How Do Layoff Costs Affect Employment?

by

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General equilibrium analyses of layoff costs have had mixed messages on the implications for employment. This paper brings out the economic forces at work and explains the disparate results. Specifically, we show that positive employment effects of layoff costs come through reducing labor reallocation, whereas negative effects come through reducing the private return to work due to those layoff costs and the associated inefficient allocation of labor. Additional adverse employment effects can arise through an increase in the effective bargaining strength of workers. These forces explain why layoff costs tend to increase employment in search models while the opposite is true in models with employment lotteries. In matching models, we show that the employment effects depend critically on how layoff costs are assumed to enter the bargaining process.

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1. *Introduction and Summary*

A common concern is that labor market rigidities such as layoff costs are responsible for high European unemployment (see e.g. OECD (1994)). As documented by Emerson (1988) and Lazear (1990), layoff costs are particularly burdensome in Europe. This paper explores a few general equilibrium models to see what kind of relationship there is between layoff costs and an economy's level of employment. The analysis focuses solely on layoff costs in isolation from other European labor market policies that might also influence unemployment rates such as minimum wages and generous unemployment compensation.

As pointed out by Lazear (1990), any mandated severance pay can be offset by an efficient labor contract and hence, there would be no real effects. The literature on layoff costs and employment have therefore focused on layoff costs that are not pure transfers between firms and workers but rather some form of resource costs or taxes paid to the government. It has been shown that such layoff costs do have real but ambiguous employment effects in partial equilibrium analyses (see Bentolila and Bertola (1990), and Bertola (1990)). These costs reduce both firms' hiring rates and firing rates. The cyclical implications are therefore fairly clear; layoff costs increase employment in troughs and reduce employment in peaks. But it is unclear what the effects are on the average employment level. Bentolila and Bertola find in their model that layoff costs actually increase average employment since the fact that they prevent layoffs dominates the effect from lower hiring. The question is whether or not this result is born out in a general equilibrium.

Early general equilibrium analyses by Burda (1992), Hopenhayn and Rogerson (1993), and Saint-Paul (1995) conclude that layoff costs affect employment negatively. They reach the same result but in quite different models of employment determination. However, later general equilibrium models by Alvarez and Veracierto (1998), and Mortensen and Pissarides (1999) display positive employment effects of layoff costs. Our paper integrates and explains these disparate results by studying bare-bones models in three dominant frameworks of employment determination; a search model, a matching model and a model with employment lotteries. We conclude that there is a strong presumption why employment implications of layoff costs should be either positive or negative in a particular framework. There is a fundamental economic force at work in each framework which interacts with an essential feature of that class of models. This insight is obscured in the literature because of all the extra features and complications that are added to the models. Though, earlier general-equilibrium analyses of layoff costs do illustrate our finding that the employment implications in a framework are robust and invariant to different specifications of the rest of the model.

To shed light on Hopenhayn and Rogerson's (1993) conclusion that layoff costs significantly reduce equilibrium employment, we abstract from the elaborate firm size dynamics of their model and focus on employment lotteries as the sole important feature of their analysis. Since the private economy perceives layoff costs as equivalent to a less productive technology, these costs induce households to choose a lower probability of working in the lotteries over employment. This substitution between number of employed and unemployed can operate smoothly since the complete-market equilibrium has aggregate consumption sharing that insures individual workers against unemployment. Thus, in models with employment lotteries, negative employment implications of layoff costs are explained by the substitution effect in response to a lower private return to work. In contrast, a standard search model where agents are left to fend for themselves tends to produce the opposite result, i.e., employment increases with higher layoff costs. The explanation is that layoff costs slow down the reallocation of labor, and thereby reduce the rate of frictional unemployment. This effect of labor being "locked into" their current employment drives the lower unemployment rate in Alvarez and Veracierto's (1998) analysis of layoff costs. Their auxiliary assumptions on capital accumulation, risk aversion and incomplete markets are not essential for the employment outcome (but do matter for the welfare implications).

In the case of the matching model, the effects of layoff costs depend upon the specific assumption on how these costs affect the bargaining game between firms and workers. When using Saint-Paul's (1995) assumption that layoff costs increase workers' relative share of the match surplus, the model reproduces his result that layoff costs increase the unemployment rate. The reason is that the equilibrium condition that firms finance vacancy costs and layoff costs with retained earnings from the matches becomes difficult to satisfy when higher layoff costs erode the fraction of match surpluses going to firms. An increase in the equilibrium unemployment rate accomplishes two things; the expected time and cost for firms to fill vacancies are reduced, and workers' bargaining position is weakened because of longer average unemployment spells. In contrast, if layoff costs do not alter the relative split of the match surplus between firms and workers, the employment effect tends to be the same as in the search model where higher layoff costs reduce the rate of unemployment. Once again, the dominating effect is that layoff costs diminish the value of reallocating labor so that job tenures lengthen and unemployment falls.

The last explanation applies also to Mortensen and Pissarides' (1999) matching model with a two-tier wage system such that layoff costs do not affect the relative split of the match surplus when firms bargain with not yet hired workers, while these costs do increase the relative surplus share of hired workers in consecutive renegotiations. We demonstrate that their specification is formally equivalent to our second assumption that the relative split of the match surplus is unaffected throughout the employment relationship. The only difference between the two formulations is that the wage profile in the Mortensen and Pissarides' setting is tantamount to new workers posting a bond equal to their share of any future layoff tax.

A prerequisite for layoff costs to reduce unemployment in the search model and the matching with a constant relative split of the match surplus is that the production technology allows for an endogenous lengthening of job tenures. Burda's (1992) finding that layoff costs unambiguously increase unemployment in a matching model follows from his assumption of an exogenous rate of job destruction. We use such counterexamples with extreme parameterizations to further shed light on the workings of the different models.

The next section describes the production technology and the government's policy of imposing a layoff tax for each job that is destroyed. These assumptions are maintained throughout the paper, and they capture the essential features of the general equilibrium analyses of layoff costs in the literature. Section 3 presents our three different models of employment determination, which are bare-bones versions of the models in the literature in order to highlight their central mechanisms in the most transparent way. Numerical simulations and robustness tests are utilized in Section 4 to study the employment effects of layoff taxes, and Section 5 explains the economic forces at work. After a discussion of welfare implications in Section 6, we offer some concluding comments in the final section.

2. *Technology and Government Policy*

A very simple technology will be useful to bring out the employment implications of layoff costs in different models. An agent is either unemployed in period t, $n_t = 0$, or full-time employed, $n_t = 1$.[1] The productivity of a new job is equal to p^o, and the future productivity level follows a Markov process given by the distribution function $G(p, p') = \text{Prob}(p_{t+1} \leq p' \,|\, p_t = p)$ which is decreasing in p. The job disappears when there is no worker assigned to the job. The productivity level is observed at the beginning of a period before the decision whether or not to retain the job is made.

The government imposes a tax $\tau \geq 0$ for each job that is destroyed. The tax revenues, denoted T per capita, are handed back lump-sum to the agents. By abstracting from distortionary transfer policies and other kind of taxes, we can isolate the employment effects due to layoff costs. These assumptions on government policy and technology capture the essential features of the general equilibrium analyses of layoff costs in the literature.

3. *Alternative Models of Employment Determination*

We consider three alternative models of employment determination; a search model, a matching model and a model with employment lotteries. We study stationary equilibria when each model is populated by a continuum of infinitely lived workers of measure one.

First, in the spirit of McCall (1970), we will assume that workers must search for new jobs. Unemployed workers choose an optimal search intensity, which will influence the average length of unemployment spells. Taking the search costs into account, employed workers will in turn have to decide on an optimal reservation productivity. For realizations of the productivity level greater than or equal to the reservation productivity, they remain on the job, and otherwise they leave to search for another job.

