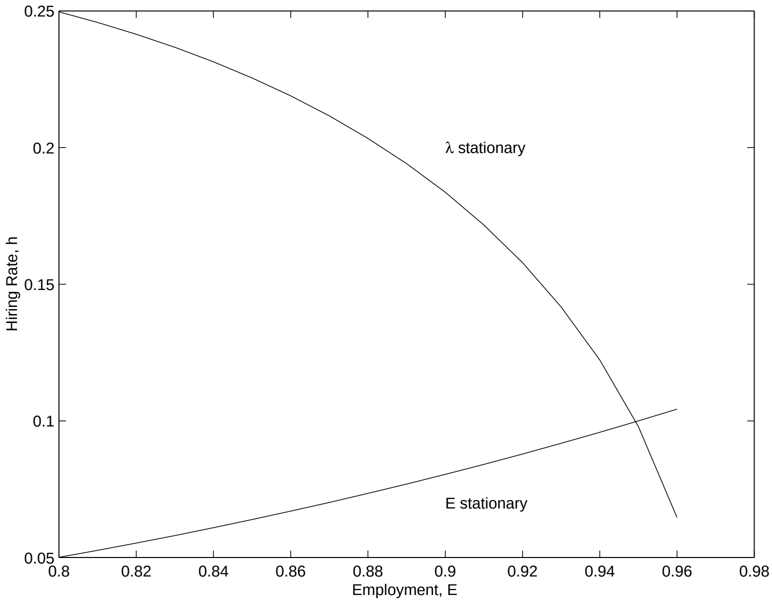

Figure 1: The Steady-State in h-E Space

4 The Dynamic Analysis

4.1 Saddlepath Stability

To analyze the local stability of the dynamic system (19) and (20) in the vicinity of the unique deterministic steady state, we evaluate the Jacobian

$$J = \begin{pmatrix} F_E & F_\lambda \\ G_E & G_\lambda \end{pmatrix} \tag{26}$$

where partial derivatives $F_E \equiv \frac{\partial F}{\partial E}$, etc. are evaluated at the steady state. The eigenvalues $\mu = \mu_1$ and $\mu = \mu_2$ are the solutions of

$$\mu^2 - (F_E + G_\lambda)\mu + \Theta = 0 \tag{27}$$

where $\Theta \equiv F_E G_\lambda - F_\lambda G_E$. Since we have one predetermined and one non-predetermined variable, saddlepath stability requires that one root has real part positive and the other has real part negative.

From (27) the eigenvalues are given by

$$\mu = \frac{F_E + G_\lambda \pm \sqrt{(F_E + G_\lambda)^2 - 4\Theta}}{2} \tag{28}$$

In the Appendix A we show that $\Theta < 0$; implying that one root ($\mu = \mu_1$) is real and negative and one root ($\mu = \mu_2$) is real and positive

Proposition 3.

The dynamic system is saddlepath stable.

4.2 The Impact of Macroeconomic Shocks

In this section we study the impact of aggregate demand and supply shocks. First, we analyze a shock to aggregate demand arising from an exogenous fall in the world real interest rate engineered by central banks outside the control of our economy. Second, we study shocks to aggregate supply arising from exogenous productivity shocks. As in Figure 1 we are $h - E$ space (although the dynamic analysis is in $\lambda - E$ space).