Second, we will examine a matching model along the lines of Diamond (1982), Mortensen (1982) and Pissarides (1985). The number of vacancies and unemployed workers enter as arguments in a matching function to determine the number of successful matches in any

[1] The assumption of only full-time jobs is innocuous in the search model and the matching model, but it is a key element in the model with employment lotteries.

given period. The surplus associated with a match is split between the worker and the firm through Nash bargaining. We will explore the implications of two different bargaining assumptions: a) the worker's relative share of the match surplus stays constant when varying the layoff cost, b) the worker's relative share increases with the layoff cost. In an equilibrium, the number of vacancies is such that the expected discounted profit associated with posting a vacancy is zero.

Third, we will follow the approach taken in Hopenhayn and Rogerson's (1993) analysis of layoff costs, in which variations in the employment level is driven by optimal changes in employment lotteries. In their framework, workers and jobs can be matched without any frictions. But the restriction that all jobs must be full-time is binding and, thus, it is welfare enhancing to introduce employment lotteries as in Hansen (1985) and Rogerson (1988). In each period, agents are assumed to choose a probability of working instead of the number of hours to work. A lottery then determines which agents actually work. The choice of probabilities and the outcome of the lottery are assumed to be public information, so that insurance markets are fully operational for the idiosyncratic risk associated with the lottery. Firms create new jobs as long as the expected discounted profits are nonnegative.

3.1 Search model

An unemployed worker chooses a search intensity $s \geq 0$ at a disutility of $\gamma(s)$ which is increasing in s. With probability $\pi(s)$, the unemployed worker finds a new job at the beginning of next period. We assume that $\pi(s) \in [0, 1]$, and that it is increasing in s. The agents are assumed to be risk neutral with preferences given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \Big[c_t - A_s n_t - \gamma(s_t) \Big] , \qquad (1)$$

where E_0 is the expectation operator conditional upon information at time 0 and $\beta \in (0, 1)$ is a discount factor. The agent's consumption and employment in period t are denoted $c_t \geq 0$ and $n_t \in \{0, 1\}$, respectively. An agent suffers disutility $A_s > 0$ when working.

Under the assumption of risk neutrality, each worker can be treated as self-employed and liable for any layoff tax. Let $V(p)$ be the value of the optimization problem for an employed worker with productivity p at the beginning of a period. The value associated with being unemployed is V_u. Bellman's equations can then be written as follows.

$$V(p) \;=\; \max_{\text{work, layoff}} \left\{ p \,-\, A_s \,+\, T \,+\, \beta \int V(p')\, dG(p,p')\;,\;\; V_u - \tau \right\}, \tag{2}$$

$$V_u \;=\; \max_{s} \left\{ -\gamma(s) \,+\, T \,+\, \beta \Big[(1 - \pi(s))\, V_u \,+\, \pi(s) V(p^o) \Big] \right\}. \tag{3}$$

Associated with the solution of equations (2) and (3) will be two numbers $(\bar{s}, \bar{p})$ giving an optimal search intensity of an unemployed worker and a reservation productivity of an employed worker.

Given this formulation with self-employed workers and no other assets in the economy, the expected life-time utility of an employed worker with productivity p is given by $V(p)$, and the welfare of an unemployed worker is equal to V_u.[2]

3.2 Matching model

The preference specification for the matching model is the same as for the search model except that we drop the disutility of searching,

$$E_0 \sum_{t=0}^{\infty} \beta^t \Big[c_t \,-\, A_m n_t \Big]\,. \tag{4}$$

The cost of posting a vacancy is κ per period. The number of successful matches is given by a linearly homogeneous matching function $M(u, v)$, where u and v are the measures of unemployed workers and vacancies, respectively.

[2] The aggregate implications of the model would be the same, if we instead let financial intermediaries offer the following insurance contracts to job finders under the assumption of *full commitment*. A contract indexed by (p, w) specifies that the intermediary receives the output of the job and pays w to the worker as long as the productivity is equal to or greater than p. When the productivity falls below p, the contract expires with the intermediary liable for the layoff tax. In a competitive equilibrium with free entry of intermediaries, there will be a unique contract $(\bar{p}, \bar{w})$ traded where $\bar{p}$ is the same as the reservation productivity under self employment, and $\bar{w}$ is such that the expected present value of an intermediary's profits is zero. That is, both job finders and intermediaries will be indifferent to entering into the contract; job finders attain the same expected utility as under self employment and intermediaries just break even. The equilibrium contract is sustainable since the intermediary and the worker will never mutually agree to renegotiate a signed contract. Not surprisingly, introducing insurance contracts in an economy with risk-neutral agents cannot essentially change things.

Let $Z(p)$ be the match surplus associated with a productivity level p, i.e., the expected discounted value of the match in excess of the worker's outside option Z_u. For a given Z_u, the Bellman's equation can be written as[3]

$$Z(p) + Z_u = \max_{\text{work, layoff}} \left\{ p - A_m + \beta \int [Z(p') + Z_u] \, dG(p,p') \, , \; Z_u - \tau \right\} . \tag{5}$$

Associated with the solution of equation (5) is a number $\bar{p}$ giving a reservation productivity of a match.

A standard approach in the matching literature is to assume that the match surplus is split between the worker and the firm through Nash bargaining. Let $F(p)$ and $W(p)$ denote the firm's and the worker's expected discounted value in a match with productivity level p, where $W(p)$ includes the worker's continuation value Z_u. That is, the following identity holds

$$Z(p) = F(p) + W(p) - Z_u \, . \tag{6}$$

The firm's and the worker's shares of the match surplus are then set so as to maximize a Nash product. Here we will explore the implications of two alternative specifications of the Nash product:

$$\big(W(p) - Z_u\big)^{\delta} F(p)^{1-\delta} \, , \tag{7.a}$$

$$\big(W(p) - Z_u\big)^{\delta} \big(F(p) + \tau\big)^{1-\delta} \, . \tag{7.b}$$

Specification (7.a) leads to the usual result that the worker receives a fraction δ of the match surplus, while the firm gets the remaining fraction $(1-\delta)$;

$$W(p) - Z_u = \delta Z(p) \qquad \text{and} \qquad F(p) = (1-\delta) Z(p) \, . \tag{8.a}$$

The alternative specification (7.b) adopts the assumption of Saint-Paul (1995) that the layoff cost changes the firm's threat point from 0 to $-\tau$, and thereby increases the worker's relative share of the match surplus. Solving for the sharing rules yields:

$$W(p) - Z_u = \delta\big(Z(p) + \tau\big) \qquad \text{and} \qquad F(p) = (1-\delta) Z(p) - \delta\tau \, . \tag{8.b}$$

[3] Note that the expression does not include any earnings of the worker which are independent of the match such as the lump-sum transfer from the government, T, and any asset earnings.

Mortensen and Pissarides (1999) propose still another bargaining specification where (7.a) is the Nash product when a worker and a firm meet for the first time, while the Nash product in (7.b) characterizes all their consecutive renegotiations. The idea is that the firm will not incur any layoff tax if the firm and worker do not agree upon a wage in the first encounter because there is never an employment relationship. In contrast, the firm's threat point is weakened in future negotiations with an already employed worker since the firm would then have to pay a layoff tax if the match is broken up. Except for the wage profile, the appendix demonstrates that this alternative specification is equivalent to just assuming (7.a) for all periods. The intuition is that the modified wage profile under the Mortensen and Pissarides' assumption is tantamount to a new hire posting a bond equal to his share of the future layoff tax. It is therefore sufficient to here focus on the first two bargaining specifications.

The worker's continuation value outside of the match, Z_u, is the expected discounted value of an unemployed worker, which in turn depends on the bargaining game between workers and firms. The two alternative expressions for Z_u associated with Nash product (7.a) and (7.b), respectively, are

$$Z_u \;=\; \beta\left[\frac{M(u,v)}{u}\delta\, Z(p^o) \;+\; Z_u\right], \tag{9.a}$$

$$Z_u \;=\; \beta\left[\frac{M(u,v)}{u}\delta\;[Z(p^o)+\tau] \;+\; Z_u\right]. \tag{9.b}$$

The expressions capture the two possible outcomes in the next period; the unemployed worker either finds a job or continues to look for one. The remaining equilibrium condition that firms post vacancies until the expected profits are driven down to zero can be expressed as follows for Nash products (7.a) and (7.b), respectively,

$$\beta\,\frac{M(u,v)}{v}(1-\delta)\,Z(p^o) \;=\; \kappa\,, \tag{10.a}$$

$$\beta\,\frac{M(u,v)}{v}\Big[(1-\delta)\,Z(p^o) \;-\; \delta\tau\Big] \;=\; \kappa\,. \tag{10.b}$$

In order to do welfare calculations in the matching model, we need to compute profit flows from firms. In a stationary equilibrium, let $H(p)$ be the fraction of all filled jobs with a productivity less than or equal to p. Since $\bar{p}$ is the reservation productivity, we have $H(\bar{p}) = 0$. A job with productivity p generates a current profit of $p - w(p)$ where $w(p)$ is the wage rate determined in the described Nash bargaining. The profit can then be deduced from the equilibrium function for the firm's share of the match surplus,

$$p - w(p) \;=\; F(p) - \beta \int F(p')\, dG(p, p')\,. \tag{11}$$

Among all jobs with a current productivity of p, there will be a fraction $G(p, \bar{p})$ that shuts down next period with a layoff tax of τ per destroyed job. The firm is solely liable for the layoff tax under Nash product (7.b) but it only pays a share $1 - \delta$ under Nash product (7.a). Firms posting vacancies generate a profit of $-\kappa$ per vacancy and period. In all, the aggregate profits from firms in any given period are as follows for Nash products (7.a) and (7.b), respectively,

$$\Pi \;=\; (1-u) \int \left[p \,-\, w(p) \,-\, (1-\delta)\tau G(p,\bar{p})\right] dH(p) \;-\; \kappa\, v\,, \tag{12.a}$$

$$\Pi \;=\; (1-u) \int \left[p \,-\, w(p) \,-\, \tau G(p,\bar{p})\right] dH(p) \;-\; \kappa\, v\,, \tag{12.b}$$

where $(1-u)$ and v are the equilibrium measures of filled jobs and vacancies.

A stationary equilibrium is consistent with any arbitrary distribution of firm ownership among the workers. The asset value of each firm is such that its expected gross rate of return is equal to $1/\beta$, and the economy's aggregate assets generate the same but deterministic rate of return. Let us here assume that all workers own identical shares of the economy's total assets. The expected life-time utility of an employed worker with productivity p is then given by

$$W(p) + \frac{\Pi + T}{1 - \beta}\,,$$

where the lump-sum transfer from the government, T, is just equal to the per capita value of all paid layoff taxes. By replacing $W(p)$ by Z_u, the expression shows the welfare of an unemployed worker.

3.3 Model with employment lotteries

The linear preferences in the two previous models do not leave any room for welfare-improving employment lotteries. We therefore introduce curvature on the consumption term. As in Hopenhayn and Rogerson (1993), we postulate the following preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t \Big[u(c_t) \, - \, v(n_t) \Big] ,$$

where $v(0) = 0$ and $v(1) = A_l$. All agents are identical and have access to markets to insure against the idiosyncratic risk associated with employment lotteries. This implies that the economy behaves as though there were a representative agent with preferences defined by

$$E_0 \sum_{t=0}^{\infty} \beta^t \Big[u(c_t) \, - \, A_l N_t \Big] , \tag{13}$$

where N_t is the fraction of agents who are working in period t.

Firms and workers meet without any frictions in a Walrasian labor market. In a stationary equilibrium with the gross interest rate equal to $1/\beta$, the equilibrium wage rate is determined from the demand side for labor as follows. Consider a firm that maximizes expected discounted profits and takes the wage w as given. Let $X(p; w)$ be the firm's value of a job with productivity p. The Bellman's equation can then be written as

$$X(p; w) \; = \; \max_{\text{work, layoff}} \Big\{ p \, - \, w \, + \, \beta \int X(p'; w) \, dG(p, p') \; , \; -\tau \Big\} . \tag{14}$$

Associated with the solution of equation (14) is a reservation productivity $\bar{p}$. The equilibrium wage w^* must be such that expected profits associated with new jobs are zero, i.e., $X(p^o; w^*) = 0$.

As noted by Hopenhayn and Rogerson (1993), another implication of a stationary equilibrium is that the representative agent's optimization problem reduces to a static problem of the form,

$$\max_{N} \; u(c) \, - \, A_l N \qquad \text{subject to } c \, \leq \, w^* N \, + \, \Pi \, + \, T \, , \tag{15}$$

where the profits from firms, Π, and the lump-sum transfer from the government, T, are taken as given by the agents. In a stationary equilibrium with (w^*, N^*), we have

$$\Pi \, + \, T \; = \; N^* \int [p \, - \, w^*] \; dH(p) \, ,$$

where $H(p)$ is once again the fraction of all jobs in a stationary equilibrium with a productivity less than or equal to p. Since all agents are identical including their asset holdings, the expected life-time utility of an agent before seeing the outcome of the employment lottery is equal to

$$\sum_{t=0}^{\infty} \beta^t \left[u \left(N^* \int p \, dH(p) \right) - A_l N^* \right] .$$

4. *Numerical Examples*

4.1 Calibration

The model period is chosen to be two weeks. We set the discount factor $\beta = 0.9985$, making the annual interest rate 4.0 percent. Productivity levels are confined to the unit interval (with a grid size of 500 points), and the productivity of a new job is $p^o = 0.75$. The Markov process for the future productivity level is constructed as follows. With probability 0.96, the productivity will be the same as in the previous period, and, with probability 0.04, the productivity is drawn from a distribution $\tilde{G}(p, p')$. That is, the worker will on average draw a new productivity level once a year. The distribution function $\tilde{G}(p, p')$ for the new productivity level p' is given by a normal distribution with a mean equal to the previous productivity level p and a variance of 0.01, which is truncated to the unit interval and normalized to integrate to one.

Additional parameter values for the search model are as follows. The disutility from searching and the function mapping search intensities into probabilities of obtaining a wage offer are assumed to be

$$\gamma(s) = \gamma_0 \, s = 0.5 \, s \, ,$$
$$\pi(s) = \pi_0 \, s^{\pi_1} = 0.2 \, s^{0.3} \, , \qquad \text{where } s \in [0, 1] \, ,$$

with a grid size of 1000 points for the search intensity s. These parameter values are the same as in Ljungqvist and Sargent (1998), except that we have multiplicatively scaled down the probability of finding a job to offset the present assumption that all new jobs offer wage p^o which will always be acceptable in an equilibrium with production. The disutility from work, A_s, is set equal to 0.5.

In the matching model, we keep the same parameter value of the disutility from work, $A_m = 0.5$. The cost per period of posting a vacancy is $\kappa = 0.2$, and the matching function is assumed to be

$$M(u, v) \;=\; \phi\, u^{\alpha}\, v^{1-\alpha} \;=\; 0.1\, u^{0.5}\, v^{0.5}\,.$$

The Cobb-Douglas form and a match elasticity with respect to unemployment, α, of around 0.5 are common in the matching literature, and so is our next assumption that the worker's bargaining strength, δ, is equal to α.[4] (See e.g. Pissarides and Mortensen, 1999.)

Following Hopenhayn and Rogerson (1993), the preference specification in the model with employment lotteries is $u(c) = \log(c)$ and the disutility of work is calibrated to match an employment to population ratio equal to 0.6 which leads us to choose $A_l = 1.6$.