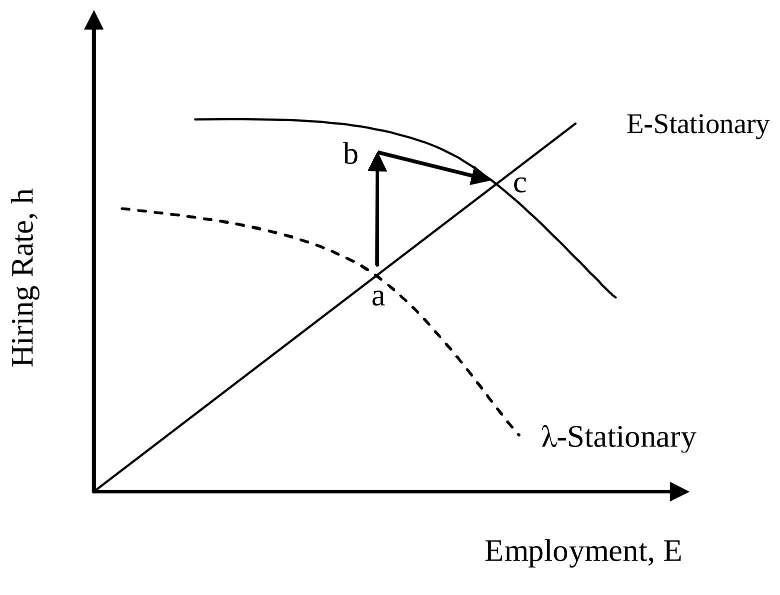

Figure 2: Macroeconomic Shocks

Recall that the interest rate appears in (23) and it represents the opportunity cost of investing on an employee. Assuming that we are initially at the steady-state (point a in Figure 2), a fall in the real interest rate implies that $\dot{\lambda}$ curve shifts to the right from (20) and also tilts upwards from (25). The firms now find themselves in a position where the stream of marginal cash flow attributable to an extra employee is too high relative to her marginal opportunity costs of employment. This implies that shadow value of a worker must jump with a corresponding rise in investment on new workers. The firm therefore increases hiring causing the training cost and wage cost (from (24)) to climb until marginal profit contribution of an extra employee just equate to the marginal opportunity cost of employment. This is demonstrated by the arrows of motion in Figure 2. At first the hiring rate jumps to point b since the shadow value of the workers jumps. As more people are employed the rise in training costs and wage bills increase, this reduces the shadow-value of a worker eventually bringing the growth in employment to a halt (travelling from b to$c$). The natural *employment* rate permanently rises to point c.

The second shock we study is a permanent positive shock to productivity. We analyze by following Hoon and Phelps (1992) by interpreting the training costs as some fraction, τ, of a trained worker's productivity Λ. Thus, $T(H) = \tau(H)\Lambda$, where the fraction of productivity that is consumed by training new workers is determined by the level of hiring. In the dynamic system the curve $\dot{E} = 0$ is not affected and we can rewrite (25) as:

$$\frac{dh}{dE} = -\frac{w'(E)}{\Lambda(\tau' + r\tau'')} < 0$$

Now from the equations above a rise in productivity has a very similar affect as the permanent fall in the real interest in that the $\dot{\lambda} = 0$ curve shifts and tilts to the right. However, this time the marginal profit contribution of an employee instantaneously increases and as a result λ jumps up with a corresponding rise in investment in new workers and the hiring rate h . As the hiring process continues, training costs and wage bill rise and this serves to pull back the marginal cash flow contribution of the marginal worker to the same level as the opportunity cost of employing her. Thus, the value of h gradually declines and the steady-state employment permanently achieves higher levels.

It is clear from the both shocks that risk-aversion does not play any role in determining the level of the steady state. However, in the next section we show that when the economy is in the state of transition from one steady-state to another, i.e., the arrows of motion in Figure 2, risk-aversion plays a leading role.

4.3 Hysteresis and Risk Aversion

Thus far, we have shown that the firm's risk aversion neither affects the steady state nor the possibility of instability (or indeterminacy[4]). However the degree of risk aversion does affect the *size* of the eigenvalues and hence the rate at which the system reverts to the steady state following an exogenous shock. From standard analysis of linear systems with non-predetermined variables (see, for example, Currie and Levine (1993)) the solution to the linearized dynamic system

$$\begin{bmatrix} dE \\ \mathcal{E}_t[d\lambda] \end{bmatrix} = \begin{bmatrix} F_E & F_\lambda \\ G_E & G_\lambda \end{bmatrix} \begin{bmatrix} E \\ \lambda \end{bmatrix} dt + \begin{bmatrix} dv \\ 0 \end{bmatrix} \tag{29}$$

is given by

$$\lambda - \bar{\lambda} = -M_{22}^{-1} M_{21} (E - \bar{E}) \tag{30}$$

$$dE = [F_E - F_\lambda M_{22}^{-1} M_{21}](E - \bar{E})dt + dv \tag{31}$$

where $\bar{\lambda}$ and $\bar{E}$ denote the deterministic steady-state values and M is a matrix of eigenvectors defined by

$$\begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix} \begin{bmatrix} F_E & F_\lambda \\ G_E & G_\lambda \end{bmatrix} = \begin{bmatrix} \mu_1 & 0 \\ 0 & \mu_2 \end{bmatrix} \begin{bmatrix} M_{11} & M_{12} \\ M_{21} & M_{22} \end{bmatrix} \tag{32}$$

where μ_1 and μ_2 are the real negative and positive eigenvalues found in the previous subsection. Solving (32) we find that

$$M_{22}^{-1} M_{21} = \frac{\mu_2 - G_\lambda}{F_\lambda} = \frac{F_E - \mu_1}{F_\lambda} \tag{33}$$

[4] Indeterminacy and multiple equilibria occurs in our model if both eigenvalues have negative real parts. Both instability and indeterminacy are ruled out by proposition 3.