The simulations based on these parameter values are followed by a sensitivity analysis. The qualitative results are then found to be robust to perturbations of plus and minus 50 percent in all dimensions of the benchmark parameterization.

4.2 Simulation results

We compute stationary equilibria for different values of the layoff cost, $\tau \in [0, 30]$. As a point of reference, $\tau = 20$ corresponds to a layoff cost roughly equal to one year of an average worker's output. In each figure, there are curves referring to the search model ('S'), the model with employment lotteries ('L'), and the two versions of the matching model where the workers' relative share of the match surplus is either constant ('Ma') or positively related to the layoff cost ('Mb').

Figures 1 through 5 display a number of similarities across the different frameworks. A higher layoff cost is associated with a lower reservation productivity in figure 1. That is, firms choose to retain workers with lower productivity when it becomes more costly to lay them off and, hence, the average output per employed worker decreases in figure 2.

[4] In the case of no layoff costs, Hosios (1989) shows that the matching process is efficient when the workers' share of the match surplus, δ, and the match elasticity with respect to unemployment, α, are equal.

Another consequence of a lower reservation productivity is fewer layoffs as a fraction of employment as shown in figure 3 but, according to figure 4, total layoff costs as a fraction of GNP is still increasing in the layoff cost. Figure 5 reveals changing fortunes for the unemployed. A higher layoff cost reduces the probability of finding a job. This maps directly into a lower probability of working in the model with employment lotteries, while the same aspect manifests itself in the search model and the matching model as a lower probability of finding a job within, let say, 10 weeks of unemployment. Note especially the sharply declining probability in the matching model where the worker's relative share of the match surplus is positively related to the layoff tax.

In contrast to these qualitative similarities across frameworks, a stark difference appears in figure 6. Employment increases with higher layoff costs in the search model and the matching model with a constant relative split of the match surplus, while the opposite is true in the two other models. We next demonstrate that these employment effects are robust to large perturbations in parameter values, before turning to a discussion of the economic forces at work.

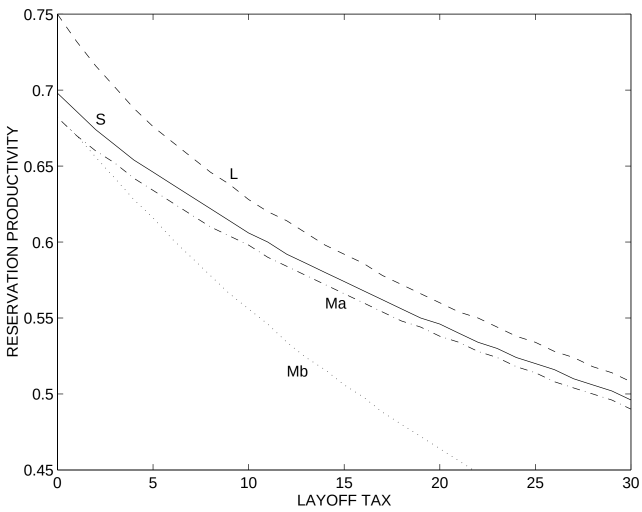

Figure 1. Reservation productivity for different values of the layoff tax.

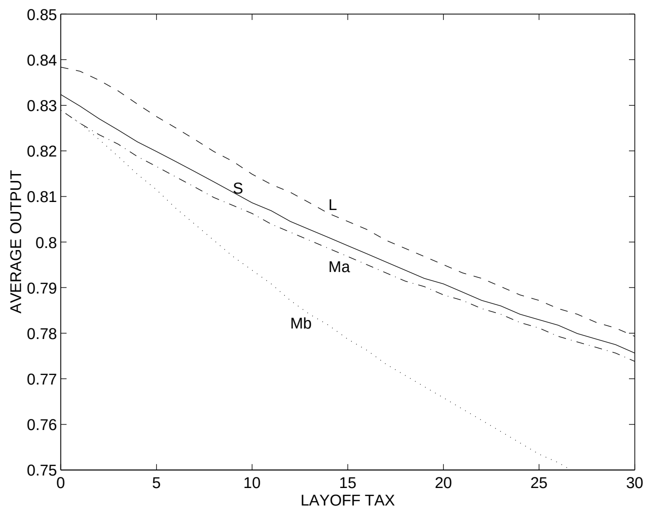

Figure 2. Average output per employed worker for different values of the layoff tax.

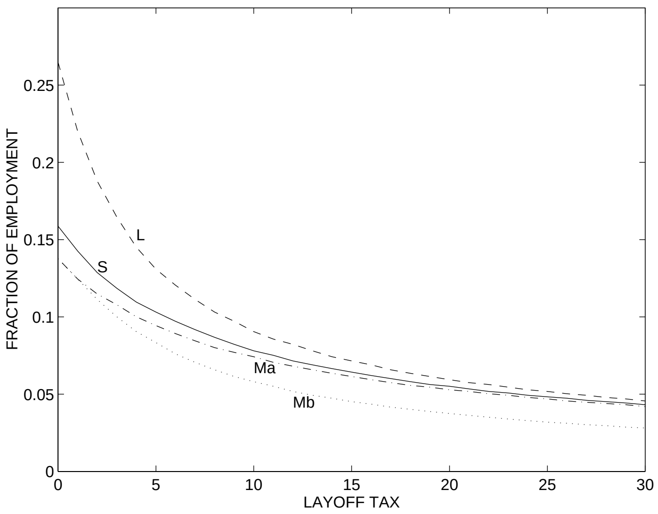

Figure 3. Annual layoffs as a fraction of employment for different values of the layoff tax.

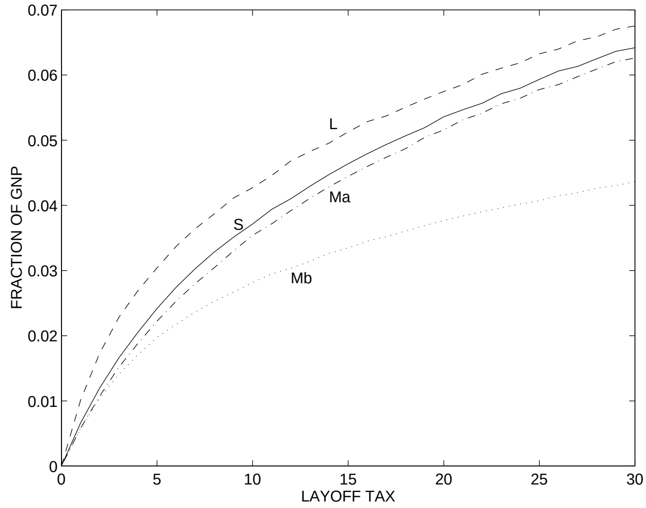

Figure 4. Layoff costs as a fraction of GNP for different values of the layoff tax.

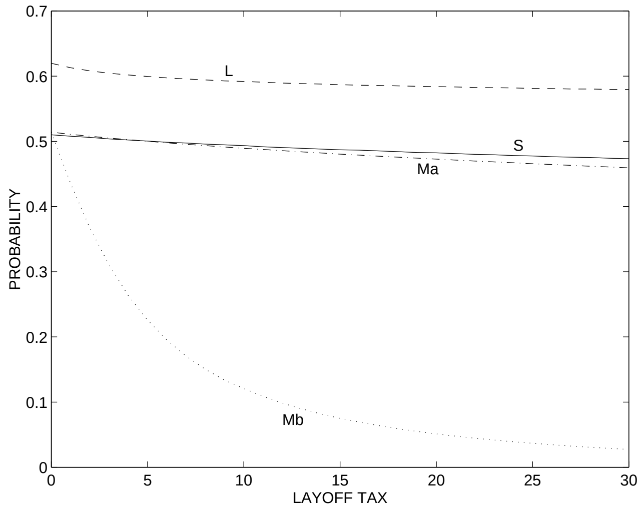

Figure 5. Probability of working in the model with employment lotteries and probability of finding a job within 10 weeks in the search model and the matching models, for different values of the layoff tax.