Hence (30) becomes

$$dE = [F_E + G_\lambda - \mu_2](E - \bar{E})dt + dv = \mu_1(E - \bar{E})dt + dv \tag{34}$$

using trace$(J) \equiv F_E + G_\lambda = \mu_1 + \mu_2$.

We have now established that the rate at which employment returns to the steady following either a temporary shock to employment itself (in which case the economy reverts to the same steady state) or to a permanent change in the natural rate of employment (then reversion is to a new steady state) is given by the absolute size of the negative eigenvalue μ_1:

$$\mu_1 = \frac{F_E + G_\lambda - \sqrt{(F_E + G_\lambda)^2 - 4\Theta}}{2} \tag{35}$$

Provided that the dynamic system is saddlepath stable, which we have shown to be the case, the dynamics of expected employment are given by

$$\mathcal{E}_t[E(t)] = E(0)\mathrm{e}^{\mu_1 t} \tag{36}$$

To see how μ_1 changes as risk aversion increases, consider a constant coefficient of relative risk aversion profit function

$$\begin{aligned} u(\pi) &= \frac{\pi^{1-\rho}}{1-\rho}\,;\ \rho > 0,\ \rho \neq 1 \\ &= \log(\pi)\,;\ \rho = 1 \end{aligned} \tag{37}$$

where $\rho = -\frac{\pi u''}{u'}$ is the constant coefficient of risk aversion. Though we do not explicitly model it, the value of this coefficient but it may be negatively influenced by the risk-taking incentives such as stock-options grants. In the steady state, using (23) we have that economy-wide profits are $\pi = rT'E$. Then in terms of ρ, from Eqs. (66), (67) and (65) we have

$$F_E(\rho) = \left(\frac{\rho T'(r - E(Eq'' + q'))}{\rho(Eq'T'' + T') + rT''} - Eq'\right) \tag{38}$$

$$G_\lambda(\rho) = \frac{rT'\left[2 + \frac{T''}{T'}(r + Eq')\right]}{\rho(Eq'T'' + T') + rT''} \tag{39}$$

$$\Theta(\rho) = \frac{rE\left[-q'(2T' + rT'' + Eq'T'') - Eq''T'\right]}{\rho(Eq'T'' + T') + rT''} \tag{40}$$

We are interested in the sign of $\frac{d\mu_1}{d\rho}$. If it is positive, them increasing risk aversion pushes μ_1 towards zero and towards pure hysteresis. If the derivative is negative, it has the opposite effect and risk aversion actually improves the stability of the dynamic system. Differentiating (35) we have

$$\frac{d\mu_1}{d\rho} = \frac{1}{2}\left(\frac{dF_E}{d\rho} + \frac{dG_\lambda}{d\rho}\right)\left(1 - \frac{(F_E + G_\lambda)}{\sqrt{(F_E + G_\lambda)^2 - 4\Theta}}\right) + \frac{2}{\sqrt{(F_E + G_\lambda)^2 - 4\Theta}}\frac{d\Theta}{d\rho} \tag{41}$$

Differentiating (66) we have that

$$\frac{d\Theta}{d\rho} = (Eq'T'' + T')\frac{rE\left[q'(2T' + rT'' + Eq'T'') + Eq''T'\right]}{(\rho(Eq'T'' + T') + rT'')^2} > 0 \tag{42}$$

and so the last term in (41) is positive. Since $F_E + G_\lambda < \sqrt{(F_E + G_\lambda)^2 - 4\Theta}$ the first term has the sign of $\frac{dF_E}{d\rho} + \frac{dG_\lambda}{d\rho}$. Indeed, consider first derivatives in the vicinity of $\rho = 0$. Differentiating (55) and (39), at $\rho = 0$ we find that

$$\frac{d(F_E + G_\lambda)}{d\rho} = -Eq' - \frac{1}{r(T'')^2}\left[(Eq'T'' + T')(2T' + T''Eq') + T''T'E(Eq'' + q')\right] \tag{43}$$

which is negative. It follows that in the vicinity of $\rho = 0$, the effect of increasing risk aversion on the degree of stability of the macro-economy is ambiguous. However, we can establish an unambiguous result for higher values of ρ, the case where $r << \rho\bar{q}$, $\bar{q}$ being the quit rate in the steady-state. Then from the calibrations we can establish that $\frac{\Theta}{(F_E+G_\lambda)^2} << 1$ and $-F_E >> G_\lambda$. Then expanding (35) as a binomial series we have

$$\mu_1 = \frac{F_E + G_\lambda - |F_E + G_\lambda|\left[1 - \frac{\Theta}{(F_E+G_\lambda)^2}\right]^{\frac{1}{2}}}{2} \approx F_E + G_\lambda + \frac{\Theta}{|F_E + G_\lambda|} \approx F_E \tag{44}$$

From (38) for $r << \rho\bar{q}$, and $r << E(Eq'' + q')$ and it follows that $\frac{dF_E}{d\rho} < 0$. Hence we have established the following proposition:

Proposition 4

For $r << \rho\bar{q}$, an increase in risk aversion increases the degree of stability of the economy.

The intuition for this result can best be seen by examining the decision variables of the firm, trajectories for the wage rate and the hiring rate, $\{w(t), h(t)\}$ in terms of a *policy feed-back rule* that responds to the current state of employment in the firm and the value of the trained worker. In terms of aggregate employment (assuming all firms are identical), in the vicinity of the steady state $[\bar{w}, \bar{h}]$ the policy rule of the representative firm is is given by

$$\begin{bmatrix} w(t) - \bar{w} \\ h(t) - \bar{h} \end{bmatrix} = \begin{bmatrix} w_E & w_\lambda \\ h_E & h_\lambda \end{bmatrix} \begin{bmatrix} E(t) - \bar{E} \\ \lambda(t) - \bar{\lambda} \end{bmatrix} \tag{45}$$

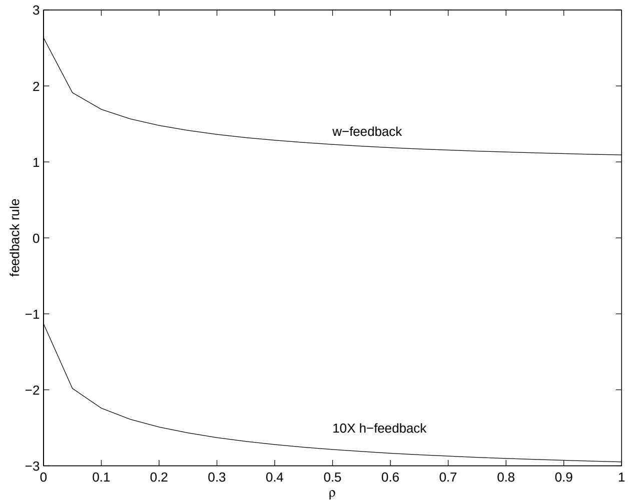

Figure 3: Feedback Rules

Now consider the firm is adjusting to the steady state along a trajectory where $E(t) > \bar{E}$. For $r << \rho\bar{q}$ we have seen that $\mu_1 \approx F_E$ and hence from (30) $\lambda(t) \approx \bar{\lambda}$. Then the policy rule takes the approximate form

$$\begin{bmatrix} w - \bar{w} \\ h - \bar{h} \end{bmatrix} = \begin{bmatrix} w_E \\ h_E \end{bmatrix} (E(t) - \bar{E}) = \begin{bmatrix} [(Eq'' + q')T' + Eq'T''h_E] \\ h_E \end{bmatrix} (E(t) - \bar{E}) \tag{46}$$

substituting for w_E from (63). Now compare a firm with relatively low and high degrees of risk aversion. In the former case h_E is small so the firm responds to being above the equilibrium employment level by raising the wage, but only changes the hiring rate slightly. In the more risk averse case, for $r < E(Eq'' + q')$ (easily satisfied in our calibration), $h_E < 0$ and grows in absolute size as ρ increases, so the wage is raised *by less* than in the less risk averse case, quits are therefore *higher*, and now the firm responds by *lowering* the hiring rate. As a result of these differences employment returns faster to its steady state for the risk averse firm. Clearly adjustment for $e(t) < \bar{e}$ is symmetrical: now the more risk averse firm hires more and engineers less quits than the less risk averse risk neutral firm. In short, *firms are self-stabilizing in the face of shocks, and the more risk averse firm will stabilize employment by more than the less risk averse firm.* Figure (3) plots the exact feedback coefficients $w_E - M_{22}^{-1}M_{21}w_\lambda$ of the wage on employment (the 'w-feedback') and the corresponding 'h-feedback' $h_E - M_{22}^{-1}M_{21}h_\lambda$ computed without the approximation used in the analysis, for parameter values discussed in next sub-section. The same features revealed in the analysis carry over to the exact solution: the positive w-feedback on employment falls and the negative h-feedback rises in absolute value, increasing the self-stabilization of the firm as risk aversion increases[5].