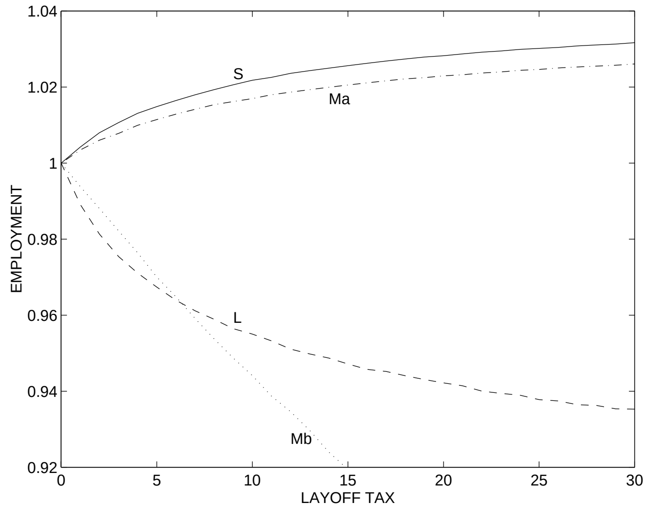

Figure 6. Employment index for different values of the layoff tax. The index is equal to one at a zero layoff tax.

4.3 Sensitivity Analysis

To examine the sensitivity of the results to changes in the parameterization of the models, we have analyzed deviations of plus and minus 50 percent in all parameter values or, in some cases, deviations of plus and minus 50 percent in the relevant economic measures implied by the parameters. An example of the latter is the discount factor β which is chosen to be 0.9985 in the baseline case, making the annual interest rate 4.0 percent. We analyze deviations in β such that the annual interest rate is either 2.0 or 6.0 percent. In each sensitivity test of any one parameter, all other parameters are kept at their values in the benchmark calibration of section 4.1.

Besides the discount factor, other parameters common to all models are varied as follows. The probability of drawing a new productivity level at work in the benchmark parameterization is such that a worker will on average draw a new productivity once a year. We examine deviations in this probability so that the average time between productivity draws is 0.5 or 1.5 years. The variance of the conditional distribution of new productivity levels is also decreased and increased by 50 percent relative to its benchmark value of 0.01.

Concerning the search model, we study deviations of plus and minus 50 percent in each parameter of the functions mapping search intensities into disutility of search and probabilities of obtaining a wage offer; $\{\gamma_0, \pi_0, \pi_1\}$. The remaining parameter in the search model is the disutility of work A_s which is equal to 0.5 in the benchmark case. We do examine a 50 percent reduction in this parameter but we only allow for an upper parameter value of 0.6 since a full 50 percent increase makes the disutility of work equal to the productivity of a new job which turns out to close down all economic activity. Except for this caveat which also applies to the matching framework, we analyze deviations of plus and minus 50 percent in all other parameters specific to the matching model, i.e., the cost of posting a vacancy and the parameters in the matching function and the Nash product; $\{\kappa, \phi, \alpha, \delta\}$.

Because of the recursive nature of the employment lottery model where the reservation productivity is computed before calculating the employment to population ratio, it turns out that the parameter value of the disutility of working does not affect the *relative* change in employment in response to a change in the layoff tax. But we do perform a sensitivity analysis with respect to the coefficient of relative risk aversion in consumption which is unity in the benchmark case of logarithmic utility. We examine a 50 percent increase and decrease in that coefficient for the utility function $u(c) = (c^{1-\eta} - 1)/(1-\eta)$.

The results of the sensitivity analysis are reported in figures 7 through 10. The layoff tax takes on three values, $\tau \in \{0, 10, 20\}$. Recall that $\tau = 10$ and $\tau = 20$ correspond roughly to half a year and one year of an average worker's output, respectively, in the benchmark calibration. Of course, this approximation may no longer hold for some of our sensitivity tests which all involve large perturbations in parameters. Each employment index is normalized to unity at a zero layoff tax for the particular parameterization considered. The solid line in a figure reproduces the benchmark result from figure 6 but here only for three values of the layoff tax.

Figures 7 through 10 show robustness of our earlier findings that a layoff tax is associated with higher employment in the search model and the matching model with a constant relative split of the match surplus, and lower employment in the other two models. To get a feel for the sensitivity analysis let us comment on a couple of outliers in the figures. The upper curve in figure 7 is obtained when picking a higher probability of drawing a new productivity level at work so that the average time between draws is cut by 50 percent to just half a year. At a zero layoff tax, this choice of parameter value yields the highest unemployment rate in the search model among all its parameterizations. This is because the frequent arrivals of new productivity levels spur a large amount of reallocation. This frictional unemployment is then found to fall relatively sharply when increasing the layoff tax, producing large increases in the employment index. The same argument is true for the matching model with a constant relative split of the match surplus where this parameter perturbation corresponds to one of the two highest curves in figure 8. Concerning the upper and the lower curve for the employment lottery model in figure 10, these are obtained when setting the coefficient of relative risk aversion equal to 1.5 and 0.5, relatively. A low risk aversion implies here also a higher willingness to substitute leisure for consumption which explains why employment plummets in response to a layoff tax that reduces the attractiveness of working.

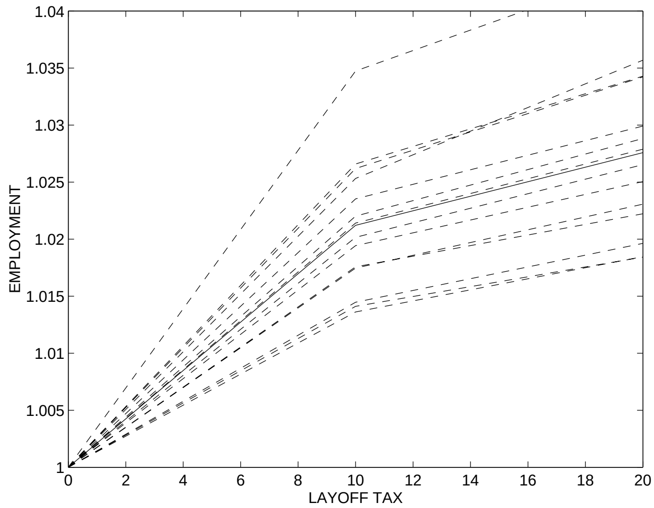

Figure 7. Sensitivity analysis of the employment index in the search model. The solid line is the benchmark parameterization. The layoff tax takes on three values, $\tau \in \{0, 10, 20\}$.

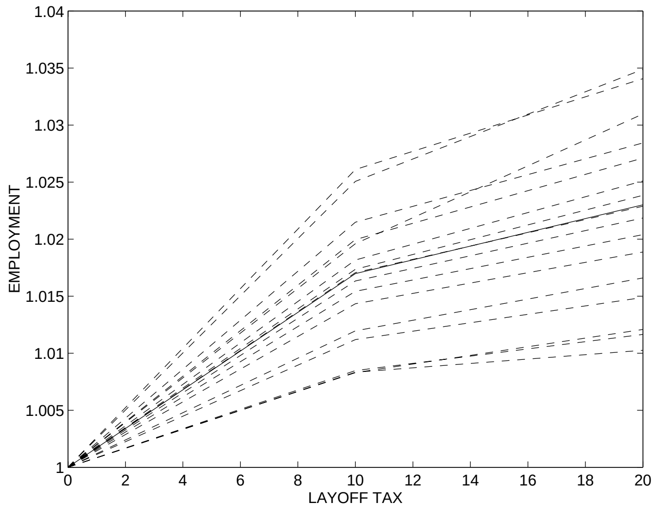

Figure 8. Sensitivity analysis of the employment index in the matching model with a constant relative split of the match surplus. The solid line is the benchmark parameterization. The layoff tax takes on three values, $\tau \in \{0, 10, 20\}$.