4.4 Numerical Illustration and Quantification

To illustrate these results and attempt to quantify their the degree to which risk-averse firms self-stabilize employment, we turn to numerical computations. We examine values of the risk aversion parameter $\rho \in [0, 1]$. We assume the following

[5] Our model is comparable to a stochastic Ramsey model. The two models are analogous in that while in Ramsey's case consumers accumulate capital and smooth consumption, in the present model firms accumulate a stock of employees and smooth profits. In the Ramsey model a greater preference for intertemporal smoothing reduces the speed of convergence of the capital stock to the steady state. The intuition is that an agent with a low taste for smoothing (a high risk-aversion parameter) is associated with a lower elasticity of substitution and therefore a lower substitution effect takes place from a change in the real interest rate. Now, assume a positive shock to capital. The real interest rate will fall if the substitution effect dominates the income effect. Agents switch from savings to consumption reducing investment and allowing capital to return to its steady-state values. If, however, the agent's taste for smoothing is low (a high risk-aversion parameter) the substitution effect diminishes and with it the speed of convergence to the steady-state. This does not happen in our model as firms take interest rates as given.

functional forms:

$$q(E) = q_0 E^\beta;\ \beta > 1 \tag{47}$$

$$T(h) = \frac{1}{2}\tilde{t}h^2 \tag{48}$$

This leaves parameters Λ, q_0, β and $\tilde{t}$. The interest rate r is exogenous and we set its value to a plausible average real interest rate. By choice of units we can normalize $\Lambda = 1$ so that a fully employed labour force produces on unit of output. $\bar{E}$ is given by $1-\bar{U}$ where $\bar{U}$ is the natural rate of unemployment for which econometric estimates are available. To calibrate the remaining three parameters we use the steady state relationships given by (21) to (23) and econometric estimates for the unemployment rate, and data for the quit rate q.[6] We need one more item of data to complete the calibration. Data on training costs $T(h)E$ is available, but leads to implausibly low degrees of persistence.[7] We therefore appeal to estimates of the latter to pin down the final parameter.

First we note that from (21), $w(E) = Eq'(E)$ and given our chosen functional forms we get

$$w'(E) = 2\beta^2 q_0^2 \tilde{t} E^{2\beta-1} > 0 \tag{49}$$

$$w''(E) = 2\beta^2(2\beta-1) q_0^2 \tilde{t} E^{2\beta-2} > 0 \tag{50}$$

Thus the 'wage curve', $w(E)$, has the familiar convex shape.

Now suppose we use data on training costs (as a proportion of total output) $\bar{T}\bar{E} = \overline{TC}$, say, and on quit rate $\bar{q}$. Then we have that $\frac{1}{2}\tilde{t}\bar{q}^2\bar{E} = \overline{TC}$ and hence $\tilde{t}$ is calibrated as:

$$\tilde{t} = \frac{2\overline{TC}}{\bar{E}\bar{q}^2} \tag{51}$$

Given $\tilde{t}$ and exogenous r, from (23) and $\bar{w} = \beta t \bar{q}^2$ we can solve for β as

$$\beta = \frac{1 - \frac{\overline{TC}}{E} - \tilde{t}\bar{q}r}{\tilde{t}\bar{q}^2} \tag{52}$$

---

[6] The annual quit rates: Japan 10.9 (1989), US 19.4, France 10.8 and Spain 9.6 (All in 1991). Source OECD (1994)).

[7] The average training cost for 12 European countries as a share of total labour costs is 1.5% and 2.8% for UK (OECD, 1999).

Finally q_0 is now calibrated as $q_0 = \frac{\bar{q}}{\bar{E}^\beta}$, though in fact this parameter is not required for the stability analysis. We have completed the calibration of parameters β and $\tilde{t}$. For the computations of μ_1 we then use

$$T' = \tilde{t}\bar{q}; \qquad T'' = \tilde{t} \tag{53}$$

$$q' = \frac{\beta\bar{q}}{\bar{E}}; \qquad q'' = \frac{\beta(\beta-1)\bar{q}}{\bar{E}^2} \tag{54}$$

Then substituting into (19), (38) and (39) we have

$$F_E = \frac{\rho\bar{q}(r-\bar{q}\beta^2)}{(\rho\bar{q}(\beta+1)+r)} - \beta\bar{q} \tag{55}$$

$$G_\lambda = \frac{r[(2+\beta)\bar{q}+r]}{(\rho\bar{q}(\beta+1)+r)} \tag{56}$$

$$\Theta = -\frac{\bar{q}\beta r[(2+\beta)\bar{q}+r]}{(\rho\bar{q}(\beta+1)+r)} = -\bar{q}\beta G_\lambda \tag{57}$$

From these expressions it is clear that if $r << \rho\bar{q}$, then $\frac{\Theta}{(F_E+G_\lambda)^2} << 1$, justifying the approximations made in the analysis of the previous section.

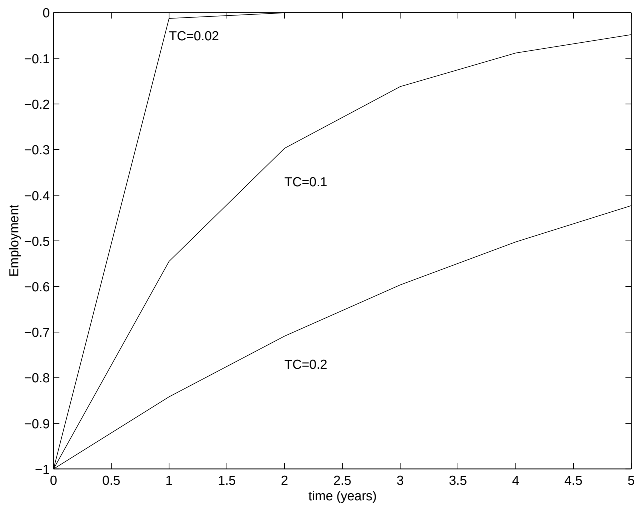

Figure 4: Calibration of Training Costs

We can now compute μ_1 using these functional forms and parameters. Figure (4) sets $\rho = 0.5$ and shows the employment response to a unit negative shock (i.e.,

$E(0) - \bar{E} = -1$) about the steady state for empirical data $\bar{q} = 0.1$, $\bar{U} = 0.05$, $\overline{TC} = 0.02$ and $r = 0.025$ and compares the response with those with higher values of $\bar{TC}$. Clearly using data that suggests $\overline{TC} = 0.02$ leads to an implausibly quick responses: the economy returns to equilibrium within a year! However, a 50% recovery within 3 years fits in with the stylized facts[8] and from our graphs this suggests the $\overline{TC}$ should be between 0.1 and 0.2. We choose $\overline{TC} = 0.15$. Our data suggest that much of this cost of training does not appear as measured investments and counts as the 'intangible investment,' highlighted for instance in Parente and Prescott (2000). Since their estimate of total intangible investment could be as much as 50% of GDP for the US, our figure of 15% for training costs does not seem excessive.

With these parameter values, increasing risk aversion then increases the absolute size of the negative eigenvalue Figure (5) (See Appendix B) making the macro-economy *more* stable, and *decreases* unemployment persistence following a negative transient shock at $t = 0$ to employment Figure (6). The policy rules for the risk-neutral and risk averse firms are contrasted in Figure (7). For the risk averse case wages are higher, quits are therefore lower and more hiring takes place confirming the increased self-stabilization of the firm following a negative employment shock. Another way of quantifying the degree of hysteresis is to evaluate the asymptotic variance of employment subject to a white noise shock of variance σ^2. This is given by $\frac{\sigma^2}{-\mu_1}$. Then the effect of increasing ρ from 0 to 1 is to decrease the variance of employment by a factor $\frac{\mu_1(0)}{\mu_1(1)}$ which turns out to be about $\frac{2}{3}$ in our example.

5 An Anecdotal Application of the Model

A key testable hypothesis of the model is that: a) high risk-aversion speeds up the response of unemployment to shocks on fundamentals and consequently b) in an economy with highly risk-averse firms one would observe a level of activity revolving

[8] See, for example, Alogoskoufis and Manning (1988) and Henry et al. (2000).

close to the long-term unemployment rate as firms attempt to match the steady-state employment levels, as discussed in Section 4.4.

These hypotheses are not straightforward to test as there is much noise in the data on unemployment adjustment. Nonetheless, the Table below gathers some anecdotal evidence on the U.S. economy related to our hypotheses. Consider first Table 1a where we report the importance of stock-options as a tool for wage payment for firm-managers. It is clear that payment by stock-options has become a dominant force for managerial pay. Indeed, in 1994 88% of managers in publicly owned firm received almost 50% of their wages in options. Taking, this into consideration, Cohen, Hall and Viciera (2000) find that the elasticity of wealth with respect to risk has increased by 600% between 1984-1994. Moreover, Empirical Studies such as Core and Guay (1999, 2002) and Oyer and Sheafer (2001) also find a positive trade-off between risk and incentives and there is an emerging theoretical literature such as Predergast (2002) and Guo and Ou-Yang (2005) that discuss a possible positive link between the responsiveness of pay to output risk. In the light of this literature, the more one loads CEO's with stock-options the more prepared CEO's are to take risks which is interesting for us in that it may imply a less risk-averse CEO. An aggregation of this effect in terms of our hypothesis imply that the U.S. firm managers were more risk averse in the 80's compared to the 90's. Now let us compare the corresponding figures on U.S job flow data Table 1b reports that from 1980's and 1990's the relative variation in job creation and worker's flow to employment fell. Furthermore, real wages were a touch less flexible[9] in 1980's relative to the 1990's implying lower quits rate due to wages in the 1980's (see Section 4.4).