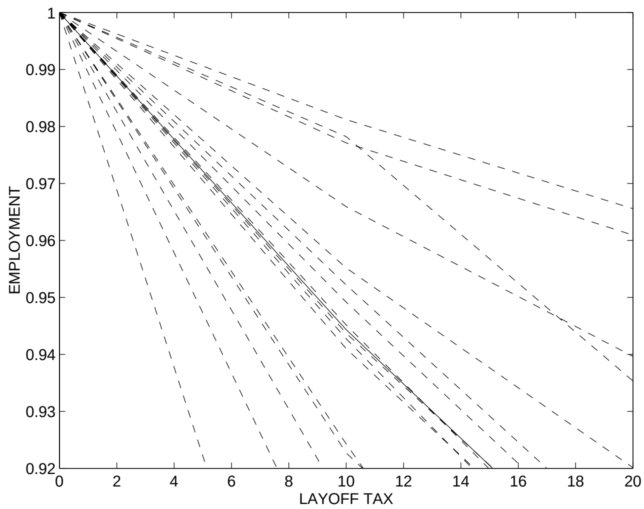

Figure 9. Sensitivity analysis of the employment index in the matching model when workers' relative share of the match surplus increases with the layoff tax. The solid line is the benchmark parameterization. The layoff tax takes on three values, $\tau \in \{0, 10, 20\}$.

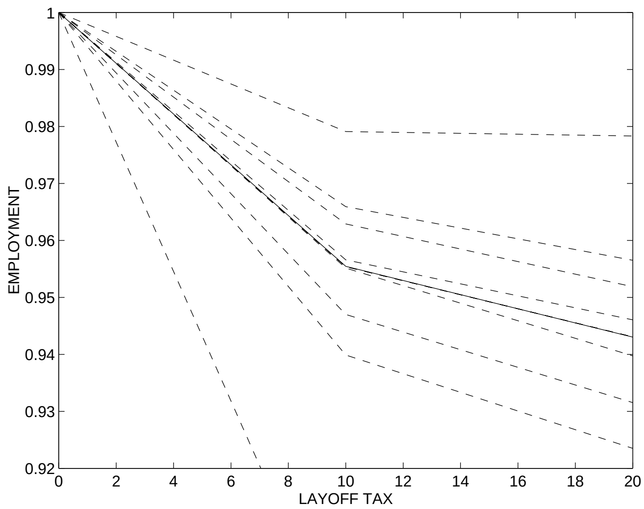

Figure 10. Sensitivity analysis of the employment index in the employment lottery model. The solid line is the benchmark parameterization. The layoff tax takes on three values, $\tau \in \{0, 10, 20\}$.

5. *Economic Forces at Work*

5.1 Search model

The intuition for lower unemployment in the search model is quite straightforward. Layoff costs make it more costly to reallocate labor in response to productivity shocks. Fewer reallocations in the economy translates into less frictional unemployment and workers are "locked into" their jobs. Lower unemployment is thus attained at the cost of a less efficient labor allocation. The common argument that layoff costs will reduce the number of jobs in the economy does not apply for the following reason. Jobs are available in the search model as long as the unemployed have "reasonable" demands for compensation. Layoff costs will naturally reduce labor's earnings because of not only the layoff costs incurred in the production process but also the lower productivity associated with a less efficient labor allocation. However, workers who do accept necessary cuts in compensation will be working in the search model and they will on average enjoy longer job tenures as compared to an economy without layoff costs.

There is one qualification to the above description of the economic forces at work in the search model. The presence of layoff costs makes jobs less attractive, thus, the potential return to job search falls. This lower return causes unemployed workers to invest less in job search, i.e., they choose a lower search intensity. The reduced search intensity is reflected in figure 5 in form of a lower probability of finding a job within 10 weeks.[5] If we fix the length of job tenures in the model, a lower search intensity would necessarily increase the economy's unemployment rate. As an illustration, consider the following alternative parameterization with two possible values of the productivity level on the job,

$$p = \begin{pmatrix} 0 \\ .75 \end{pmatrix} \qquad \text{and} \qquad \pi(p, p') = \begin{pmatrix} 1 & 0 \\ .005 & .995 \end{pmatrix}, \tag{16}$$

where the transition probabilities, $\pi(p, p')$, are chosen so that the equilibrium level of unemployment without layoff costs is roughly the same as in Section 4. The parameterization has the implication that all jobs in an equilibrium are exogenously destroyed at

[5] There would be still other effects on the probability of finding a job if we had assumed that unemployed workers draw a productivity from a distribution of productivities rather than one single possible value, p^o.

the rate .005, i.e., layoff costs cannot affect the length of job tenures. As a consequence, figure 11 shows how higher layoff costs which reduce workers' search intensity must necessarily increase unemployment. In the more general case, the final effect upon equilibrium unemployment depends on the relative importance of less diligent job search versus longer job tenures.

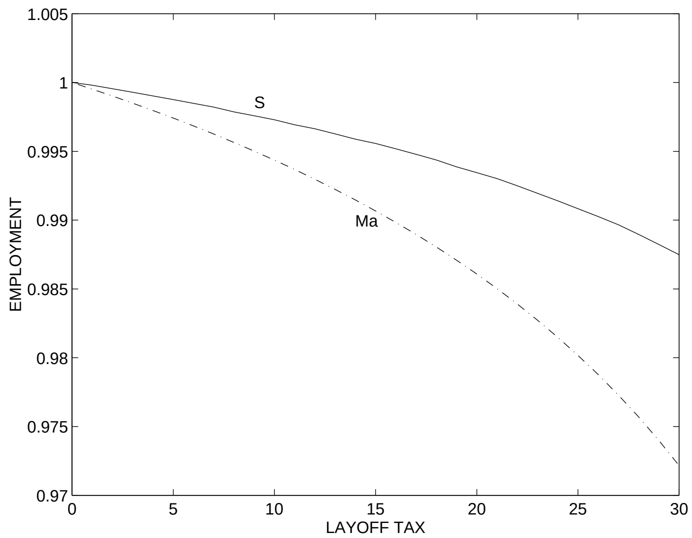

Figure 11. Employment index for different values of the layoff tax. The index is equal to one at a zero layoff tax. The parameterization is modified according to (16).

5.2 Matching model

Unemployment is also lower with layoff costs in the matching model with a constant relative split of the match surplus, as shown in figure 6. The explanation is once again that the costly reallocation of labor results in longer job tenures and lower frictional unemployment. But as before there exists an opposing effect that would necessarily increase the unemployment rate if the length of job tenures was exogenously given in our model. This time the opposing effect is not workers' search intensity falling in response to less attractive jobs but rather the impact of layoff costs on firms' ability to recover incurred vacancy costs. It is instructive to examine the break-even condition for new vacancies in (10.a). The left-hand side of (10.a) is the expected gain of posting a vacancy which is negatively affected by a higher layoff cost. In an equilibrium, the expected gain must be restored and be equal to the cost of posting a vacancy, κ. Market forces can attain this outcome in two ways; 1) a longer average job tenure (through a lower reservation productivity on the job) means that the expected discounted stream of surpluses from a consummated match, $Z(p^o)$, becomes larger; 2) a higher unemployment to vacancy ratio maps into a higher probability of filling a vacancy, $M(u, v)/v$, which also increases the expected gain of posting a vacancy. While longer job tenures tend to decrease unemployment, a higher probability of filling a vacancy (a higher unemployment to vacancy ratio) may be associated with a higher *absolute* level of unemployment. In the special case when the length of job tenures is exogenously given, higher layoff costs will unambiguously raise both the unemployment to vacancy ratio and the level of unemployment, as shown by Burda (1992). Our matching model with the parameterization in (16) inherits those same properties, and the employment effects are depicted in figure 11.