[9] Calculated using the coefficient of variation of the growth in average industrial wage (Total Compensation/Total Employment).

Table1a . Summary Statistics on Options and Unemployment

	1984	1994
CEO's Holding Options (%)	69	88
Share of Options in Compensation (%)	25	48
Avg. Value of Options ($)	258,402	1,213,180
Elasticity of Wealth to Risk†	0.02	0.141

Source: Hall and Liebman (1998); †Cohen et al. (2000).

Table 1b.	1980-1990	1991-2000
Avg. % of Long-term Unemployment	8%	9%
CV* of Job Creation ‡	22.5	10.1
CV* of Worker Flow to Employment♮	5.3	4.7
Wage Flexibility§ (Author's Calculation)	0.31	0.32

Source: ‡Baldwin et al.(1998) availability 1980-1993; WDI;

♮Bleakley et al. (1999). *Coefficient of variation.

§ Based on the CV of %△average US manufacturing wage (Source: OECD).

From the viewpoint of our hypotheses, these figures imply that when firms were less risk-averse (as in the 1980's), the labour market appeared to be more active implying an economy less prone to hysteresis and quicker to adjust.

The evidence we have discussed is by no means a direct test for model but rather an anecdotal evidence. More importantly, the purpose is to show that corporate governance, through firm risk-aversion, may have potentially played a more important role in macroeonomic phenomenon than previously thought.

6 Conclusion

The model we discuss is a first step towards understanding the link between firm risk-aversion and the intertemporal path of unemployment. We have shown that high risk aversion in firms tend to speed up the adjustment process towards the steady-sate employment levels as the firms attempt to minimize fluctuations in profits.

Also, risk-aversion in firms may change with time; one possible mechanism for risk-aversion to rise is firms' managers responding to risk-taking incentives generated by the compensation schemes such as stock option grants. A policy implication is that when firms are risk averse there is *less* need for macroeconomic policy stabilization through monetary and fiscal policy. Our calibrated model suggests however that allowing the coefficient of risk aversion increase from $\rho = 0$ to $\rho = 1$ removes around one-third of employment variation, therefore still leaving a substantial role for government. The most pressing issue is to address is the treatment of risk-aversion in a general equilibrium setup. This would allow us to consider the two effects of risk-aversion of households and firms on the convergence unemployment.

7 Appendix A

Partially differentiating $F(E, \lambda)$ and $G(E, \lambda)$ defined in (19) and (20) at the steady-state and using (21) and (23), we have

$$\begin{aligned} F_E &= E(h_E - q') && (58) \\ F_\lambda &= Eh_\lambda && (59) \\ G_E &= \lambda \left[h_E - q' + \frac{1}{T'}(w_E + h_E(rT'' + T')) \right] && (60) \\ G_\lambda &= \lambda \left[h_\lambda + \frac{1}{T'} \left(h_\lambda T'' r + w_\lambda + T' h_\lambda \right) \right] && (61) \end{aligned}$$

where $q = q(E)$, $T = T(H)$, $f = f(E)$ and we omit the arguments in q', T', T'' and f''. It follows that

$$\Theta \equiv F_E G_\lambda - F_\lambda G_E = \frac{E\lambda}{T'} \left[-q' h_\lambda (T' + T'' r) + w_\lambda (h_E - q') - h_\lambda w_E \right] \quad (62)$$

This expression can be simplified further by partially differentiating (15) to obtain

$$\begin{aligned} w_\lambda &= Eq'T''h_\lambda && (63) \\ w_E &= (Eq'' + q')T' + Eq'T''h_E && (64) \end{aligned}$$

These partial derivatives imply that, other things being equal, the higher the shadow-value of a worker or the employment rate, the higher wages that has to be paid to the employees at the equilibrium. Such a policy will help deter workers from quitting and hence reduce firms' turnover and training costs.

Hence (58) becomes

$$G_\lambda = \lambda h_\lambda \left[2 + \frac{T''}{T'} (r + Eq') \right] \tag{65}$$

Substituting back into (62) we get

$$\Theta = \frac{E\lambda h_\lambda}{T'} [-q'(2T' + rT'' + Eq'T'') - Eq''T'] \tag{66}$$

To complete the dynamic analysis we require partial derivatives[10]

$$h_\lambda = \frac{1}{u'(\pi)T'' - u''(\pi)ET'(Eq'T'' + T')} \tag{67}$$

$$h_E = -\frac{u''(\pi)(T')^2(r - E(Eq'' + q'))}{u'(\pi)T'' - u''(\pi)ET'(Eq'T'' + T')} \tag{68}$$

We can now use these results in Section (4.1) to examine the saddlepath stability of the dynamic system. The eigenvalues are given in Eq. (28). Hence one root (μ_1) is real and negative and the other (μ_2) is real and positive if $\Theta < 0$. From (68) $h_\lambda > 0$, and hence from (66), since $\lambda > 0$, we have that $\Theta < 0$ iff $[-q'(2T' + rT'' + Eq'T'') - Eq''T'] < 0$. Since we have made the usual convexity assumption that $q', q'', T', T'' > 0$, all the terms in this expression are negative. Therefore, we have saddlepath stability.

7.1 Appendix B

[10] These derivations use (15) and (16).

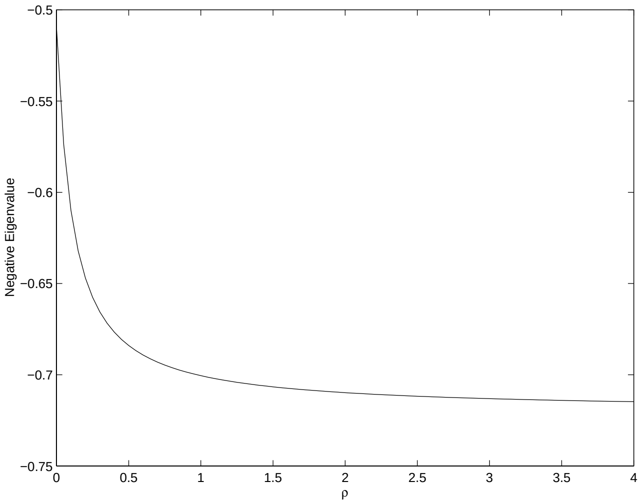

Fig 5. The Negative Eigenvalue As changes

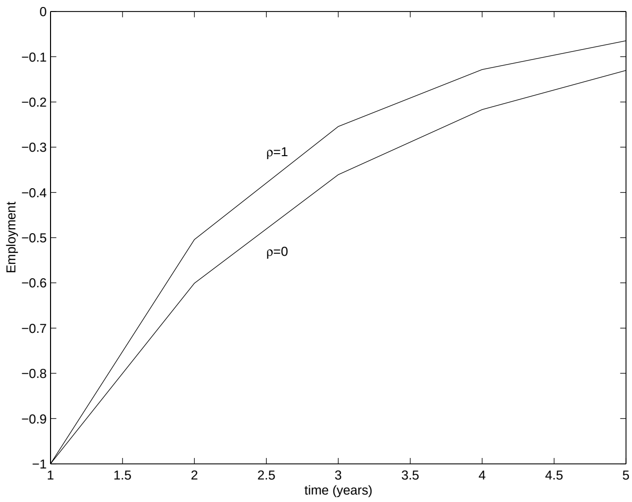

Fig 6. Employment Trajectories as ρ change

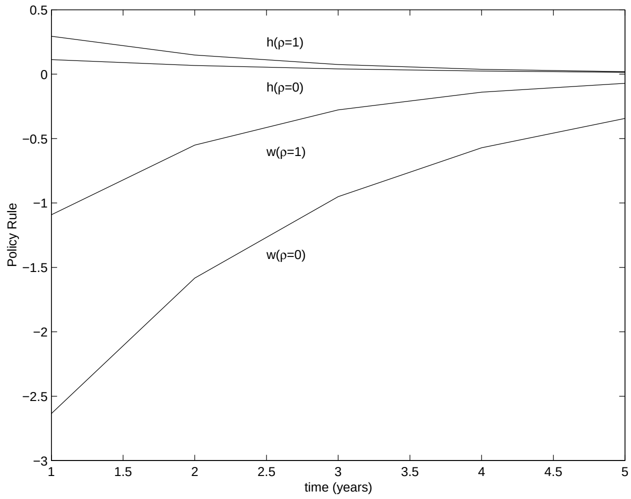

Fig 7. Hiring and Wage Trajectories as ρ change

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Risk-Averse Firms and Employment Dynamics

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Abstract

In this paper we reconsider the standard assumption that firms are risk neutral in the context of employment dynamics. By altering this assumption in a turnover-training model of Hoon and Phelps (1992, 1996) we show that high risk-aversion implies that firms are eager to return speedily to the steady-state profit levels in the face of temporary or permanent shocks and hence restore *quicker* employment levels to pre-shock levels. We present some anecdotal evidence of such behavior on the U.S. by linking firm risk-aversion with corporate behavior.

JEL Classification: E24, E27

Keywords: Employment Dynamics; Risk-Aversion; Uncertainty