The alternative specification of the matching model where workers' relative share of the match surplus increases with the layoff cost has dramatically different employment implications. Employment in figure 6 is seen to plummet in response to higher layoff costs. The equilibrium condition that firms finance incurred vacancy costs with retained earnings from the matches becomes exceedingly difficult to satisfy when a higher layoff cost erodes the fraction of match surpluses going to firms. Firms can only break even if the expected time to fill a vacancy is cut dramatically, i.e., there has to be a large number of unemployed workers for each posted vacancy. This equilibrium outcome is reflected in the very low probability of a worker finding a job within 10 weeks in figure 5.[6]

But there is also a qualification to the economic forces at work in the matching model where workers' relative share of the match surplus increases with the layoff cost. The model has the same opposing effects on the equilibrium unemployment rate as in the matching model with a constant relative split of the match surplus. We can therefore find

[6] It is worth noting that every worker faces the same probability of finding a job regardless of past experience including the length of the current unemployment spell. The model assumes that all the unemployed serve as a reserve of workers capable and willing to fill posted vacancies.

a parameterization for which higher layoff costs can actually reduce the unemployment rate due to an endogenous large increase in the length of job tenures that outweighs the decline in the firms' share of the match surplus. Such an example is as follows,

$$p = \begin{pmatrix} 0 \\ .70 \\ .75 \end{pmatrix} \qquad \text{and} \qquad \pi(p, p') = \begin{pmatrix} 1 & 0 & 0 \\ .0005 & .9995 & 0 \\ 0 & .005 & .995 \end{pmatrix}. \tag{17}$$

Parameterization (17) is similar to (16), we have just included an additional intermediate state with $p = .70$. It turns out that the economy will not operate at this productivity level when there are no layoff costs, so the rate of job destruction will then be .005. However, if the layoff cost reaches a critical value of 3, the economy's reservation productivity drops down to .70 and figure 12 displays a sharp increase in employment. The fact that firms are now retaining workers with productivity .70 means that the job destruction rate has fallen by a factor of 10 from .005 to .0005.

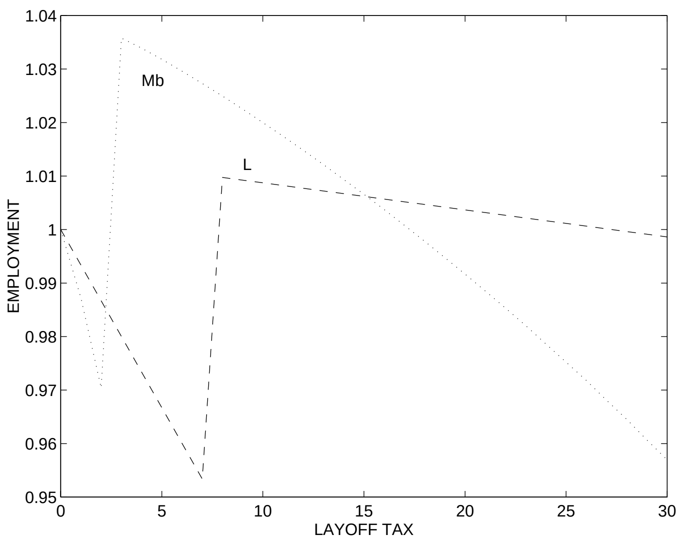

Figure 12. Employment index for different values of the layoff tax. The index is equal to one at a zero layoff tax. The parameterization is modified according to (17).

5.3 Model with employment lotteries

As in Hopenhayn and Rogerson (1993), the model with employment lotteries delivers the result that employment decreases with a higher layoff cost. In general, a higher layoff cost is synonymous from a private perspective to a deterioration in the production technology, the optimal change in the workers' employment lotteries will therefore depend on the strength of the substitution effect versus the income effect. Loosely speaking, the first-order impact of the income effect is eliminated by the government lump-sum transfer of the layoff tax revenues back to the private economy. Thus, layoff costs in models with employment lotteries have strong negative employment implications caused by substitution away from consumption toward leisure.

In the special case of logarithmic preferences used by Hopenhayn and Rogerson, the optimal choice of employment in (15) is given by

$$N^* = \frac{1}{A_l} - \frac{T + \Pi}{w^*}.$$

The precise employment effect is here driven by profit flows from firms gross of layoff taxes expressed in terms of the wage rate. Since these profits are to a large extent generated in order to pay for firms' future layoff taxes, a higher layoff tax tends to increase the accumulation of such funds with a corresponding negative effect on the optimal choice of employment. However, it is conceivable that the peculiar parameterization in (17) might overturn the monotonicity of profit flows when the reservation productivity suddenly falls from 0.75 to 0.70 with a dramatic reduction in the layoff incidence by a factor of 10. This conjecture is confirmed in figure 12 where employment increases when moving from a layoff tax of 7 to 8.

To summarize, it takes fairly extreme parameterizations to overturn the negative employment implications of layoff taxes in models with employment lotteries. The first-order effect in these models is that agents substitute away from consumption toward leisure by reducing the probability of working in the lotteries.

6. *Welfare Implications*

The equilibria without layoff taxes are Pareto optimal in the models of this paper. This can be seen by considering the issues of externalities and missing markets. First, there are no externalities in the search model or the model with employment lotteries, and we have assumed that the parameter restriction for efficiency holds in the matching model (see footnote 4). Second, markets are complete in the model with employment lotteries, and the assumption of risk-neutral workers in the search model and the matching model makes the absence of insurance markets in those models unimportant. Thus, the fact that the laissez-faire outcomes are Pareto optimal implies that the imposition of layoff taxes cannot lead to any Pareto improvements but instead, these taxes reduce welfare by distorting firms' and workers' behavior. Note that the welfare losses are solely due to adverse incentive effects since there are no real resources consumed in the collection of layoff taxes or in the lump-sum transfer of tax revenues back to the private economy.

The negative relationship between layoff taxes and the reservation productivity in Figure 1 is symptomatic of the welfare losses associated with layoff taxes. Since the laissez-faire outcomes are first best, it is suboptimal to have workers employed in jobs with productivities below the reservation productivity at a zero layoff tax. To quantify the welfare losses of the inefficient labor allocation and other adverse effects of layoff taxes, we compute the amount of consumption per period that would have to be confiscated from a worker in the laissez-faire economy to make him as worse off as if he were living in an equilibrium with layoff taxes. These consumption equivalences are expressed as a fraction of per-capita laissez-faire consumption. Because of the absence of insurance markets in the search model and the matching model, there will be one measure for each possible state of a worker, i.e., unemployed versus employed, and the productivity of any current job. Instead of computing a weighted welfare measure across agents in different states, we find it instructive to examine the welfare of an employed and an unemployed worker separately. Concerning the former state, we choose a worker who has just find a job. (Recall our assumption that all new jobs have productivity p^o.)

Using the benchmark parameterization in Section 4, figures 13 and 14 depict the welfare losses of layoff taxes experienced by a job finder and an unemployed worker, respectively.

As a comparison, when Hopenhayn and Rogerson (1993) calibrated their employment-lottery model allowing for elaborate firm-size dynamics, they found welfare losses in the order of 1.3% (2.8%) at a layoff tax equal to 6 months (12 months) of wages. Since that kind of layoff tax correspond to $\tau = 10$ ($\tau = 20$) in our calibration, we see that similar welfare losses arise in two of our bare-bones models and the other two, including the model with employment lotteries, are associated with even larger losses. We conclude, in agreement with Hopenhayn and Rogerson, that the welfare losses arising from layoff taxes can be quite substantial, and we add that this finding seems to hold across different frameworks of employment determination.

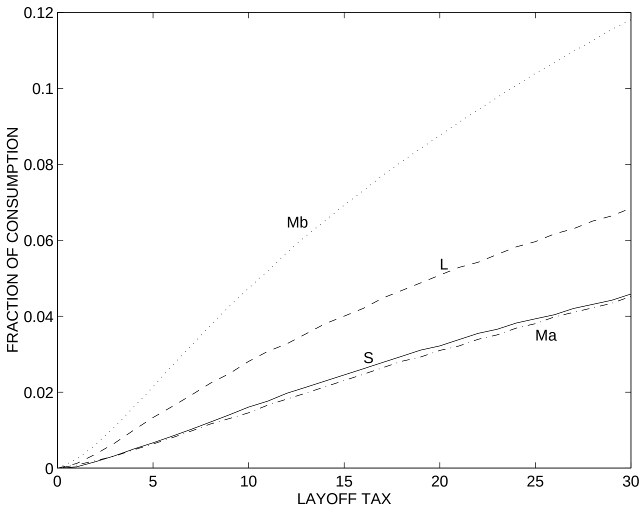

Figure 13. A job finder's welfare loss due to the presence of a layoff tax, computed as a fraction of per capita consumption at a zero layoff tax.

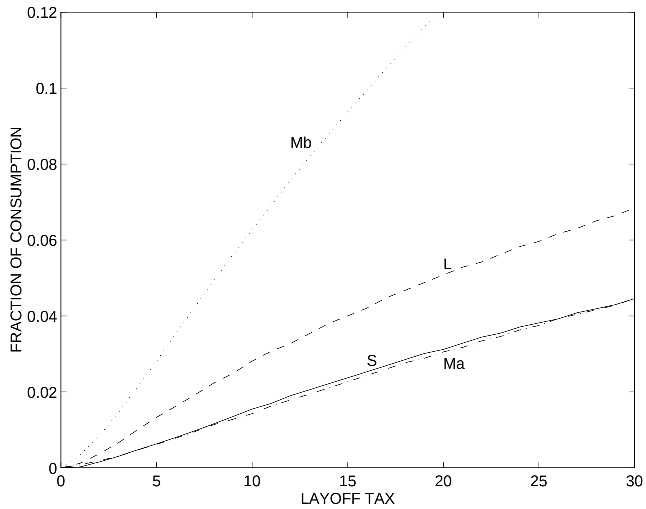

Figure 14. An unemployed worker's welfare loss due to the presence of a layoff tax, computed as a fraction of per capita consumption at a zero layoff tax.

A comparison of figures 13 and 14 shows that the welfare losses of a job finder and an unemployed worker are rather similar except for one of our models. Similar welfare losses in the model with employment lotteries is hardly surprising since the only difference between an employed worker and an unemployed worker is the current period's work effort. Next period, they will be *ex ante* identical and participate in the same employment lottery. In the search model and the matching models, there is no aggregate consumption sharing and an unemployed worker's welfare depends crucially on the probability of finding a job. From figure 5, we know that this probability falls sharply in response to a higher layoff tax in the matching model where workers' relative share of the match surplus is positively related to the layoff tax. This explains why the welfare loss of an unemployed worker as compared to a job finder is so much larger in that model.

As described, our model specifications do not allow for any positive welfare effects of layoff taxes. In order to have such effects, the laissez-faire outcomes would have to be distorted by externalities or missing markets. An example of the latter is provided by Alvarez and Veracierto (1998), who consider a search model with missing insurance markets and risk-averse workers. They show that layoff taxes can improve welfare by providing implicit insurance to workers through longer job tenures and lower unemployment. The fact that unemployment falls in their analysis should not come as a surprise. The point of our analysis is that there is a strong presumption why employment implications of layoff taxes should be positive in a search model, and the economic force at work is obviously robust to the specification of the rest of the model.

7. *Concluding Comments*

What does general equilibrium analysis tell us about the effects of layoff costs? This paper sheds light on the implications of three dominant frameworks of employment determination; search models, matching models and models with employment lotteries. The predictions of these various frameworks are shown to be the same in a number of economic dimensions. For example, layoff costs do reduce the reservation productivity in layoff decisions and thereby diminish the incidence of layoffs. The economic cost of doing so manifests in a less efficient allocation of labor. Despite these common implications, the models provide diametrically different answers to how layoff costs affect employment. Our bare-bones versions of the models help us to understand their contradictory conclusions.

In each framework, we identify the main economic force at work and how it interacts with features of the model to produce employment outcomes. In search models and matching models with the standard assumption of a constant relative split of the match surplus between firms and workers, layoff costs tend to increase employment by reducing labor reallocation, whereas employment effects tend to be negative in models with employment lotteries due to the diminished private return to work. Note that the disparate employment outcomes are driven by forces that are present in all three frameworks. Layoff costs also reduce labor turnover in models with employment lotteries but since these models have no frictional unemployment, the central causation of the other two models is absent. Layoff costs also make working less attractive in search models and matching models but here there are no negative employment effects associated with indivisibilities in individual labor supply. The reason is that workers in these models are typically assumed to have linear preferences or, in the case of risk aversion, the common assumption of market incompleteness precludes employment lotteries and aggregate consumption sharing. In matching models where the workers' relative share of the match surplus increases with layoff costs, there is still another economic force at work that completely dominates everything else. Strong negative employment effects of layoff costs arise through an increase in the effective bargaining strength of workers.

Appendix

We here demonstrate that the Mortensen and Pissarides' (1999) analysis of a two-tier wage system have the same implications as a model with Nash product (7.a). The only difference between the two formulations is that the wage in the Mortensen and Pissarides' setting is reduced in the first period by the worker's share of any future layoff tax, and future wages are increased by an amount equal to the net interest on this posted "bond."

The wage function associated with Nash product (7.a) is obtained from (11) and (8.a),

$$\begin{aligned} w(p) &= p - F(p) + \beta \int F(p')\, dG(p,p') \\ &= p - (1-\delta)\, Z(p) + \beta \int (1-\delta)\, Z(p')\, dG(p,p')\,. \end{aligned} \tag{18}$$

Mortensen and Pissarides' Nash product in the first period of employment is

$$\big(W_1(p) - Z_u\big)^{\delta} F_1(p)^{1-\delta}\,,$$

while the Nash product for future periods of negotiations in a continuing match is

$$\big(W_+(p) - Z_u\big)^{\delta} \big(F_+(p) + \tau\big)^{1-\delta}\,.$$

The solutions to the maximization of these Nash products are

$$\begin{aligned} W_1(p) - Z_u &= \delta Z(p)\,, \\ F_1(p) &= (1-\delta) Z(p)\,, \\ W_+(p) - Z_u &= \delta\big(Z(p) + \tau\big)\,, \\ F_+(p) &= (1-\delta) Z(p) - \delta\tau\,, \end{aligned} \tag{19}$$

where we conjecture that the match surplus $Z(p)$ is the same as in (18). The associated wage functions can be written as

$$\begin{aligned} w_1(p) &= p - F_1(p) + \beta \int F_+(p')\, dG(p,p') = w(p) - \beta\,\delta\tau\,, \\ w_+(p) &= p - F_+(p) + \beta \int F_+(p')\, dG(p,p') = w(p) + r\,\beta\,\delta\tau\,, \end{aligned}$$

where the second equalities follow from (18) and (19), and $r \equiv \beta^{-1} - 1$.

Given the conjecture that the match surplus $Z(p)$ is identical for the two models, we have shown that the present value of a worker's total compensation for any completed job is the same across models which in turn implies the same present value of a firm's payoffs. It then follows that the two models share the same equilibrium allocation of labor in spite of the different bargaining formulations.

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